Module Handbook

for the study program

Mechanical Engineering B.Sc.

Kleve, February 2017

Content

Curriculum Mechanical Engineering B.Sc

Curriculum ME		HPW	Type						Examination form		CP	HPW						
			V	SL	S	Ü	Pra	Pro	Attestation	graded		WS1	SS2	WS3	SS4	WS5	SS6	WS7
1st Semester																		
ME 1 2000	Introductory Mathematics	8	5			3				x	8	8						
ME 1 2007	Chemistry of Materials	4	2			2				x	5	4						
ME 1 2008	Statics and Strength of Materials	4	2			2				x	5	4						
ME 1 2011	Programming	4	2				2		x	x	3	4						
ME 1 2013	Business Economics and Project Management	4	3				1		x		5	4						
ME 1 2700	Introduction to Mechanical Engineering	3	2		1				x		5	3						
2nd Semester																		
ME 2 2001	Applied Mathematics	8	5			3				x	7		8					
ME 2 2003	Physics	4	2			1	1		x	x	5		4					
ME 2 2009	Advanced Strength of Materials	4	2			2				x	5		4					
ME 2 2014	Cross-Cultural Management and Creativity	4	2			2			x		5		4					
ME 2 2106	Metallic Materials and Testing	4	2				2			x	5		4					
ME 2 2701	Engineering Drawing and Design	4	2			1	1		x	x	5		4					
3rd Semester																		
ME 3 2010	Dynamics	4	2			2				x	5			4				
ME 3 2107	Non-metallic Materials	4	2			1	1		x	x	5			4				
ME 3 2305	Fundamentals of Electrical Engineering	4	2			1	1		x	x	5			4				
ME 3 2704	Advanced Engineering Design	4	2			1		1		x	5			4				
ME 3 2708	Thermodynamics	4	2			1	1			x	5			4				
ME 3 2711	Drive Systems	4	2			2				x	5			4				
4th Semester																		
ME 4 2002	Numerical Mathematics	4	3			1				x	5				4			
ME 4 2705	Product Design	4	2			1		1		x	5				4			
ME 4 2706	Manufacturing Technology	4	3			1				x	5				4			
ME 4 2902	System Theory and Controls	4	2			1	1			x	5				4			
	Focus Field (see catalogue individual subjects: Focus Fields)																	
	Focus Field Subject 1	4									5				4			
	Focus Field Subject 2	4									5				4			
5th Semester																		
ME 5 2015	Group Project	1						1	x		5					1		
ME 5 2511	Quality and Production Management	4	3				1			x	5					4		
ME 5 2903	Controls	4	2			1	1			x	5					4		
ME 5 2904	Modelling and Simulation	4	2			2				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																		
ME 6 2016	Internship / Semester abroad								x		30							
7th Semester																		
ME 7 2017	Bachelor Thesis									x	12							
ME 7 2018	Colloquium									x	3							
ME 7 2510	Technology and Innovation Management	4	2				2			x	5							4
ME 7 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**	**16**	**17**		**9**
		HPW	**Type**						**Examination form**		**CP**	**WS1**	**SS2**	**WS3**	**SS4 HPW**	**WS5**	**SS6**	**WS7**

Catalogue Individual Subjects ME		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 Design	**16**	**8**			**5**	**3**				**20**				**8**	**8**		
ME 4 2121	Material Testing and Failure Analysis	4	2				2			x	5				4			
ME 4 2714	Virtual Product Development	4	2			1	1			x	5				4			
ME 5 2704	Advanced Product Design	4	2			2				x	5					4		
ME 5 2905	Finite Element Method	4	2			2				x	5					4		
	Focus Field Process Engineering	**16**	**8**			**3**	**5**				**20**				**8**	**8**		
ME 4 2709	Fundamentals of Process Engineering	4	2			1	1			x	5				4			
ME 4 2710	Fluid Mechanics	4	2			1	1			x	5				4			
ME 5 2711	Design of Plants	4	2				2			x	5					4		
ME 5 2712	Control of Plants in Process Engineering	4	2			1	1			x	5					4		
	Focus Field Machinery and Systems	**16**	**8**			**7**	**1**				**20**				**8**	**8**		
ME 4 2715	Material Handling Systems	4	2			2				x	5				4			
ME 4 2716	Agricultural Engineering	4	2			2				x	5				4			
ME 5 2717	Mobile Hydraulics	4	2			1	1			x	5					4		
ME 5 2718	Cylindrical Gears	4	2			2				x	5					4		
	Focus Field Simulation and Validation	**16**	**8**			**7**	**1**				**20**				**8**	**8**		
ME 4 2719	Applied Strength of Materials	4	2			2				x	5				4			
ME 4 2908	Multibody Dynamics	4	2			2				x	5				4			
ME 5 2720	Machine Dynamics	4	2			1	1			x	5					4		
ME 5 2905	Finite Element Method	4	2			2				x	5					4		
	Focus Field Technical Sales	**16**	**7**			**4**	**2**	**3**			**20**				**8**	**8**		
ME 4 2513	Global Economy and Trade	4	2			2				x	5				4			
ME 4 2514	Technical Investment Planning and Purchasing	4	1					3		x	5				4			
ME 5 2505	Production and Logistics	4	2				2			x	5					4		
ME 5 2509	Fundamentals of Law, Investment and Financing	4	2			2				x	5					4		
	Focus Field Bionics	**16**	**8**			**4**	**2**	**2**			**20**				**8**	**8**		
ME 4 2723	Biomimetic Science	4	2			2				x	5				4			
ME 4 2724	Zoological Physics	4	2				2			x	5				4			
ME 5 2725	Bioinspiration	4	2			2				x	5					4		
ME 5 2726	Bionic Design	4	2					2	x		5					4		
Electives																		
ME 7 2019	Scientific Methods (Block or online)	4	2			2			x		5							4
ME 7 2020	Foreign Language								x		5							
ME 7 2021	Module from any other Bachelor study course HSRW								x	x	5							
ME 7 2721	Design of Membrane Plants	4	2				2			x	5							4
ME 7 2722	Leadership	3			3				x		5							3

Explanations / Conditions

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

** Aus dem Wahlbereich können mit dem Einverständnis des 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 offered concurrently.

Abbreviations

HPW Semesterwochenstunden / hours per week
CP Kreditpunkte / credit points

Prüfungsinformationen Mechanical Engineering B.Sc.

Examinations ME		Examination form		CP	Duration [min]	Examination offer		
		Attestation	graded			WS I (September, 1 week)	WS II (February, 2 weeks)	SS (July, 2 weeks)
1st Semester								
ME 1 2000	Introductory Mathematics		x	8	120		x	x
ME 1 2007	Chemistry of Materials		x	5	120		x	x
ME 1 2008	Statics and Strength of Materials		x	5	90		x	x
ME 1 2011	Programming	x	x	5	120	x	x	
ME 1 2013	Business Economics and Project Management	x		5				
ME 1 2700	Introduction to Mechanical Engineering	x		3				
2nd Semester								
ME 2 2001	Applied Mathematics		x	7	120		x	x
ME 2 2003	Physics	x	x	5	90	x	x	
ME 2 2009	Advanced Strength of Materials		x	5	120		x	x
ME 2 2014	Cross-Cultural Management and Creativity	x		5				
ME 2 2106	Metallic Materials and Testing		x	5	120	x		x
ME 2 2701	Engineering Drawing and Design	x	x	5	Continuous Assessment			x
3rd Semester								
ME 3 2010	Dynamics		x	5	120		x	x
ME 3 2107	Non-metallic Materials	x	x	5	120	x	x	
ME 3 2305	Fundamentals of Electrical Engineering	x	x	5	90	x	x	
ME 3 2704	Advanced Engineering Design		x	5	90	x	x	
ME 3 2708	Thermodynamics		x	5	120	x	x	
ME 3 2711	Drive Systems		x	5	120		x	x
4th Semester								
ME 4 2002	Numerical Mathematics		x	5	120		x	x
ME 4 2705	Product Design		x	5	90		x	x
ME 4 2706	Manufacturing Technology		x	5	60		x	x
ME 4 2902	System Theory and Controls		x	5	120		x	x
	Focus Field (see catalogue individual subjects: Focus Fields)							
	Focus Field Subject 1			5				
	Focus Field Subject 2			5				
5th Semester								
ME 5 2015	Group Project	x		5				
ME 5 2511	Quality and Production Management		x	5	60		x	x
ME 5 2903	Controls		x	5	120		x	x
ME 5 2904	Modelling and Simulation		x	5	120		x	x
	Focus Field (see catalogue individual subjects: Focus Fields)							
	Focus Field Subject 3			5				
	Focus Field Subject 4			5				
6th Semester								
ME 6 2016	Internship / Semester abroad	x		30				
7th Semester								
ME 7 2017	Bachelor Thesis		x	12				
ME 7 2018	Colloquium		x	3				
ME 7 2510	Technology and Innovation Management		x	5	90		x	x
ME 7 2512	Entrepreneurship	x		2				
	Elective (see catalogue individual subjects: Electives)			5				

Catalogue Individual Subjects ME		Examination form		CP	Duration [min]	Examination offer		
		Attestation	graded			WS I (September, 1 week)	WS II (February, 2 weeks)	SS (July, 2 weeks)
Focus Fields								
	Focus Field Design			**20**				
ME 4 2121	Material Testing and Failure Analysis		x	5	90		x	x
ME 4 2714	Virtual Product Development		x	5	90		x	x
ME 5 2704	Advanced Product Design		x	5	90	x	x	
ME 5 2905	Finite Element Method		x	5	Continuous Assessment		x	
	Focus Field Process Engineering			**20**				
ME 4 2709	Fundamentals of Process Engineering		x	5	120		x	x
ME 4 2710	Fluid Mechanics		x	5	120		x	x
ME 5 2712	Design of Plants		x	5	Continuous Assessment		x	
ME 5 2713	Control of Plants in Process Engineering		x	5	Continuous Assessment		x	
	Focus Field Machinery and Systems			**20**				
ME 4 2715	Material Handling Systems		x	5	90	x		x
ME 4 2716	Agricultural Engineering		x	5	90		x	x
ME 5 2717	Mobile Hydraulics		x	5	90		x	x
ME 5 2718	Cylindrical Gears		x	5	90		x	x
	Focus Field Simulation and Validation			**20**				
ME 4 2719	Applied Strength of Materials		x	5	120		x	x
ME 4 2908	Multibody Dynamics		x	5	120		x	x
ME 5 2720	Machine Dynamics		x	5	120		x	x
ME 5 2905	Finite Element Method		x	5	Continuous Assessment		x	
	Focus Field Technical Sales			**20**				
ME 4 2513	Global Economy and Trade		x	5	30		x	x
ME 4 2514	Technical Investment Planning and Purchasing		x	5	Continuous Assessment		x	
ME 5 2505	Production and Logistics		x	5	60		x	x
ME 5 2509	Fundamentals of Law, Investment and Financing		x	5	30		x	x
	Focus Field Bionics			**20**				
ME 4 2723	Biomimetic Science		x	5	120	x		x
ME 4 2724	Zoological Physics		x	5	Continuous Assessment			x
ME 5 2725	Bioinspiration		x	5	Continuous Assessment		x	
ME 5 2726	Bionic Design	x		5				
Electives								
ME 7 2019	Scientific Methods (Block or online)	x		5				
ME 7 2020	Foreign Language	x		5				
ME 7 2021	Module from any other Bachelor study course HSRW	x	x	5				
ME 7 2721	Design of Membrane Plants		x	5	Continuous Assessment		x	
ME 7 2722	Leadership	x		5				

Die Fakultät Technologie und Bionik behält sich vor, die Prüfungsformen in Abhängigkeit der zu prüfenden Studierenden abzuwandeln (mündliche Prüfung => schriftliche Prüfung und umgekehrt). Jede Änderung wird zu Beginn des Semesters nach Kenntnis der Teilnehmerzahl an der Veranstaltung bekanntgegeben.

