Module Handbook

for the study program

Industrial Engineering B.Sc.

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

Kleve, Rev. 2, October 2020

Content

Curriculum Industrial Engineering B.Sc

Curriculum IE		HPW	Type						Examination form		CP	HPW						
			V	SL	S	Ü	Pra	Pro	Attestation	graded		WS1	SS2	WS3	SS4	WS5	SS6	WS7
1st Semester																		
2000	Introductory Mathematics	8	5			3				x	8	8						
2007	Chemistry of Materials	4	2			2				x	5	4						
2008	Statics and Strength of Materials	4	2			2				x	5	4						
2011	Programming	4	2				2		x	x	5	4						
2500	Introduction to Industrial Engineering	3	2		1				x		3	3						
2501	Fundamentals of Economics and Business	4	4							x	5	4						
2nd Semester																		
2001	Applied Mathematics	8	5			3				x	7		8					
2003	Physics	4	2			1	1		x	x	5		4					
2014	Cross Cultural Management and Creativity	4	2			2			x		5		4					
2502	External Accounting	4	2			2				x	5		4					
2701	Engineering Drawing and Design	4	2			1	1		x	x	5		4					
2706	Manufacturing Technology	4	3			1				x	5		4					
3rd Semester																		
2010	Dynamics	4	2			2				x	5			4				
2108	Materials and Testing	4	2			1	1			x	5			4				
2305	Fundamentals of Electrical Engineering	4	2			1	1		x	x	5			4				
2503	Internal Accounting	4	2			2				x	5			4				
2504	Quality and Project Management	4	3				1		x	x	5			4				
2505	Production and Logistics	4	3			1				x	5			4				
4th Semester																		
2002	Numerical Mathematics	4	3			1				x	5				4			
2507	General Management	4	2			1	1		x	x	5				4			
2508	Marketing and Sales	4	3			1				x	5				4			
2902	System Theory and Controls	4	2			1	1			x	5				4			
	Focus Field (see catalogue individual subjects: Focus Fields)																	
	Focus Field Subject 1	4									5				4			
	Focus Field Subject 2	4									5				4			
5th Semester																		
2015	Group Project	1						1	x		5					1		
2509	Fundamentals of Law, Investment and Financing	4	4							x	5					4		
2705	Engineering Design	4	2			2				x	5					4		
2708	Thermodynamics	4	2			1	1			x	5					4		
	Focus Field (see catalogue individual subjects: Focus Fields)																	
	Focus Field Subject 3	4									5					4		
	Focus Field Subject 4	4									5					4		
6th Semester																		
2016	Internship / Semester abroad								x		30							
7th Semester																		
2017	Bachelor Thesis									x	12							
2018	Colloquium									x	3							
2510	Technology and Innovation Management	4	2				2			x	5							4
2512	Entrepreneurship	2						2	x		2							2
	Elective (see catalogue individual subjects: Electives)	3									5							3
Overview		**133**	**V**	**SL**	**S**	**Ü**	**Pra**	**Pro**	**Attestation**	**graded**	**210**	**27**	**28**	**24**	**24**	**21**		**9**
		HPW	**Type**						**Examination form**		**CP**	**WS1**	**SS2**	**WS3**	**SS4 HPW**	**WS5**	**SS6**	**WS7**

Catalogue Individual Subjects IE		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 Supply Chain Management	**16**	**7**			**2**	**4**	**3**			**20**				**8**	**8**		
2513	Global Economy and Trade	4	2			2				x	5				4			
2514	Technical Investment Planning and Purchasing	4	1					3		x	5				4			
2515	Supply Chain Management	4	2				2			x	5					4		
2516	Enterprise Resource Planning	4	2				2			x	5					4		
	Focus Field Information Engineering	**16**	**8**			**2**	**5**	**1**			**20**				**8**	**8**		
2517	Controlling and Information Engineering	4	2			1	1			x	5				4			
2518	Service and Business Process Re-Engineering	4	2			1		1		x	5				4			
2506	Game Theory and Operations Research	4	2				2			x	5					4		
2904	Modelling and Simulation	4	2				2			x	5					4		
	Focus Field Process Engineering	**16**	**8**			**3**	**5**	**0**			**20**				**8**	**8**		
2709	Fundamentals of Process Engineering	4	2			1	1			x	5				4			
2710	Fluid Mechanics	4	2			1	1			x	5				4			
2712	Design of Plants	4	2				2			x	5					4		
2713	Control of Plants in Process Engineering	4	2			1	1			x	5					4		
Electives																		
2019	Scientific Methods (Block or online)	4	2			2			x		5							4
2020	Foreign Language								x		5							
2021	Module from any other Bachelor study course HSRW								x	x	5							

Explanations / Conditions

* Die Fakultät behält sich das Recht vor, sowohl eine Mindestteilnehmerzahl für das Zustandekommen eines Faches im Fokusfeld / Wahlbereich als auch eine Maximalteilnehmerzahl festzulegen. Die Möglichkeit des Erreichens der vorgeschriebenen