Prüfungsdauer 30min: mündliche Prüfung
Prüfungsdauer 60min und mehr: schriftliche Prüfung

2000 Introductory Mathematics

Module name:	Introductory Mathematics	2000
Module code:	Biomaterials Science: Electrical Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BM 1 2000 EL 1 2000 IE 1 2000 ME 1 2000 SE 1 2000
Module coordinator:	Prof. Dr. A. Kehrein	
Lecturer:	Prof. Dr.-Ing. S. Dederichs MBA Prof. Dr. A. Kehrein Prof. Dr. M. Krauledat Prof. Dr. A. Struck	
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 examination
Forms of media:	Whiteboard, Projector
Literature:	James Stewart (2011). *Calculus*. Metric International Version. 7th edition. Brooks/Cole Further Reading: 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:	Applied Mathematics	2001
Module code:	Biomaterials Science: Electrical Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BM 2 2001 EL 2 2001 IE 2 2001 ME 2 2001 SE 2 2001
Module coordinator:	Prof. Dr. A. Kehrein	
Lecturer:	Prof. Dr.-Ing. S. Dederichs MBA Prof. Dr. A. Kehrein Prof. Dr. M. Krauledat Prof. Dr. A. Struck	
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 able to use advanced mathematical concepts and methods and, in particular, are able to work with multivariate functions. They master modelling with differential equations. Students practice their general social skills working in teams. They specifically train to communicate in precise mathematical terms. By means of their homework, students further improve their problem solving skills. Students learn to interpret and summarise data in a meaningful way and to present it graphically in a suitable way. Here the main focus lies on analyses occurring in experiments. Furthermore, they should learn how to draw conclusions about a population based on sample data; here especially the application quality assurance should be considered. The fundamentals of probability theory that are necessary for this purpose are developed empirically via experiments by students.	
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	

	• Basic concepts of descriptive statistics: population, sample, qualitative/quantitative data, classification, histograms, scatter plots, stem-leaf-diagrams • Key figures: mean value, median, variance (for population and sample), standard deviation, z-values (standard units) • Regression: correlation and linear regression, non-linear regression • 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:	James Stewart (2011): *Calculus*. Metric International Version. 7th edition. Brooks/Cole John Devore (2008) *Probability and Statistics for Engineering and the Sciences*. 7th int. student edition. Brooks/Cole DeVeaux, Velleman, Bock (2004) *Stats: Data and Models*. Pearson Freedman, Pisani, Purves (2007) *Statistics*. 4th edition. Norton Recommended Video Lectures: 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 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:	Numerical Mathematics	2002
Module code:	Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	IE 4 2002 ME 4 2002 SE 4 2002
Module coordinator:	Prof. Kehrein	
Lecturer:	Prof. Kehrein Prof. Krauledat Prof. Struck	
Language:	English	
Place in curriculum:	Elective	
Timetabled hours:	Lectures: Tutorials:	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 2012 Advanced Programming	
Module objectives:	Numerical Mathematics • Learning some standard concepts and methods of numerical mathematics • Being able to develop problem-adapted methods • Understanding the limitations of doing mathematics with a computer	
Content:	• Presentation of numbers in a computer: INT and FLOAT; roundoff 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 linear systems • Iterative solution of non-linear systems, in particular Newton's Method • Numerical solution of differential equations: forward and backward Euler, Runge-Kutta, difference equations, stability, implicit vs. explicit schemes	
Assessment:	Exam	
Forms of media:	Whiteboard, projector	

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

2003 Physics

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

2007 Chemistry of Materials

Module name:	Chemistry of Materials	2007
Module code:	Industrial Engineering: Mechanical Engineering:	IE 1 2007 ME 1 2007
Module coordinator:	Prof. Dr. Christoph Heß	
Lecturer:	Prof. Dr. Christoph Heß	
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:	none	
Module objectives:	Students are able to • Denominate elements and important inorganic chemical compounds, such as acids, bases and salts • Distinguish between metals and non-metals in regard of structure and properties • Basically understand the principles of simple inorganic chemical reactions • Understand and explain the importance of basic chemical knowledge for the assessment of materials and their specific properties	
Content:	• Structure of atoms, elements and compounds • Periodic table of elements • Types of bonds (metallic, covalent and ionic bond) • Chemical reactions, chemical equilibrium, catalysis • Acids, bases, pH, neutralization • Simple introduction on thermodynamics of chemical reactions (enthalpy of reaction) • Redox reactions, basics of electrochemistry, electrolysis, galvanic cell, corrosion • Introduction on technical applications of different inorganic materials	
Assessment:	Lecture: Written Exam Laboratory: Reports	
Forms of media:	Whiteboard, PowerPoint, Projector	
Literature:	John E. McMurry, Robert C. Fay: General Chemistry: Atoms First, Prentice Hall; 2009	

2008 Static and Strength of Materials

Module name:	Statics and Strength of Materials	2008
Module code:	Biomaterials Science: Electrical Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BM 3 2008 EL 1 2008 IE 1 2008 ME 1 2008 SE 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 examination Accompanying online course
Forms of media:	Whiteboard, PowerPoint, Projector
Literature:	Ferdinand Beer, Jr. Johnston, John DeWolf, David Mazurek: Statics and Mechanics of Materials, 2nd edition, ISBN 9780073398167 Lecture Notes

2009 Advanced Strength of Materials

Module name:	Advanced Strength of materials	2009
Module code:	Mechanical Engineering: Mechatronic Systems Engineering:	ME 2 2009 SE 2 2009
Module coordinator:	Prof. NH Østergaard	
Lecturer:	Prof. NH 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:	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) Recommended text book: • Mechanics of materials (Global Ed.), McGraw-Hill Beer, Johnston, DeWolf, Mazurek Recommended secondary literature: • Vector Mechanics for Engineers: Statics (Global Ed.), McGraw-Hill • Statics (SI Ed.), Wiley & Sons, Meriam & Kraige • Mechanics of Materials (SI Ed.),Cengage Learning, Gere

2010 Dynamics

Module name:	Dynamics	2010
Module code:	Mechanical Engineering: Industrial Engineering: Mechatronic Systems Engineering:	ME 3 2010 IE 3 2010 SE 3 2010
Module coordinator:	Prof. NH Østergaard	
Lecturer:	Prof. NH 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:	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 examination
Forms of media:	Whiteboard (PowerPoint, Projector, demonstration in the lecture)
Literature:	Primary teaching material: Introduction to Dynamics, course slides and problems by NH Østergaard (will be uploaded to Moodle at the beginning of the course) Recommended text book: Beer, Johnston, Cornwell: Vector Mechanics for Engineers: Dynamics (Global Ed.), McGraw-Hill Recommended secondary literature: Meriam and Kraige: Dynamics (SI Ed.), Wiley Publishing,

2011 Programming

Module name:	Programming 2011
Module code:	Biomaterial Science: BM 1 2011 Electrical Engineering: EL 1 2011 Industrial Engineering: IE 1 2011 Mechanical Engineering: ME 1 2011 Mechatronic Systems Engineering: SE 1 2011
Module coordinator:	Prof. Dr. M. Krauledat
Lecturer:	Prof. Dr. M. Krauledat Prof. Dr. R. Hartanto Prof. Dr. A. Stamm B. Mielke
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:	
Module objectives:	After successful completion of this module, students are able to • recognize limitations and complexity of computer based operations • Use algorithmic concepts such as recursion • transfer technical problems to program code • implement simple algorithms • analyse results of mathematical calculations using appropriate tools such as graphical plots and numeric computations
Content:	Algorithmic Concepts • Input and Output • Recursion and iteration Program structures using a high-level programming language • Syntax and Semantics • Data Visualization: plotting in MATLAB • MATLAB program structures (m-files): scripts and functions • Basic programming structures: conditional statements, loops • Symbolic determination of derivatives and integrals • Built-in numerical methods • Basic tools for graphical modelling and simulation (e.g. Simulink)
Assessment:	Lecture: written examination Exercise: attestation

Forms of media:	Whiteboard, PowerPoint, Projector, PC-Pool
Literature:	Stormy Attaway (2012). *MATLAB – A Practical Introduction to Programming and Problem Solving*. 2nd edition. Butterworth-Heinemann.

2013 Business Economics and Project Management

Module name:	Business Economics & Project Management	2013
Module code:	Biomaterials Science: Electrical Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BM 3 2013 EL 1 2013 ME 1 2013 SE 1 2013
Module coordinator:	Prof. Dr. Dirk Berndsen	
Lecturer:	Prof. Dr. Dirk Berndsen	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Practical Training:	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 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:	Attestation
Forms of media:	MS Powerpoint slides via projector, added notes (electronic pen during lecture), Whiteboard Printouts of case materials and exercise sheets. Networked devices (PCs, laptops, tablets, mobiles) for pre-structured search exercises
Literature:	<u>Business Economics</u> Nickels, William G. / McHugh, James / McHugh, Susan (2015): Understanding Business. 11th edition, ISBN 978-9814670371, McGraw-Hill Hughes, Robert / Kapoor, Jack R. / Pride, William M. (2014): Business. EMEA edition. ISBN 978-1473704763, Cengage Learning Brealey, Richard A. / Myers, Stewart C. / Allen, Franklin (2016): Principles of Corporate Finance. 12th edition, ISBN 978-1259253331, McGraw-Hill

	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> 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 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 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

Module name:	Cross-Cultural Management and Creativity	2014
Module code:	Biomaterials Science: Electrical Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BM 1 2014 EL 3 2014 IE 2 2014 ME 2 2014 SE 5 2014
Module coordinator:	Anja Viermann	
Lecturer:	Anja Viermann	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Seminar: Cross-Cultural Management Creativity	4 HPW 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 cross-cultural competences (cognitive, affective and communicative) and to gain first basic knowledge and abilities to deal with creative processes in individual, team or organisational settings. For this, the students will • develop a deepened understanding of the dangers and potential arising from human differences. • reflect on the impact of different dimensions of diversity in a business context. • get a thorough understanding of the term and nature of „culture “. • look into the effects of culture shock and reflect on coping strategies. • study different cultural models and get to know different dimensions of culture. On this basis, reflect and develop an awareness of the student’s individual cultural background in contrast to other cultures in respect to values and behaviour. This supports students to become more self-reflective and mindful as well as learning strategies for dealing with negative vibes from cultural differences. • experience working within multi-cultural teams and combine theoretical and empirical work while working on a topic related project. • develop an awareness of and reflect on the importance of creativity. • be equipped with a repertoire of methods and strategies that support creative processes and know-how to build a supportive work environment and innovative climate in organizations to make best use of creative potentials.	

	• through group work, improve their intercultural collaboration and communication skills as well as presentation abilities.
Content:	<u>Cross-Cultural Management:</u> • Dealing with differences • Diversity in business environment • Globalisation of markets and economies and the need for cross-cultural competence • Definitions of culture and their key aspects • Culture shock • Cultural models and dimensions of culture • Reflect on the student's individual cultural background in relation to other cultures and on the impact of cultural differences in business environment • Organisational culture <u>Creativity:</u> • Definition of creativity • Impact of creativity on business innovation and the creation of sustainable competitive advantages • Key components of individual creativity and team creativity • Getting to know different classical creativity techniques and new approaches to creativity • Frame conditions for creativity and innovation in organizations
Assessment:	Attestation: Group assignments: preparation, submission and oral presentation (40%) of a written assignment (term paper) (60%)
Forms of media:	Whiteboard, PowerPoint, Projector, Flip-Chart, Moderation kit
Literature:	Hofstede, Geert (2010): Cultures and Organizations - Software of the Mind: Intercultural Cooperation and Its Importance for Survival, 3rd Edition, Mcgraw-Hill Education Kaufmann, J.C./Sternberg, R.J. (Ed.) (2010): The Cambridge Handbook of Creativity. Cambridge: Cambridge University Press Trompenaars, Fons (2012): Riding the Waves of Culture: Understanding Cultural Diversity in Business, 3rd Edition, N. Brealey Publishing Stamm, B. (2008): Managing innovation, design and creativity. Chichester, Wiley. Supplemental readings, e.g. additional literature, exercises, cases and other learning materials will be provided during class.

2015 Group Project

Module name:	Group Project	2015
Module code:	Biomaterials Science: Electrical Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BM 5 2015 EL 5 2015 IE 5 2015 ME 5 2015 SE 5 2015
Module coordinator:	Prof. Dr.-Ing. P.Kisters	
Lecturer:	All professors of the faculty Technology and Bionics	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Tutorials:	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	
Forms of media:	Whiteboard, PowerPoint, Projector	
Literature:	C. M. Anson and R. A. Schwegler: The Longman Handbook for Writers and Readers, fourth edition, Pearson Education Inc., 2005 G. Pahl, W. Beitz, J. Feldhusen, K.H. Grote: Engineering Design – A Systematic Approach, 3rd ed. 2007 (4. November 2014), Springer, 2014 Selected state-of-the-art papers	

2016 Internship / Semester Abroad

Module name:	Internship / Semester Abroad	2016
Module code:	Biomaterials Science: Electrical Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BM 76 2016 EL 6 2016 IE 6 2016 ME 6 2016 SE 6 2016
Module coordinator:	Course leaders	
Lecturer:	Course leaders / 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:	Bachelor Thesis	2017
Module code:	Biomaterials Science: Electrical Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BM 7 2017 EL 7 2017 IE 7 2017 ME 7 2017 SE 7 2017
Module coordinator:	Course Leaders	
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:	Colloquium	2018
Module code:	Biomaterials Science: Electrical Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BM 7 2018 EL 7 2018 IE 7 2018 ME 7 2018 SE 7 2018
Module coordinator:	Course Leaders	
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:	M. Powell: Presenting in English – how to give successful presentations, Heinle Cengage Learning, 2011 S. Krantman: The Resume Writer's Workbook, fourth edition, South-Western Cengage Learning, 2013	

2019 Scientific Methods

Module name:	Scientific Methods 2019
Module code	Biomaterial Science: BM 7 2019 Electrical Engineering: EL 7 2019 Industrial Engineering: IE 7 2019 Mechanical Engineering: ME 7 2019 Mechatronic Systems Engineering: SE 7 2019
Module Coordinator:	Prof. Dr.-Ing. P. Kisters Prof. Dr.-Ing. J. Gebel
Lecturer:	External lecturer
Language:	English
Part of Curriculum	Elective
Timetable hours	Seminar
Workload	150 h
Credits:	5
Recommended prerequisites:	
Module objectives:	The course offers an introduction to the ethics and logic of science as well as to some methods helpful for the investigation of technical questions. Beside methodological aspects the students understand their ethic responsibility as a scientist and reflect their work based on social impacts and scientific rules. The students know scientific misconduct like fabrication, falsification, copyright violation, wrong citation, plagiarism, violation of ethical standards etc. The students are able to get a full overview over their topic and use literature research for this. They repeat the basic principles of scientific procedure and are able to practically implement their knowledge on a scientific question. They are aware of the differences between theory and empiricism as well as between deductive and inductive reasoning. The students reflect their work accordingly. In case experimental validations of phenomena are required they are able to structure their test program using design of experiments. The students evaluate the limits for testing, they define and rate the required simplifications. Research results are analysed statistically and reflected critically in order to evaluate the quality of the results. Finally, the students prepare the results specific to a target groups.

Content:	Methodological principles encompass the entire process of the scientific questioning
	• Science ethics
	  - what is allowed
	  - what shall remain unexplored
	• Ethical standards in science
	• Social impacts of science
	• Analysis of the scientific question
	• Literature research
	• Definition state of the art

	• Introduction to the logic of science • Inductive vs. deductive reasoning • Formulation of hypotheses • Verification and falsification of hypotheses • Degree of testability • Simplification and probability • Design of experiments • Numerical and graphical data analysis • Descriptive and analytical statistics • Presentation of data / results • Publication of the results in different forms (report, paper, poster, web pages etc.)
Assessment:	Attestation
Forms of media:	Board, Power Point
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

2020 Foreign language

Module name:	Foreign language	2020
Module code:	Biomaterials Science: Electrical Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BM 7 2020 EL 7 2020 IE 7 2020 ME 7 2020 SE 7 2020
Module coordinator:	Study-program coordinator	
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:	acc. module description of the selected module of the language center	
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 study course HSRW

Module name:	Module from any other Bachelor study course HSRW 2021
Module code:	Biomaterials Science: BM 7 2021 Electrical Engineering: EL 7 2021 Industrial Engineering: IE 7 2021 Mechanical Engineering: ME 7 2021 Mechatronic Systems Engineering: SE 7 2021
Module coordinator:	Study-program coordinator
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

2106 Metallic Materials and Testing

Module name:	Metallic Materials and Testing	2106
Module code:	Biomaterials Science: Mechanical Engineering:	BM 2 2106 ME 2 2106
Module coordinator:	Prof. Dr.-Ing. Raimund Sicking	
Lecturer:	Prof. Dr.-Ing. Raimund Sicking	
Language:	English	
Place in curriculum	Core subject	
Timetabled hours:	Lecture: Laboratory:	2 HPW 2 HPW
Workload:	60 h Attendance 60 h Self-study 30 h Exam preparation	
Credits:	5	
Recommended prerequisites:	2005 Inorganic Chemistry or 2007 Chemistry of Materials	
Module objectives:	*Students will be able to:* • Define crystal structures and different classes of metals • Report with basic knowledge concerning alloy systems, phase transformations, strength increasing mechanisms as well as mechanical and technological properties. • Understand suitable thermal treatments in different areas of the metal industry. • Perform different testing and analysis methods for materials characterization. • Know different classifications of steel	
Content:	• Introduction into atomic structure and built-up of single and polycrystals, lattice structures, lattice defects • Strength increase mechanisms (cold forming/plastic deformation, Hall-Petch, solid solution, dispersion, precipitates, texture, phase transformation) • Thermal Effects (diffusion, recovery, recrystallization, grain coarsening, phase transitions, nucleation) • Mechanical load, stress-strain diagram, fracture, metal groups as well as a first introduction into corrosion • Equilibrium: component / phase / microstructure, 2-component system / equilibrium diagrams, phase diagrams, phase rule, lever rule. • Introduction of important testing methods (micro and macro hardness, impact test, tensile test) • Microscope techniques and its basics • Jominiy test and displacive transformation (martensite formation) • Classification of steels • In addition specific application examples are presented.	
Assessment:	Exam / Lab Reports	

Forms of media:	Board/PowerPoint/Projector/Laboratory
Literature:	Bunge, H.J., Pöhlandt, K., Tekkaya, A.E., Banabic, D.Banabic, D.; Pöhlandt, Klaus (Eds.): Formability of Metallic Materials, Plastic Anisotropy, Formability Testing, Forming Limits, XV, ISBN 978-3-540-67906-6, 2000 R.B. Ross: Metallic Materials Specification Handbook, 4th Edition, ISBN 978-0412369407, Springer US, 1991 G. Gottstein Physical Foundations of Materials Science, 1st Edition, ISBN 978-3-642-07271-0 George M. Crankovic: Metals Handbook: Materials Characterization, 9th Edition, ISBN 978-0871700162, ASM Intl., 1989 M. F. Ashby, D. R. H. Jones: Engineering Materials 2 – An Introduction to Microstructures, Processing and Design, 3rd edition, ISBN-13 978-0-7506-6381-6

2107 Non-metallic Materials

Module name:	Non-metallic Materials	2107
Module code:	Biomaterials Science: Mechanical Engineering:	BM 3 2107 ME 3 2107
Module coordinator:	Prof. Dr. Christoph Heß	
Lecturer:	Prof. Dr. Christoph Heß	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Laboratory:	2 HPW 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2006 Organic Chemistry or 2007 Chemistry of Materials	
Module objectives:	• Specify basic chemical structures of polymers, ceramics and glass • Conclude on characteristic properties of polymers, ceramics and glass from the respective structure • Select suitable materials for a given engineering application task • Optimize specific mechanical or thermal properties of a material by suitable adjustment of formulation or processing parameters • Understand and explain the most important processing technologies for synthetic materials • Select suitable processing technologies for a given industrial task • Consider probable changes of material properties during processing and evaluate process limitations • Assess processing methods in regard of product quality and economic efficiency	
Content:	• Different types of polymers (synthetic polymers, natural polymers, thermoplastics, thermosets, elastomers) • Structure and composition of polymers, ceramics and glass • Manufacture of polymers (radical polymerization, polyaddition, polycondensation) • Manufacture of ceramics and glass (ceramic process, sintering) • Homopolymers, copolymers, terpolymers, tacticity • Branched polymers, crosslinked polymers, curing, semi-crystalline and amorphous polymers • 3-dimensional structure of macromolecules, superstructures • Phase transitions in polymers (glass transition, crystallization, melting)	

	• Physical properties of polymers (viscoelasticity, thermoplasticity, thermosetting) • Physical properties of ceramics and glass (hardness, strength, thermal properties) • Fundamentals of polymer processing (material flow, equipment, products, recycling, disposal) • Compounding technology, extrusion (feeding, melting, mixing, metering, screw design), compounding line (raw material feeder, extruder, cooling section, pelletizer), blends, additives, fillers • Processing technology for polymers (profile extrusion, injection molding, blown film extrusion, die casting, extrusion blow molding, stretch blow molding, thermoforming, compression molding, spin casting, pultrusion) • Rapid prototyping • Process-induced changes of material properties (stretching, orientation, anisotropy) • Thermodynamics of polymer processing (heat flow) • Quality assurance
Assessment:	Lecture: Written Exam Laboratory: Reports
Forms of media:	Whiteboard, PowerPoint, Projector, Laboratory
Literature:	Stephen L. Rosen: Fundamental Principles of Polymeric Materials (Society of Plastics Engineers Monographs), 3rd rev. Edition, ISBN 978-0470505427, Wiley Blackwell, 2010 Jean Louis Halary, Francoise Laupretre, and Lucien Monnerie: Polymer Materials: Macroscopic Properties and Molecular Interpretations, 1st Edition, ISBN 978-0470616192, Wiley & Sons., 2011 William D. Callister: Materials Science and Engineering: An Introduction, 7th Edition, ISBN 978-0471736967, Wiley & Sons, 2006 Ian W. Hamley: Introduction to Soft Matter: Synthetic and Biological Self-Assembling Materials, 1st Edition, ISBN 978-0470516102, Wiley & Sons, 2007 G. W. Ehrenstein: Polymerwerkstoffe - Struktur – Eigenschaften – Anwendung, 3. Aufl., 2011, ISBN 978-3-446-42283-4, Carl Hanser Verlag W. Michaeli: Einführung in die Kunststoffverarbeitung, 5. Aufl., 2006, ISBN-13 978-3-446-40580-6, Carl-Hanser-Verlag C. B. Carter, M. G. Norton: Ceramic Materials - Science and Engineering, 2. Aufl., 2013, ISBN 978-1-4614-3522-8, Springer-Verlag

2121 Material Testing and Failure Analysis

Module name:	Non-metallic Materials 2107
Module code:	Biomaterials Science: BM 3 2107 Mechanical Engineering: ME 3 2107
Module coordinator:	Prof. Dr. Christoph Heß
Lecturer:	Prof. Dr. Christoph Heß
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Laboratory: 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2006 Organic Chemistry or 2007 Chemistry of Materials
Module objectives:	• Specify basic chemical structures of polymers, ceramics and glass • Conclude on characteristic properties of polymers, ceramics and glass from the respective structure • Select suitable materials for a given engineering application task • Optimize specific mechanical or thermal properties of a material by suitable adjustment of formulation or processing parameters • Understand and explain the most important processing technologies for synthetic materials • Select suitable processing technologies for a given industrial task • Consider probable changes of material properties during processing and evaluate process limitations • Assess processing methods in regard of product quality and economic efficiency
Content:	• Different types of polymers (synthetic polymers, natural polymers, thermoplastics, thermosets, elastomers) • Structure and composition of polymers, ceramics and glass • Manufacture of polymers (radical polymerization, polyaddition, polycondensation) • Manufacture of ceramics and glass (ceramic process, sintering) • Homopolymers, copolymers, terpolymers, tacticity • Branched polymers, crosslinked polymers, curing, semi-crystalline and amorphous polymers • 3-dimensional structure of macromolecules, superstructures • Phase transitions in polymers (glass transition, crystallization, melting)

	• Physical properties of polymers (viscoelasticity, thermoplasticity, thermosetting) • Physical properties of ceramics and glass (hardness, strength, thermal properties) • Fundamentals of polymer processing (material flow, equipment, products, recycling, disposal) • Compounding technology, extrusion (feeding, melting, mixing, metering, screw design), compounding line (raw material feeder, extruder, cooling section, pelletizer), blends, additives, fillers • Processing technology for polymers (profile extrusion, injection molding, blown film extrusion, die casting, extrusion blow molding, stretch blow molding, thermoforming, compression molding, spin casting, pultrusion) • Rapid prototyping • Process-induced changes of material properties (stretching, orientation, anisotropy) • Thermodynamics of polymer processing (heat flow) • Quality assurance
Assessment:	Lecture: Written Exam Laboratory: Reports
Forms of media:	Whiteboard, PowerPoint, Projector, Laboratory
Literature:	Stephen L. Rosen: Fundamental Principles of Polymeric Materials (Society of Plastics Engineers Monographs), 3rd rev. Edition, ISBN 978-0470505427, Wiley Blackwell, 2010 Jean Louis Halary, Francoise Laupretre, and Lucien Monnerie: Polymer Materials: Macroscopic Properties and Molecular Interpretations, 1st Edition, ISBN 978-0470616192, Wiley & Sons., 2011 William D. Callister: Materials Science and Engineering: An Introduction, 7th Edition, ISBN 978-0471736967, Wiley & Sons, 2006 Ian W. Hamley: Introduction to Soft Matter: Synthetic and Biological Self-Assembling Materials, 1st Edition, ISBN 978-0470516102, Wiley & Sons, 2007 G. W. Ehrenstein: Polymerwerkstoffe - Struktur – Eigenschaften – Anwendung, 3. Aufl., 2011, ISBN 978-3-446-42283-4, Carl Hanser Verlag W. Michaeli: Einführung in die Kunststoffverarbeitung, 5. Aufl., 2006, ISBN-13 978-3-446-40580-6, Carl-Hanser-Verlag C. B. Carter, M. G. Norton: Ceramic Materials - Science and Engineering, 2. Aufl., 2013, ISBN 978-1-4614-3522-8, Springer-Verlag

2305 Fundamentals of Electrical Engineering

Module name:	Fundamentals of Electrical Engineering 2305
Module code:	Industrial Engineering: IE 3 2305 Mechanical Engineering: ME 3 2305 Mechatronic Systems Engineering: SE 1 2305
Module coordinator:	Prof. Gehnen
Lecturer:	Prof. Gehnen
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practicals: 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:	Whiteboard, PowerPoint, Projector, demonstration in the lecture, practical training
Literature:	R.L. Boylestad: Introductory Circuit Analysis, 12th Edition, Pearson, 2010 T.L. Floyd D.M. Buchla, Electronics Fundamentals, 8th Edition, Person, 2010 G. Hagmann: Grundlagen der Elektrotechnik, 15. Auflage, AULA Verlag, 2011 G. Hagmann: Aufgabensammlung zu den Grundlagen der Elektrotechnik, 14. Auflage, AULA Verlag, 2010 Course materials from the lecturer Laboratory documents and Exercises from the lecturer

2505 Production and Logistics

Module name:	Production and Logistics	2505
Module code:	Industrial Engineering: Mechanical Engineering:	IE 3 2505 ME 5 2505
Module coordinator:	Prof. Dr. Alexander Klein	
Lecturer:		
Language:	English	
Place in curriculum:	Industrial Engineering: Mechanical Engineering:	Core Focus Field Subject
Timetabled hours:	Lecture: Exercises:	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 taking this course shall • understand the logistic processes in a producing company • know the paramount tasks of operations management • get insight into the target conflicts in factory design and operations management • develop skills to structure complex problems and find solutions independently	
Content:	Production and Logistics • Value chains • Work split, Scientific management (and Taylorism), balancing of capacities • Effects of lot sizes and transportation quantities on inventory level and costs • Production capacity calculation • Global footprint design (supply network design) • Optimization problems in production and logistics (application of genetic algorithms and linear optimization) • Make or buy decision and core competencies • Porter value creation model • SCOR model (supply chain operations reference model) • Aachen PPC model as reference framework (Aachener Produktionsplanungs- und Steuerungs-system) • Production planning and control tasks and processes • Intra-plant logistics • Warehousing • Distribution planning • Transport logistics and multi-modal transports • Lean production methods and principles	

	• Industrial internet of things (“Industrie 4.0”, Cyber-physical systems and their benefits and risks • Difference between fixed and variable cost and marginal cost for production of another piece
Assessment:	Individual Exercises, Continuous Assessment
Forms of media:	MS Powerpoint slides via projector, added notes (electronic pen during lecture), Whiteboard Printouts of case materials and exercise sheets. Lean game instruction manual (haptic simulation) Advanced pocket calculator (if available to students) Networked devices (PCs, laptops, tablets, mobiles)
Literature:	OM6 – Operations + Supply Chain Management, David A. Collier and James R. Evans, Cengage Learning, 2017 ISBN: 978-1-305-66479-1 Additional literature referenced in class (to be updated shortly before new study programme starts) Other self-study materials: • Lecture slides provided to students using interactive and password protected e-learning system (HSRW Moodle) • Further readings in the public domain • Electronic case study materials • Sample exams • Catalogue of possible questions for exam preparation

2509 Fundamentals of Law, Investment and Financing

Module name:	Fundamentals of Law, Investment and Financing 2509
Module code:	Industrial Engineering: IE 5 2509 Mechanical Engineering: ME 5 2509
Courses (where applicable):	Fundamentals of Business Law Investment and Financing
Module coordinator:	Prof. Dr. Dirk Berndsen
Lecturer:	Prof. Dr. Dirk Berndsen
Language:	English
Place in curriculum:	Core
Timetabled hours:	Fundamentals of Business Law Lecture + Exercises: 2 HPW Investment and Financing Lecture + Exercises: 2 HPW
Workload:	60 h attendance 45 h preparation and review (3 h per week) 45 h exam preparation
Credits:	5
Recommended prerequisites:	2501 Fundamentals of Economics and Business 2502 External Accounting 2503 Internal Accounting
Module objectives:	Fundamentals of Business Law After completing the module, students should be able to understand, recognise and apply the fundamental principles of business law. The focus lies on the legal treatment of economic activities of juridical persons, as a stand-in for business firms. They are able to judge legal developments and to evaluate their meaning for business life. Students know the requirements for conclusion of a contract as well as the general framework of performance of a contract. They are able to hold a nuanced view of the legal requirements on a business. In particular • they understand societal, economic and legal backgrounds of contract design, • they understand legal thinking and action as well as various stakeholder expectations translated into legal requirements on the business – both on a national (German) scale and across borders • they understand the basic options for legal setup of a business (sole trader vs. corporation) and their financing implications • they are able to handle the most important contractual instruments of regular business activity, with particular regard to financing • they understand the skills required to work with to legal knowledge carriers in a business context. Investment and Financing

	Students are familiar with the basics of business investment decisions and financing those decisions. They understand the specific requirements on a business' Finance function. They are acquainted with alternative sources of financing and they are able to evaluate these in a context-specific way. They know how to balance a business' liquidity with profitability goals in a regular legal environment. They understand the different financing impacts of alternate corporate forms. They can conceptually assess a business financing needs in various stages of its development.
Content:	<u>Fundamentals of Business Law</u> • Legal system and legal procedure • International legal environment for business activity • Contractual particularities among merchants, merchant perception • Function of corporate registers • Sole Trader vs. Corporation. Corporate forms • Conclusion of a contract • Material content and performance of a contract • Trade terms, general terms and conditions • Compliance with the legal environment • Product liability • Risk and Liability in Financing Agreements <u>Investment and Financing</u> • Make or Buy / Investment decision making • Investment appraisal, static methods • Investment appraisal, dynamic methods • Investment appraisal via Scoring models • Liquidity and Cash Management • Financing investment - Overview potential sources of capital • Equity Financing – Sources, Motivations, implications for business decision making, contractual obligations • Liability Financing, startup vs. fully operational needs, potential sources, contractual obligations • Business Plan vs. Financial Planning • Risk Assessment • Financial Compliance
Assessment:	Written examination
Forms of media:	MS Powerpoint slides via projector, added notes (electronic pen during lecture), Whiteboard Printouts of case materials and exercise sheets. Networked devices (PCs, laptops, tablets, mobiles)
Literature:	<u>Business Law</u> Marson, James / Ferris, Katy (2015): Business Law. 4th edition, ISBN 978-0198727347, Oxford University Press DiMatteo, Larry A. (2016): International Business Law and the Legal Environment: A Transactional Approach. 3rd edition ISBN 978-1138850989, Taylor & Francis

	Investment and Financing Brealy, Richard A / Myers, Stewart C. / Allen, Franklin (2016): Principles of Corporate Finance. 12th edition, ISBN 978-1259253331, McGraw-Hill Hillier, David et al. (2016): Corporate Finance. 3rd edition, ISBN 978-0077173630, McGraw-Hill 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 the public domain • Sample exams • Catalogue of possible questions for exam preparation

2510 Technology and Innovation Management

Module name:	Technology and Innovation Management	2510
Module code:	Electrical Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	EL 7 2510 IE 7 2510 ME 7 2510 SE 7 2510
Module coordinator:	Prof. Dirk Untiedt	
Lecturer:	Prof. Dirk Untiedt	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Practicals:	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:	<u>Technology and Life cycle management</u> • Fundamentals of Technology management • Scope of duties of Technology management • Technology forecasting • Technology planning • Protection of intellectual property • Technology evaluation • Formulation of Technology strategies <u>Innovation management</u> • Basics concepts of Innovation management • Innovation processes and structures	

	• Innovation strategies • Methods of Innovation management • Generating ideas and creativity • Open Innovation
Assessment:	Attestation
Forms of media:	Whiteboard, PowerPoint, Projector, Flip-Chart, Moderation kit
Literature:	Technology management 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 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: Burgelmann, R.: Strategic Management of Technology and Innovation. 5th revised edition, McGraw-Hill Higher Education, 2008 Arnold, H.; Erner, M.; Möckel, P.; Schläffer, Chr. (Eds.): Applied Technology and Innovation Management. Springer, 2010 Narayanan, V. K.; Colarelli O'Connor, G. (Eds.): Encyclopedia of Technology and Innovation Management. 1st edition, John Wiley & Sons, 2010

2512 Entrepreneurship

Module name:	Entrepreneurship	2512
Module code:	Biomaterials Science: Electrical Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BM 7 2512 EL 7 2512 IE 7 2512 ME 7 2512 SE 7 2512
Module coordinator:	Prof. Dirk Untiedt	
Lecturer:	Prof. Dirk 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	
Forms of media:	Whiteboard, PowerPoint, Projector, Flip-Chart, Moderation kit	
Literature:	Barringer, B. R.; Ireland, D.: Entrepreneurship – Successfully Launching New Ventures, 4th edition, Prentice Hall, 2012. Further Readings: Lambing, P. A.; Kuehl, Ch. R.: Entrepreneurship. 4th edition, Prentice Hall, 2007 Bygrave, W. D.; Zacharakis, A.: Entrepreneurship. Wiley, 2008	

2513 Global Economy and Trade

Module name:	Global Economy and Trade 2513
Module code:	Industrial Engineering: IE 4 2513 Mechanical Engineering: ME 4 2513
Courses (where applicable):	Global Economy International Trade Law
Module coordinator:	Prof. Dr. Dirk Berndsen
Lecturer:	Prof. Dr. Dirk Berndsen + External (for Trade Law)
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Global Economy Lecture + Exercises: 2 HPW International Trade Law Lecture + Exercises: 2 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:	Trading goods and services on a global scale has become the norm for the majority of larger businesses, not just in industrialized countries. Globalization is even more advanced in b2b markets than in consumer markets. Against this background, students are expected to aquire a good basic understanding of the characteristics of international markets and business organizations. They will also understand the legal frameworks governing international trade and perform a basic evaluation of contracts in international trading relationships. Global Economy Upon successful completion of this course, students will be able to: • explain the factors leading to differential economic performance in different countries • describe prevalent cultural differences and their impact on differential economic performance between regions • demonstrate skills in retrieving and analyzing country-specific macroeconomic information • recognize positive and negative country performance indicators in a set of varied economic data • demonstrate the ability to roughly assess a country's economic situation and prospects • explain the concept of comparative advantage • explain the benefits of inter-country trade, both on a country and on a global level • describe the challenges to businesses operating across borders

	• describe alternative organization models for businesses operating across borders • demonstrate research, observation, analytical and presentation skills <u>International Trade Law</u> Students will gain a complete basic understanding of the legal framework governing cross-border trading relationships. • They know the extent and objectives of the basic agreements and institutions in international trade • They know where to find and how to apply individual country rules on import and export taxation, tariffs, and customs regulation • They understand the substance of standard terms (Incoterms) and can apply them • They can analyze an international trading contract on a basic level (division of benefits, obligations and risks)
Content:	<u>Global Economy</u> • Long-term economic performance (e.g. why is Germany more prosperous than Greece and less prosperous than Switzerland?) • GDP and alternative indicators for country economic well-being and development • What are short-term fluctuations (where are select economies headed?) • How to get into and out of macroeconomic crises • Comparative Advantage and international trade • What are the challenges of doing business in countries with limited openness to trade • What is a transnational, what is a global business? • What are the challenges these businesses have to meet • How are these businesses organized <u>International Trade Law</u> • Mutual recognition of legal frameworks across countries • Specific trade regulation • Trade and intellectual property • Cross-border transactions and customs proceedings • Incoterms • Risk management in international trade • Dispute settlement • Contract design
Assessment:	Written examination
Forms of media:	MS Powerpoint slides via projector, added notes (electronic pen during lecture), Whiteboard Printouts of case materials and exercise sheets. Networked devices (PCs, laptops, tablets, mobiles)
Literature:	<u>Global Economy</u>

	Cowen, Tyler / Tabarrok, Alexander (2015): Modern Principles of Economics. 3rd edition, ISBN 978-1464128745, Freeman Hill, Charles W. L. / Hult, G. Tomas M. (2015): Global Business Today. 9th edition, ISBN 978-9814738255, McGraw-Hill Jorgenson, Dale W. et al., Hg. (2016): World Economy. Growth or Stagnation? ISBN 978-1316507742, Cambridge University Press <u>International Trade Law</u> Carr, Indira / Stone, Peter (2013): International Trade Law. ISBN 978-0415659239, Routledge Feenstra, Robert C. / Taylor, Alan M. (2014): International Trade. 3rd edition, ISBN 978-1429278447, Worth 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 the public domain • Sample exams • Catalogue of possible questions for exam preparation

2514 Technical Investment Planning and Purchasing

Module name:	Technical Investment Planning and Purchasing	2514
Module code:	Industrial Engineering: Mechanical Engineering:	IE 4 2514 ME 4 2514
Module coordinator:	Prof. Dr.-Ing. Dirk Untiedt	
Lecturer:	Prof. Dr.-Ing. Dirk Untiedt Prof. Dr. Dirk Berndsen	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lecture: Practicals:	1 HPW 3 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2504 Quality and Project Management or 2511 Quality and Production Management 2503 Internal Accounting”	
Module objectives:	Students are able to evaluate planned technological investments. They are able to systematize issues, to formulate investment-planning tasks, to compile requirement and functional specifications if applicable and to select suitable methods and instruments of evaluation. They are able to evaluate results, assess them critically and to present them to a well-informed audience. Students know the methodical fundamentals of organising purchases, types of goods and acquisition strategies. They are especially able to select and apply suitable context-specific methods and tools of technical purchasing. The students know the difference between strategic and operational purchasing.	
Content:	Within the framework of a project, a limited (industrial) investment project is made available to students. Students work in teams. They analyse the task, create requirement and functionality specifications when applicable, invite offers and evaluate investment alternatives according to technical and especially economical points of view. There will be a presentation of the overall results of the investment project. <u>Purchasing</u> • Order processing • Terms and objectives of acquisition • Financial importance of acquisition • Single, modular, system and global sourcing	

	• Material groups and supplier strategy • Supplier management • Organisation of acquisition • Analysis of purchasing programme (ABC, XYZ analysis) • Purchase pricing and negotiations • Statistical methods of demand forecasts and disposition methods, and optimal order volume
Assessment:	Oral Examination
Forms of media:	Whiteboard, PowerPoint, Flip-Chart, Moderation kit
Literature:	Literature and material from lecturer Lysons, K.; Farrington, B.: Purchasing and Supply Chain Management. 7th edition, Prentice Hall, 2006

2700 Introduction to Mechanical Engineering

Module name:	Introduction to Mechanical Engineering 2700
Module code:	Mechanical Engineering: ME 1 2700
Module coordinator:	Prof. Dr.-Ing. Peter Kisters
Lecturer:	Prof. Dr.-Ing. Peter Kisters Prof. Dr.-Ing Joachim Gebel Prof. Dr. Alexander Struck Prof. Dr. Achim Kehrein Anja 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 Mechanical 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 Mechanical Engineering: 15h attendance Field trips
Credits:	3
Recommended prerequisites:	none
Module objectives:	Descriptive Statistics and Reporting: • Students learn to present, summarize, and interpret data in a meaningful way. They learn to present data graphically using standard software packages. The focus lies on enabling the students to handle experimental data in future lab reports. Basics of Communication and Self-Management: • Getting to know and apply helpful first basic knowledge, methods and strategies in order to build up skills and capabilities to succeed in studying, communicating and working together with others. • Supporting with adequate exercises and team building elements the team building processes within the study courses in the first semester. On this base, reflect on the experiences and proceedings in order to learn from it for other transferable settings in teams and organizations.

	Introduction to Mechanical Engineering • The students get a feeling for the study program and the field of Mechanical Engineering. The know how to prepare for lectures and organize themselves. After the introduction, the students are familiar with their rights and their duties.
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 Introduction to Mechanical Engineering • Introduction of different field in Mechanical Engineering • Excursions to different companies • Presentations from professionals and former students of the university • Information about exam registration, examination forms and internship regulations • Where to find what? • Introduction of the university career service
Assessment:	Attestation
Forms of media:	Whiteboard, PowerPoint, Projector, Flip-Chart, Moderation kit, Films
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.

2701 Engineering Drawing and Design

Module name:	Engineering Drawing and Design	2701
Module code:	Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	IE 2 2701 ME 2 2701 SE 2 2701
Module coordinator:	Prof. Dr.-Ing. Stéphane Danjou	
Lecturer:	Prof. Dr.-Ing. Stéphane Danjou	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practicals:	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:	After successfully concluding the module, students should be able to sketch ideas in two and three dimensions. Furthermore, the students know the structure on a design process in engineering They are able to draw and read technical drawings for various projection methods. They are able to produce drawings for given components independently, to define the necessary views and sections, to prepare the drawing for an intended purpose and to compile the necessary parts lists. Students prove their learning progress with independently produced technical drawings. They learn to use checklists to ensure drawings according to international standards. They competently document what they have learned according to valid referencing rules. Students get to know the organizational and contentual structure of a development project and its building blocks. They understand the need for a structured approach and define requirements for product development and utilization of the product.	
Content:	• General introduction to Product Development • Design process acc. VDI 2221 • Conceptual design, embodiment design and detailed design • Importance of Technical Drawing • Standardization: DIN, EN, ISO • Layout and lettering • Application of lines, line groups and line widths • Orthographic projection	

	• Axonometric 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: working drawings, assembly drawings, variant drawings, electronic drawings, piping drawings, welding drawings • Introduction to electronic drawings: representation of electric/electronic components, draughting of circuit diagrams • 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) • Introduction to 3D CAD modelling
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

2702 Advanced Engineering Design

Module name:	Advanced Engineering Design	2702
Module code:	Mechanical Engineering:	ME 3 2702
Module coordinator:	Prof. Dr.-Ing. Peter Kisters	
Lecturer:	Prof. Dr.-Ing. Peter Kisters Prof. Dr.-Ing. Stéphane Danjou	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Project:	2 HPW 1 HPW 1 HPW
Workload:	60 h attendance 30 h preparation and review 30 h individual project work 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 calculations of components. They recognize the flow of forces and disruptions of these and develop improvement measures to reduce stress concentration. Students know essential design rules and apply them to the design of components. They conduct dimensioning calculations of simple machine elements and finally are able to select and design them with due consideration of reliability, material use and costs. They are able to determine component stresses and evaluate them in comparison to given material properties and permitted values. By introducing a 3D-CAD system, students expand their spatial perception. They master the creation of individual parts, assemblies of planar and spatial components. They have a deeper knowledge of technical representation of components. They master the processes required for the production of components derived from 2D workshop drawings from 3D models. Students validate the design rules learned in the course in first simulation calculations and proof their knowledge in a small individual calculation and drawing project.	
Content:	• Introduction to strength calculation of machine elements • Material characteristics, elastic and plastic deformation, yield strength, breaking strength • Equivalent stress concepts and hypothesis for calculation of machine elements	

	• Definition of fatigue limit for finite life and fatigue strength, influence of load cycles on component durability • Influence of design on component stressing, notch effects and shape influence • Dimensioning and calculation of elastic springs under bending and torsional load • Design, drawing annotations and arrangement of springs • Dimensioning and calculation of elastomer springs • Systematic characterization of mechanical joints • Welding techniques and applications as well as weldability • Representation of various verification concepts • Design guidelines and structural limits of welded joints • Calculation of welded joints under dynamic strain assumptions • Interpenetration and drawing annotations for welds • Introduction to the CAD program, basic structure, command levels, features and model trees • Modelling of parts and part drawings • Extrusion and rotation of basic elements • Creation of sheet metal designs • Derivation of 2D workshop drawings • Dimensioning of components presented in the 2D drawings • Modelling of assemblies • Referencing and multiple usage of individual parts in assemblies • Inclusion of standardized parts and machine elements contained in program's libraries • Simulation calculations via implemented calculation software
Assessment:	Continuous assessment (25% project, 75 % written examination)
Forms of media:	Whiteboard, PowerPoint, Projector, demonstration in the lecture, practical training
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

2703 Product Design

Module name:	Product Design: 2703
Module code:	Mechanical Engineering: ME 4 2703
Module coordinator:	Prof. Dr.-Ing. Peter Kisters
Lecturer:	Prof. Dr.-Ing. Peter Kisters Prof. Dr.-Ing. Stéphane Danjou
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Project: 1 HPW
Workload:	60 h attendance 30 h preparation and review 30 h individual project work 30 h exam preparation
Credits:	5
Prerequisites:	2701 Engineering Drawing and Design 2702 Advanced Engineering Design
Module objectives:	Students are able to independently select suitable mechanical connections using form-fit, friction or adhesive bonding and design them against the background of mechanical and physical dependencies. They master basic proof concepts and are aware of the additional requirements resulting from interfaces in between machine elements. They differentiate between the design of threaded joints for fastening purposes and for motion transfer. Based on the task, they comprehend different bearing demands and convey them in a suitable selection of suitable machine elements. Regarding design and calculation, they are able to realize long life times at minimum application of material and cost, thereby ensuring sustainable design concepts. Students have knowledge of the influence of operation conditions on the lifetime and critically question these for ensuring an optimized, stress-related design of all components. In an individual project the students apply their knowledge, calculate components and document their findings in reports and drawings.
Content:	• Introduction of a basic proof concepts • Design of linking elements • Dimensioning and designing of non-permanent mechanical joints • Design and Dimensioning of shaft-to-hub connections such as interference fits and parallel key connections

	• Theoretical fundamentals of threads, selection and application limits of screwed joints • Designing and calculating of bolted fasteners under consideration of different load conditions, representation of the loading conditions in the joint diagram • Static and dynamic calculation and effects of clamping length modification • Design of rolling contact bearings • Calculation of rolling contact bearings under consideration of operating conditions (temperature, lubrication) and combined axial/radial loads • Cases of application for and design of hydrostatic and • hydrodynamic bearing • Calculation of hydrostatic and hydrodynamic bearings • Lubricants and lubrication • Representation of the discussed machine elements, generation of drawings and discussion of cost effects
Assessment:	Written examination
Forms of media:	Continuous assessment (25% individual project, 75% written examination)
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

2704 Advanced Product Design

Module name:	Advanced Product Design	2704
Module code:	Mechanical Engineering:	ME 5 2704
Module coordinator:	Prof. Dr.-Ing. Stéphane Danjou	
Lecturer:	Prof. Dr.-Ing. Stéphane Danjou	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lecture: Exercise:	2 HPW 2 HPW
Workload:	60 h attendance 50 h preparation and review 40 h exam preparation	
Credits:	5	
Prerequisites:	2701 Engineering Drawing and Design 2702 Advanced Engineering Design	
Module objectives:	After completion of the course the students have a broad knowledge about the design of complex units consisting of many parts. The students understand the influence of temperature, dirt and moisture resulting from operation conditions on different parts of the product. They are able to separate single parts and to analyze them under consideration of the loading conditions. The students master the calculation of the units. After the lecture the students are able to run design processes. They know the basic challenges to be mastered. The students decide on materials and take into account the operation phase of the product during development of it. The students gain a feeling for product families and decide on variants required to fulfill customer requirements.	
Content:	• Product Design for assemblies such as gears, couplings and brakes • Light weight design • Design guidelines for different manufacturing methods including additive manufacturing • Selection of materials and substitution of conventional materials • Holistic development process under consideration of usage phase • The operation phase: condition monitoring and service development • Importance of complexity, division of work and communication for the design process • Development strategies (design to market, design to cost etc.)	

	• Introducing the concepts of reliability and availability • Impact of the manufacturing method on costs and environment • Impact of material selection on manufacturing and • environment • Impact of component design on costs and environment • Similitude laws and optimization of product portfolios • Modular Design and design variants
Assessment:	Written examination
Forms of media:	Whiteboard, PowerPoint, Projector, demonstration in the lecture
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 G. Pahl, W. Beitz, J. Feldhusen, K.H. Grote: Engineering Design – A Systematic Approach, 3rd ed. 2007 (4. November 2014), Springer, 2014 Klaus Ehrlenspiel, Alfons Kiewert et al: Cost Efficient Design, ISBN 978-3-642-07100-3, Springer Verlag, Berlin Heidelberg, 2010 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 Klaus Ehrlenspiel: Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit, Carl Hanser Verlag GmbH & Co. KG; 4. Auflage, 2009, ISBN: 978-3446420137

2706 Manufacturing Technology

Module name:	Manufacturing Technology	2706
Module code:	Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	IE 2 2706 ME 4 2706 SE 2 2706
Module coordinator:	Prof. Dr.-Ing. Alexander Klein	
Lecturer:	Prof. Dr.-Ing. Alexander 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

2707 Quality and Production Management

Module name:	Quality and Production Management	2707
Module code:	Mechanical Engineering:	ME 5 2707
Module coordinator:	Prof. Dr.-Ing. Alexander Klein	
Lecturer:	Prof. Dr.-Ing. Alexander 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:	2706 Manufacturing Technology	
Module objectives:	Students have, based on their knowledge about manufacturing technologies, machine tools and production equipment, knowledge about the design and control of a factory as a whole. This means, they understand a factory or even a network of factories as a system of interrelated components, which deliver goods to each other, consume resources and which need to be controlled. They understand that a factory needs to be planned “from the inside to the outside”. This means that only after the manufacturing processes (value chains) have been selected and the the manufacturing times have been quantified, the types and numbers of machines can be determined and a factory layout be derived. The students understand the target conflicts in factory design and understand the principles of production control, lean production and industrial internet of things (smart factories) (Industry 4.0). Based on the knowledge about quality assurance, they understand the additional benefit and scope of total quality management and understand miscellaneous methods and targets of state-of-the-art quality management.	
Content:	Contents Production Management • Value chains • Lot creation, lot sizes • Work planning • Aggregate planning • Make or buy strategy • Operations control (production planning and scheduling), Aachen PPC model • Production capacity calculation	

	• Factory layout (workshop, lines, flexible manufacturing systems) • Production building design (basics only) • Target conflicts in production management (economies of scale vs. economies of scope; planning orientation vs. value orientation; high utilization vs. low inventory) • correlation between average throughout time and inventory level (and other basics of production logistics) • Technology selection • Fixed and variable cost • ERP and MES systems (enterprise resource planning and manufacturing execution systems) • Industry 4.0 (industrial internet of things) • Building technology • Conveying technologies (intra logistics) • Production networks, global footprint design • Optimization problems (operations research examples) • Lean production (diverse methods, lean game to be played in smaller groups) • Value stream analysis and value stream design Quality management (not quality assurance) • Disambiguation against quality assurance (QA), purpose of QM • DIN ISO 9001 series • Process capability, sigma levels • Six sigma methods (e.g. DMAIC) and basic idea of six sigma approach • APQP (advanced product quality planning) including FMEA • Corporate governance, whistleblowing, (basics only) • Aachen quality management model • Business process management • Quality in service industries • Quality Function Deployment (House of Quality) • Statistical Process Control Environmental management and occupational health and safety management: • Environmental Management DIN EN ISO 14001 • Work safety BS OSHAS 18001 • Sustainability
Assessment:	Written examination
Forms of media:	projector, PowerPoint slides with notes (added with electronic pen during the lecture), whiteboard

Literature:	Lecture slides provided to students Mike Rother: Learning to see The Toyota way, Jeffrey Liker (Mc Graw Hill) Sanders, Donald A., Scott, C. Frank: Passing Your ISO 9000/QS-9000 Audit, CRC Press LLC, 1997 May, Constantin, Schimek, Peter: TPM Total Productive Management, 2nd edition, CETPM Publishing, 2009 Hoyle, David: ISO 9000 Quality Systems Handbook, 6th edition, Routledge, 2009 Kelly, John M: IMS: The Excellence Model, BSI Business Information, 2004 Lindsay, Evans: The Management and Control of Quality, 8th edition, South-Western, Cengage Learning, 2011 DIN ISO EN 9000ff, raw documents (extracts) BS OHSAS 18001; raw documents (extracts) DIN ISO EN 14000 f, raw documents (extracts) Lecture slides provided to students (on moodle server) • Further readings in public domain (e.g. open courseware or wikipedia articles on selected topics) • Question catalogue for exam preparation • Eventually book summaries or script (running text) developed by other students of HSRW

2708 Thermodynamics

Module name:	Thermodynamics	2708
Module code:	Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	IE 5 2708 ME 3 2708 SE 3 2708
Module coordinator:	Prof. Dr.-Ing. J. Gebel	
Lecturer:	Prof. Dr.-Ing. J. Gebel	
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:	Smartboard/WACOM-Board, PowerPoint, Projector
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

2709 Fundamentals of Process Engineering

Module name:	Fundamentals of Process Engineering 2709
Module code:	Industrial Engineering: IE 4 2709 Mechanical Engineering: ME 4 2709
Module coordinator:	Prof. Dr.-Ing. J. Gebel
Lecturer:	Prof. Dr.-Ing. J. Gebel / Prof. Dr.-Ing. S. Danjou
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:	2000 Introductory Mathematics 2003 Physics 2701 Engineering Drawing and Design
Module objectives:	On successful completion of this module, students are able to: • apply strategies of process engineering analysis and problem solving (specifically in relation to unit operations, basic process control, material & energy balances, process flow diagrams) to design basic industrial processes; • create simple process flow diagrams using computer aided design techniques; • apply and utilise dimensionless analysis and similitude • analyse, describe and model solid particles; • apply the unit operations size reduction and filtration; • analyse, describe and model heat transfer situations; • apply the unit operations heat exchange and evaporation; • analyse, describe and model mass transfer situations; • apply the unit operations distillation, rectification, absorption and stripping; In the practical training framework, students perform tests on pressure losses within tubes and fittings. They are able to determine the performance curve of a centrifugal pump, and to recognize cavitation within nozzles and pumps. They learn how to operate a crusher and how to perform a sieve analysis. They are able to operate a sedimentation plant as well as a CO_2 gas absorption plant.
Content:	• Process Flow Sheets - Block diagrams - Process flow diagrams (PFD) - Piping and instrumentation diagram (P&ID)

	• Dimensional Analysis and Similitude • Mechanical Process Engineering - Characterization of solid particles (particle size, shape and density) - Particle size analysis - Distributions - Screening - Size reduction - Crushing - Grinding - Energy requirements - Application - Jaw crusher, hammer mill - Filtration - Constant pressure filtration - Constant rate filtration • Thermal Process Engineering - Basics of heat transfer - Thermal conduction - Free and forces convection - Condensation and boiling - Heat transfer coefficient - Application - Multiple-Effect Evaporation - Basics of mass transfer - Fick's law of diffusion - Mass transfer coefficient - Application - Distillation and rectification - Gas absorption and stripping
Assessment:	Graded written examination
Forms of media:	Smartboard/WACOM-Board, owerPoint, Projector,
Literature:	Warren L. McCabe, Julian Smith, Peter Harriot: Unit Operations of Chemical Engineering, 7th edition, ISBN 978-0-07-284823-6 Further Readings: Ullmann's Chemical Engineering and Plant Design Wiley-VCH, 2004, ISBN 978-3-52-731111-8, 2 vols. Robin M. Smith: Chemical Process: Design and Integration, ISBN 978-0-471-48681-7 K.S.N. Raju: Fluid Mechanics, Heat Transfer, and Mass Transfer Chemical Engineering Practice John Wiley & Sons, 2011 ISBN 978-0-470-63774-6 Merle C. Potter, David C. Wiggert, Bassem H. Ramadan: Mechanics of fluids, Fourth edition, ISBN 978-1-4390-6203-6

2710 Fluid Mechanics

Module name:	Fluid Mechanics 2710
Module code:	Mechanical Engineering: ME 4 2710 Industrial Engineering: IE 4 2710 Mechatronic Systems Engineering: SE 4 2710
Module coordinator:	Prof. Dr.-Ing. J. Gebel
Lecturer:	Prof. Dr.-Ing. J. Gebel Prof. Dr. N. Ostergaard
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. - use the software tools ANSYS fluent 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 - How to use the ANSYS Fluent software tool
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.

2711 Drive Systems

Module name:	Drive Systems	2711
Module code:	Mechanical Engineering:	ME 3 2711
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: 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 2001 Applied Mathematics 2003 Fundamentals of Physics 2008 Statics and Strength of Materials 2009 Advanced Strength of Materials 2700 Introduction to Mechanical Engineering 2701 Engineering Drawing and Design	
Module objectives:	After completion of the module students are able to • analyse different drive systems, describe their components and transfer functions and perform motion analyses • understand the working principle of belt- and chain-drives, spur gears, bevel gears, planetary and differential gears, hydraulic drives, mechanical linkages, power split and power merging, continuously variable drives, electric DC-motors with separate, shunt and wound-field excitation, electric AC-asynchronous motors and electric AC-synchronous motors • explain the advantages and disadvantages of different drive systems • perform simple calculations on them, arrange components to drive systems, calculate ratios, reduced masses of inertias, rotational speeds, velocities, accelerations, torques, powers and efficiencies • dimension simple drive systems	
Content:	• Torque over speed- and power over speed-diagrams, motion analysis, drive resistance and load graph, torque and speed ratios, mileage chart, power conversion and efficiency • physical basics and mass inertia • belt- and chain-drives • gears and gearboxes • hydraulic drives • mechanical linkages • combined transmissions	

	• DC-motors (separate excited, shunt excited, wound field-excited), AC-asynchronous and AC-synchronous-motors
Assessment:	Written examination
Forms of media:	Presentation, Whiteboard, Projector, Practical Demonstrations with Training-Systems
Literature:	Course materials from the lecturer Exercises from the lecturer 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 Juvinall, Robert C., Marshek, Kurt M. Fundamentals of Machine Component Design, John Wiley and Sons, 4th edition, 2006, ISBN 978-0-471-74285-2 Automotive Handbook, published by Robert Bosch GmbH, 8th Edition, John Wiley & Sons Ltd., Chichester, 2011 ISBN 978-1-119-97556-4 Further Reading: Hughes, A., Drury, B. Electric motors and drives, 4th edition, Elsevier, 2013 ISBN 978-0-08-099368-3

2712 Design of Plants

Module name:	Design of Plants 2712
Module code:	Industrial Engineering: IE 5 2712 Mechanical Engineering: ME 5 2712
Module coordinator:	Prof. Dr.-Ing. J. Gebel
Lecturer:	Prof. Dr.-Ing. J. Gebel / Prof. Dr.-Ing. S. Danjou
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lectures: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2702 Advanced Engineering Design 2708 Thermodynamics 2709 Fundamentals of Process Engineering
Module objectives:	Using the example of a thermal seawater desalination plant, students learn how to design such a plant. Based on the application of mass, material and energy balances, students learn how to design main devices and components and how to assemble them into an overall system. They are able to recognise the influence of material selection and corrosion behaviour on the construction of devices and components and how this in turn influences the selection of the overall system. Here, structural aspects such as required space and necessary fundaments are also taken into consideration. Students implement the results of the plant design and the constructive design graphically by using an appropriate software tool (Autodesk Plant3D).
Content:	1 Process development and planning 1.1 Establishing the basis of the project 1.2 Feasibility study 1.3 Planning - Preliminary design - Basic engineering - Detail engineering 2 Desalination technologies 2.1 Thermal processes - Multi-Stage-Flash evaporation (MSF) - Multiple-Effect distillation (ME) - Thermal vapour compression (TVC) 2.2 Mechanical processes - Reverse osmosis (RO) 3 Mass, material and energy balances 3.1 Multiple-Effect distillation (ME) 3.2 Thermal vapour compression (TVC)

	4 Corrosion and material selection 4.1 Corrosion forms of metallic materials 4.2 Material selection 5 Structural design of a thermal desalination plant 5.1 Structural requirements for main components 5.2 Arrangement of main components and devices 6 AutoCAD based graphic presentation 6.1 Structural drawings of main devices 6.2 Layout chart (3D) 6.3 Presentation of results as 3D animation
Assessment:	Continuous Assessment
Forms of media:	Smartboard/WACOM-Board, PowerPoint, Projector
Literature:	Joachim Gebel, Süleyman Yüce: An Engineer's Guide to Desalination, VGB Powertech Service GmbH, Essen, 2008, ISBN-13 978-3-86875-000-3 Further Readings: Frank Peter Helmus: Process Plant Design: Project Management from Inquiry to Acceptance, 1st edition, Wiley-VCH Verlag GmbH & Co. KGaA, 2008, ISBN 978-3527313136 Ullmann's Chemical Engineering and Plant Design Wiley-VCH, 2004, ISBN 978-3527311118, 2 vols.

2713 Control of Plants in Process Engineering

Module name:	Control of Plants in Process Engineering	2713
Module code:	Industrial Engineering: Mechanical Engineering:	IE 5 2713 ME 5 2713
Module coordinator:	Prof. Dr.-Ing. J. Gebel	
Lecturer:	External lecturer	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lectures: Exercises: Practical Training:	2 HPW 1 HPW 1 HPW
	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2709 Fundamentals of Process Engineering 2902 System Theory and Controls	
Module objectives:	After completing this elective course, students have knowledge of controls for plants in process engineering. Students are able to compare and evaluate the interplay of the knowledge already gained in the modules “System Theory and Controls” and “Fundamentals of Process Engineering”. Students gain knowledge of advanced control methods (for instance, cascade control, feedforward control, disturbance compensation, etc.) that are widely applied in industrial plants. In particular, students learn also the methodology of model predictive control. They are able to apply the necessary control methods for different cases of application. Furthermore, students know the main features of field devices in plants and distributed control systems. They understand the background and know the basic idea of control performance monitoring, alarm monitoring and plant asset management, which are currently receiving much attention in the process industry. The gained knowledge will be deepened by exercises and practical training. Here, computer based development tools such as MATLAB/Simulink will be used.	
Content:	• Overview - Terminology: feedback control, logic control, etc. - Representative processes - Typical control problems in plants - Automation pyramid • Field devices - Sensors - Actuators • Advanced control schemes - Two point control - Three point control - Ratio control	

	- Split range control - Cascade control - Feedforward control - Disturbance compensation - Smith predictor - Internal model control • Model predictive control • Batch control • Distributed control systems • Process information and management systems • Control performance monitoring • Alarm management • Process monitoring • Plant asset management
Assessment:	Continuous Assessment
Forms of media:	Smartboard/WACOM-Board, PowerPoint, Projector
Literature:	Udo Enste, Jochen Müller: Datenkommunikation in der Prozessindustrie. Oldenbourg Industrieverlag, ISBN 978-3-8356-3116-8 B. Wayne Bequette: Process Control – Modeling Design and Simulation. Prentice Hall. 2003, ISBN 0-13-353640-8 Karl F. Früh: Handbuch der Prozessautomatisierung. Oldenbourg Industrieverlag, ISBN 978-3835631427 Günther Strohrmann: Automatisierungstechnik 1. Oldenbourg Verlag, ISBN 3486230964 J. P. Corriou. Process Control – Theory and Applications. Springer, 2004

2714 Virtual Product Development

Module name:	Virtual Product Development	2714
Module code:	Mechanical Engineering	ME 4 2714
Module coordinator:	Prof. Dr.-Ing. Stéphane Danjou	
Lecturer:	Prof. Dr.-Ing. Stéphane Danjou	
Language:	English	
Place in curriculum:	Elective Focus Field “Design”	
Timetabled hours:	Lecture: Exercise:	2 HPW 2 HPW
Workload:	60 h attendance 50 h preparation and review 40 h exam preparation	
Credits:	5	
Prerequisites:	ME 02 EDaD 17: Engineering Drawing and Design ME 03 AdED 17: Advanced Engineering Design	
Module objectives:	After completion of the course students will understand the process of developing and prototyping products in a completely digital 2D/3D environment. They will be able to predict a product’s performance, ultimately minimizing time to market, failure potential, and product development costs. Students will be able to select and apply methods to integrate simulation and calculation into the development process at an early stage. They will get to know how to work out product knowledge as early as possible to identify product characteristics. By introducing different concepts to support company-internal as well as cross-company communication / collaboration within distributed development processes students will learn to select appropriate tools for shared access of product information in all phases. The students will exercise their gained knowledge in selected applications.	
Content:	• Introduction to virtual product design • Authoring systems (M-CAD, E-CAD) • Product and process modelling • Administrative IT solutions for a common data backbone (PDM, PLM) • Digital production planning (CAD/CAM, CAP) • Methods and applications of Rapid Prototyping (RP) • Digital Mock-ups (DMU) • Virtual Reality (VR) • Augmented Reality (AR)	

	• Integration of embodiment design and calculation / simulation (Computer-Aided Engineering): FEM, MBD, CFD, NVH • Topology optimization • Knowledge Based Engineering concepts for integration of knowledge into the product • Methods for Collaborative Engineering • File formats for product data transfer
Assessment:	Written examination
Forms of media:	Whiteboard, PowerPoint, Projector, demonstration in the lecture
Literature:	Hirz, Mario (2013): Integrated Computer-Aided Design in Automotive Development – Development Processes, Geometric Fundamentals, Methods of CAD, Knowledge-Based Engineering Data Management. Berlin: Springer. Bordegoni, Monica, Rizzi, Caterina (2011): Innovation in Product Design. From CAD to Virtual Prototyping. 1st ed. London: Springer. Course materials from the lecturer Exercises from the lecturer Further Reading: Stjepandic, Josip; Wognum, Nel; J.C. Verhagen, Wim (2015): Concurrent Engineering in the 21st Century. Foundations, Developments and Challenges. Cham: Springer

2715 Material Handling Systems

Module name:	Materials Handling Systems	2715
Module code:	Mechanical Engineering:	ME 4 2715
Module coordinator:	Prof. Dr.-Ing. P. Kisters	
Lecturer:	Prof. Dr.-Ing. P. Kisters	
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:	2701 Engineering Drawing and Design 2702 Advanced Engineering Design 2711 Drive Systems	
Module objectives:	After completion of the module students are able to • know solutions to transport different kinds of materials • design the building block of conveyors • understand the difference in between continuous conveyors and non-continuous handling equipment • differentiate different types of material handling equipment • analyse a materials handling task • design material handling systems in terms of mass flow and drive selection • understand the working principles of material handling units such as conveyors, hoists, cranes, floor conveyors, stacker cranes and storage equipment • design load handling devices • select appropriate equipment for a given application • combine different types of conveying equipment to a system under consideration of	

Content:	• Structures and strategies for Materials Handling Systems
	• Building blocks of equipment
	  • Cables and rope drives
	  • Undercarriage elements
	  • Chains and Belts
	  • Drives
	  • Load handling equipment
	• Non-Continuous handling equipment
	  • Hoists
	  • Cranes
	  • Floor conveyors
	• Continuous handling equipment
	  • Belt conveyors
	  • Chain conveyors	

	• Storage technology
	  • Stacker and reclaimer
	  • Stacker cranes

Assessment:	Written examination
Forms of media:	Presentation, Whiteboard, Projector, Practical Demonstrations with Training-Systems
Literature:	Course materials from the lecturer Exercises from the lecturer J. Fruchtbaum: Bulk Materials Handling Handbook, ISBN 978-1475746976, Springer, 2013 P.M. McGuire: Conveyors: Application, Selection and Integration, ISBN 978-1439803882, CRC Press, 2009 Juvinall, Robert C., Marshek, Kurt M. Fundamentals of Machine Component Design, John Wiley and Sons, 4th edition, 2006, ISBN 978-0-471-74285-2 Further Reading: R. Griemert, P. Römisch: Fördertechnik – Auswahl und Berechnung von Elementen und Baugruppen, 11th edition, ISBN 978-3-658-0908, SpringerVieweg, 2014

2716 Agricultural Engineering

Module name:	Agricultural Engineering	2716
Module code:	Mechanical Engineering:	ME 4 2716
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: Exercise:	2 HPW 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2305 Fundamentals of Electrical Engineering 2711 Drive Systems	
Module objectives:	After finishing the module, students are able to • explain the objectives and tasks of the technology of agricultural machines, • describe the main functions and assemblies of the most important agricultural machines, • conduct simple calculations of assemblies, • calculate mass flows in and productivity of agricultural machines, • make decisions regarding the selection of agricultural machines and the application of agricultural machines for different machining tasks, • recognise weak spots in agricultural machines and to propose improvements.	
Content:	After basics like objectives and tasks of agricultural machines, definitions and contexts various agricultural machines are treated according to the seasonal workflow in agriculture. In addition, there is the focus on basic technologies like terramechanics and advanced technologies like precision farming, too. • Tillage and cultivation machines • Sowers and planters • Fertilizers and pest-control machines • Machines for harvesting hay and silage • Self-propelled forage harvesters • Combine harvesters • Terramechanics • Tractors • Precision farming	
Assessment:	Written examination	

Forms of media:	Presentation, Whiteboard, Projector, Excursions to manufacturers and local training facilities, Practical demonstrations with a combine harvester and different tractors
Literature:	CIGR Handbook of Agricultural Engineering, Volume III Plant Production Engineering, 1st edition 1990, ISBN 1-892769-02-6, Publisher: American Society of Agricultural and Biological Engineers, St. Joseph, MI 49085-9659, USA Srivastava, A., Goering; C., Rohrbach, R., Buckmaster, D.. Engineering Principles of Agricultural Machines, 2nd edition 2006, ISBN 1-892769-50-6, Publisher: American Society of Agricultural and Biological Engineers, St. Joseph, MI 49085-9659, USA Course materials from the lecturer Exercises from the lecturer

2717 Mobile Hydraulics

Module name:	Mobile Hydraulics	2717
Module code:	Mechanical Engineering: Mechatronic Systems Engineering:	ME 5 2717 SE 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: Exercise:	2 HPW 2 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

2718 Cylindrical Gears

Module name:	Cylindrical Gears	2718
Module code:	Mechanical Engineering:	ME 5 2718
Module coordinator:	Prof. Dr.-Ing. P. Kisters	
Lecturer:	Prof. Dr.-Ing. P. Kisters	
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:	2711 Drive Systems	
Module objectives:	After completion of the module students • understand the basic principles of gears and gear transmission • know the advantages of gear units in terms of size, power density and efficiency • differentiate internal and external gears and know details about the design of them • are able to analyse the operation conditions of gears and apply them to the design and calculation of the unit • understand operational influences on the running behaviour of gears and gear units • have a feeling for lubrication and thermal loading of gears and the consequences on design • know basic failure modes for gear units and are able to find countermeasures • can design simple gears and gear units • are able to prepare the required drawings • evaluate different materials and select appropriate ones for a given purpose • know basic production principles and steps in the manufacturing process of gears	

Content:	• Overview and general principles for cylindrical gears
	• Geometry of gear teeth
	  • Spur gears
	  • Helical gears
	  • Meshing Interference
	  • Special Involute gearing
	• Running performance of external and internal gears
	  • Loads on teeth and load capacities
	  • Lubrication
	  • Power losses
	  • Gear Heating
	  • Efficiency	

	• Noise generation
	• Design of gears and gear systems
	  • Number of stages and ratio splitting
	  • Precision and quality
	  • Material selection
	  • Drawings and annotation
	• Manufacturing of gear teeth

Assessment:	Written examination
Forms of media:	Presentation, Whiteboard, Projector, Practical Demonstrations with Trainings System
Literature:	H. Linke, J. Börner, R. Heß: Cylindrical Gears – Calculation, Materials, Manufacturing, First Edition, ISBN 978-1-56990-489-3, Carl-Hanser Verlag, Munich, 2016 Course materials from the lecturer Exercises from the lecturer

2719 Applied Strength of Materials

Module name:	Applied strength of materials	2719
Module code:	Mechanical Engineering:	ME 4 2719
Semester:	4th semester	
Module coordinator:	Prof. NH Østergaard	
Lecturer:	Prof. NH Østergaard	
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:	2001 Applied Mathematics 2008 Statics and strength of Materials	
Module objectives:	The students will in this course on basis of an extension of the theoretical framework for strength of materials be taught how to apply developed calculation methods to structural design.	
Content:	• Applied calculation methods for 2D frames and plates – relevant theories and standard solutions o Practical applications in structural design and analysis • Failure analysis o Lessons learned from field failures • Field data strain measurements and processing o Strain gauge measurements and their link to the transformation equations/stress calculations o Single/Rosette gauges measurements and appropriate bridge couplings o Rainflow counting and related processing methods • Principles of engineering design against fatigue o The S-N curves (re-cap) o The Haigh diagram and accounting for a non-zero mean strain (the Soderberg and Goodman lines, the Gerber parabola) • Load case engineering o Design against ULS and ALS cases o Loads due to environmental effects (wind, waves and current)	
Assessment:	Written examination	
Forms of media:	Whiteboard (PowerPoint, Projector, demonstration in the lecture)	
Literature:	• Mechanics of materials (Global Ed.), McGraw-Hill Beer, Johnston, DeWolf, Mazurek • Dynamics of structures, CRC Press	

	JL Humar • Advanced strength and applied elasticity, Pearson Education AC Ugural & SK Fenster • Course slides from the lecturer

2720 Machine Dynamics

Module name:	Machine Dynamics	2720
Module code:	Mechanical Engineering:	ME 5 2720
Module coordinator:	Prof. NH Østergaard	
Lecturer:	Prof. NH Østergaard	
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:	2010 Dynamics	
Module objectives:	The students will after completing this cause have learned to apply their understanding of dynamics to extract and interpret information about the state of a mechanical system. The course will mainly be centred around machine dynamics.	
Content:	• Single DOF vibrations and application to analysis of machinery ▪ Steady state and transient vibrations (complementary and particular solutions) ▪ In-phase and out-of-phase motions ▪ Estimation of damping for measured responses ▪ Quasi-static stress estimation • Multi-DOF vibrations and applications to rotating machinery ▪ Procedure for derivation of equations of motions ▪ Calculation of eigenfrequencies by solving eigenvalue problems ▪ Balancing of rotating masses ▪ Vibrations of systems of rigid bodies ▪ Introduction to simple numerical solution methods • Interpretation of measurements and vibration based diagnostics ▪ Application of Fast Fourier Transforms (FFTs) ▪ The physical interpretation of FFT spectrums of field data (peaks, sidebands, harmonics) ▪ Log rates and the Nyquist criterion ▪ Accelerometer based field data acquisition and impact tests • Calculation and estimation of fault and eigenfrequencies for selected mechanical systems ▪ Bearing kinematics ▪ Dynamics of Jeffcott rotors (single rotor systems)	

	▪ Dunkerley's formula (multiple rotors) • Introduction to condition monitoring ▪ Sensor and model based approaches • Introduction to reliability engineering and maintenance strategies ▪ Approaches and examples of application
Assessment:	Written examination
Forms of media:	Whiteboard (PowerPoint, Projector, demonstration in the lecture)
Literature:	RB. Randall: Vibration-based condition monitoring, Wiley A. Davies: Handbook of condition monitoring, Chapman & Hall, Ed. by A. Davies Course slides by lecturer H. Dresig, F. Holzweißig: Dynamics of Machinery – Theory and applications, Springer

2721 Design of Membrane Plants

Module name:	Design of membrane plants	2721
Module code:	Mechanical Engineering:	ME 7 2721
Module coordinator:	Prof. Dr.-Ing. J. Gebel	
Lecturer:	Prof. Dr.-Ing. J. Gebel	
Language:	English	
Place in curriculum:	Elective	
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:	2704 Advanced Engineering Design 2709 Fundamentals of Process Engineering 2711 Design of Plants	
Module objectives:	Students understand the fundamental chemical-physical processes occurring in mass separation via membranes. They are able to apply the chemical potential as the driving force for different separation processes and to determine transport resistances from this. Students know the technical standards for the construction of membrane modules and are able to apply this knowledge to different separation methods. They master the calculations needed to be able to arrange modules in serial or parallel order to full systems. They are also able to design a so-called “Christmas tree”. The practical training is dedicated to understand the design of a spiral wound module. The students disassemble a used module, they identify the different parts, i.e. feed and permeate channel, spacers, membranes, and they clarify how this parts are arranged and connected. They visit a large drinking water purification plant equipped with nanofiltration plant. There they clarify the question how the modules are arranged and how the membrane plant is implemented in the drinking water purification plant.	
Content:	1 Membrane processes – driving forces and mass transport resistances 1.1 Basic concepts – selectivity, fluxes, permeability 1.2 Chemical potential as driving force 1.3 Osmotic pressure and van’t Hoff law 2 Modelling mass transfer in membranes 2.1 Pore model for filtration applications 2.2 Solution-Diffusion Model 2.3 Definition of rejection rate and recovery rate 3 Module design and module characteristics 3.1 Modules with tubular membranes	

	3.2 Modules with flat membranes 4 Plant design and module arrangement 4.1 Determination of overall recovery rate 4.2 Parallel and serial arrangement 4.3 “Christmas tree”- arrangement 5 Special applications for membrane processes 5.1 Leachate water treatment 5.2 Membrane bioreactor (MBR-techonology) 5.2 Enrichment of the methane content of biogas
Assessment:	Continuous Assessment
Forms of media:	Smartboard/WACOM-Board, PowerPoint, Projector
Literature:	Joachim Gebel, Süleyman Yüce: An Engineer’s Guide to Desalination, VGB Powertech Service GmbH, Essen, 2008, ISBN-13 978-3-86875-000-3 Further Readings: Heinrich Strathmann: Introduction to Membrane Science and Technology Wiley-VCH, Weinheim 1st edition – September 2011 ISBN-13: 978-3-527-32451-4 Thomas Melin, Robert Rautenbach: Membranverfahren, Grundlagen der Modul- und Anlagenauslegung (Membrane Technology, Fundamentals of Module and Plant Design) ISBN 3-540-00071-2; 2nd edition Jane Kucera: Reverse Osmosis: Design, Processes, and Applications for Engineers, Wiley-Scrivener; 1st edition (April 5, 2010) ISBN-13: 978-0470618431

2722 Leadership

Module name:	Leadership	2722
Module code:	Mechanical Engineering:	ME 7 2722
Module coordinator:	Anja Viermann	
Lecturer:	Anja Viermann Responsible Lecturer for a selected tutorial	
Language:	English	
Place in curriculum:	Elective	
Timetabled hours:	Seminar:	3 HPW
Workload:	60 h attendance 90 h preparation, review and working on the assignment	
Credits:	5	
Recommended prerequisites:	2014 Cross-Cultural Management 2700 Introduction to Mechanical Engineering	
Module objectives:	The students will • gain profound knowledge of the theories and methods of leadership research and acquire the ability to make use of this knowledge facing concrete practical challenges. • acquire personal, social and methodical competencies which enable them to take on leadership responsibilities. • improve their intercultural collaboration and communication skills as well as presentation abilities. • be prepared to take over first official leadership roles in the university environment in the context of tutorials and for this role will learn as well the basics of coaching and teaching	
Content:	• Definition and Significance of Leadership • Leadership and Management • The Global and Cultural Contexts of Leadership • Leadership in Groups or Teams and Organisations • The Foundations of Modern Leadership and Contemporary Concepts • Power and Empowerment • Personality Traits, Abilities and Skills • The Link between Motivation and Performance • The Leader as a Coach: Supporting positive learning processes of individuals and teams	
Assessment:	Examination: • Individual assignments: preparation, submission and oral presentation of a written assignment (50%) • Assessment of a tutorial offered for one of the subjects listed in the curriculum (50%)	

Forms of media:	Whiteboard, PowerPoint, Projector, Flip-Chart, moderation kit, films, role playing, case analyses
Literature:	• Afsaneh Nahavandi (2015): Art and Science of Leadership, 7th Edition, Pearsons Education • Edgar H. Schein (2017): Organizational Culture and Leadership, 5th Edition, John Wiley & Sons Supplemental readings, e.g. additional literature sources, exercises, cases and other learning materials will be provided during class.

2723 Biomimetic Science

Module name:	Biomimetic Science	2723
Module code:	Mechanical Engineering	ME 4 2723
Module coordinator:	Prof. Dr. William Megill	
Lecturer:	Prof. Dr. William Megill	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lecture: Exercises:	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 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:	Zoological Physics	2724
Module code:	Mechanical Engineering	ME 4 2724
Module coordinator:	Prof. Dr. William Megill	
Lecturer:	Prof. Dr. William Megill	
Language:	English	
Place in curriculum:	Focus Field Subject	
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:	none	
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:	Lab Reports & Final written exam (120 min.)	
Forms of media:	Board and projector, video, online research	
Literature:	Core text: Ahlborm B-K. (2006): Zoological Physics: Quantitative Models of Body Design, Actions, and Physical Limitations of Animals	

2725 Bioinspiration

Module name:	Bioinspiration	2725
Module code:	Mechanical Engineering	ME 5 2725
Module coordinator:	Prof. Dr. William Megill	
Lecturer:	Prof. Dr. William Megill	
Language:	English	
Place in curriculum:	Focus Field Subject	
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:	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:	Board and projector, video, online research	
Literature:	Core text: A. Mukherjee (2010): Biomimetics Learning from Nature, InTech	

2726 Bionic Design

Module name:	Bionic Design	2726
Module code:	Mechanical Engineering	ME 5 2726
Module coordinator:	Prof. Dr. William Megill	
Lecturer:	Prof. Dr. William 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:	Board and projector, video, online research	
Literature:	Course notes	

2902 System Theory and Controls

Module name:	System Theory and Controls	2902
Module code:	Electrical Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	EL 4 2902 IE 4 2902 ME 4 2902 SE 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: Practicals:	2 HPW 1 HPW 1 HPW
Workload:	60 h attendance 50 h preparation and review 40 h exam preparation	
Credits:	5	
Recommended prerequisites:	2010 Dynamics 2305 Fundamentals of Electrical Engineering	
Module objectives:	After finishing this module, students have fundamental knowledge and abilities for the mathematical description and regulation of technical systems and are able to present these via block wiring diagrams. Furthermore, students are able to analyse and evaluate mathematically described time-continuous single-input/single-output (SISO) control systems by means of system theory knowledge. By doing this, a controller can be designed correspondingly meeting given requirements regarding stationary and dynamic behaviour. Additionally, students gain the ability to deduce requirements for the necessary measurement technique. The control engineering methods learnt this way will be deepened and attested by a tutorial as well as by laboratory work. Here, computer based development tools will be used, particularly Matlab/Simulink, so students are also able to cope with descriptions, calculations and analyses in a practice-oriented manner.	
Content:	• Mathematical modelling of technical systems by means of differential equations • System description via block diagrams • Functionality and basic structure of control circuits • Characteristics of control systems - Linear and non-linear systems - Linearization - Systems with concentrated/distributed parameters - Time-variant and time-invariant systems - Causal and non-causal systems • Description of linear continuous systems	

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

2903 Controls

Module name:	Controls	2903
Module code:	Electrical Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	EL 5 2903 ME 5 2903 SE 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: Practicals:	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:	Whiteboard, PowerPoint, Projector
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:	Modelling and Simulation	2904
Module code:	Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	IE 5 2904 ME 5 2904 SE 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: Exercises:	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:	Whiteboard, PowerPoint, Projector, in PC exercises: MATLAB/Simulink
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 FEM

Module name:	Finite Element Analysis	2905
Module code:	Mechanical Engineering: Mechatronic Systems Engineering:	ME 5 2905 SE 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: Practicals:	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:	whiteboard, PowerPoint, Projector, ANSYS Workbench
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

2908 Multibody Dynamics

Module name:	Multibody Dynamics	2908
Module code:	Mechanical Engineering: Mechatronic Systems Engineering:	ME 4 2908 SE 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