** 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

Abbreviations

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

2000 Introductory Mathematics

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

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

2001 Applied Mathematics

Module name/Module code:	Applied Mathematics	2001
Degree:	Biomaterials Science: Electrical and Electronics Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BMS 2 2001 EL 2 2001 IE 2 2001 ME 2 2001 MSE 2 2001
Module coordinator:	Prof. Dr. A. Kehrein	
Lecturer:	Dr. T. Camps 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. In particular, they are able to work with multivariate functions and master modelling with differential equations. Students learn to model situatons that involve uncertainty and to calculate with discrete as well as continuous random variables. They learn how to draw conclusions about a population when only sample data is available. In particular, measurements are interpreted as samples. The fundamentals of probability theory that are necessary for this purpose are demonstrated empirically by data from student experiments. Students practice their general social skills by working in small teams on their homework. They specifically train to communicate in precise mathematical terms. By means of their homework, students improve their problem solving skills.	
Content:	• Linear algebra: matrices, determinants, inverse matrix, eigenvalue problems • Series: approximations using partial sums, convergence and divergence tests, power series, Taylor series • Differential calculus of several variables: partial derivatives, gradient, extrema	

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

2002 Numerical Mathematics

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

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

2003 Physics

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

2007 Chemistry of Materials

Module name/Module code:	Chemistry of Materials 2007
Degree:	Industrial Engineering: IE 1 2007 Mechanical Engineering: ME 1 2007
Module coordinator:	Prof. Dr. C. Heß
Lecturer:	Prof. Dr. A. Fahmi
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:	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:	Written Examination on campus
Forms of media:	Moodle
Literature:	John E. McMurry, Robert C. Fay: General Chemistry: Atoms First, Prentice Hall; 2009

2008 Static and Strength of Materials

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

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

2010 Dynamics

Module name/Module Code:	Dynamics 2010
Degree:	Industrial Engineering: IE 3 2010 Mechanical Engineering: ME 3 2010 Mechatronic Systems Engineering: MSE 3 2010
Module coordinator:	Prof. Dr. N. H. Østergaard
Lecturer:	Prof. Dr. N. H. Østergaard
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Exercise: 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2001 Applied Mathematics 2008 Statics and Strength of Materials
Module objectives:	The students will be taught the basic kinematics and kinetics for plane motions of particles, systems of particles and rigid bodies required for development and engineering analysis of mechanical systems. The course content will be based on Newtonian mechanics with focus on the link between kinematic properties and force. After having completed the dynamics course, students can independently formulate equations of motion and are familiar with the solution procedures.
Content:	• Particle kinematics ▪ Cartesian coordinates (recti- and curvilinear motions, rotating motion, ballistics) ▪ Polar coordinates and curvi-linear frames ▪ The concepts of relative motion and kinematic constrains • Particle dynamics, Newton's 2nd law in cartesian coordinates ▪ Free-body diagrams and kinetic diagrams ▪ mass-wire-pulley problems ▪ Coulomb friction • The linear and angular momentums and their properties ▪ Motion under a central force (for example satellites) ▪ Application to a system of particles ▪ The rocket equation (Tsiolkovsky) • Free and forced vibrations of damped and undamped single degree of freedom systems ▪ Mass-spring-damper systems ▪ The mathematical pendulum • Kinematics of rigid bodies ▪ Application of relative motion for formulation of kinematic constrains • Dynamics of rigid bodies

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

2011 Programming

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

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

2014 Cross Cultural Management

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

	• through group work, improve their intercultural collaboration and communication skills as well as presentation abilities.
Content:	<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 <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%) and a written assignment (term paper) (60%)
Forms of media:	Webex/Moodle
Literature:	1. Hofstede, Geert: Cultures and Organizations, (2010, Mcgraw-Hill) 2. Trompenaars, Fons: Riding the Waves of Culture, (2012, Brealey Publishing) 3. Lewis, Richard: When cultures collide – Leading across cultures (2006, Brealey Publishing) 4. De Bono, Edward: Serious Creativity, (2015, Vermilion // Trade Paperback) 5. Keeley, Larry Ten Types Of Innovation, (2013, Wiley) 6. Michalko, Michael: Thinkertoys, (2006,Ten Speed Press) 7. Wolff, Jurgen: CREATIVITY NOW, (2012, Pearson International) 8. Van Aerssen, B. et al: Das Große Handbuch Innovation, (2018, Vahlen) V9. on Oech, Roger: A Kick In The Seat Of The Pants, (1986, Warner Books) 10. Supplemental readings, e.g. additional literature, exercises, cases and other learning materials will be provided during class.

2015 Group Project

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

2016 Internship / Semester Abroad

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

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

2017 Bachelor Thesis

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

2018 Colloquium

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

2019 Scientific Methods

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

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

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

2020 Foreign language

Module name/Module code:	Foreign language 2020
Degree:	Biomaterials Science: BMS 7 2020 Electrical and Electronics Engineering: EL 7 2020 Industrial Engineering: IE 7 2020 Mechanical Engineering: ME 7 2020 Mechatronic Systems Engineering: MSE 7 2020
Module coordinator:	Heads of the degree programme
Lecturer:	acc. selected module of the language center
Language:	English
Place in curriculum:	Elective: The choice of the students has to be confirmed by the study program coordinators to avoid clashes with core subjects and to ensure the fitting to the study program.
Timetabled hours:	Recommended: 4 HPW
Workload:	acc. module description
Credits:	5
Recommended prerequisites:	none
Module objectives	At the beginning of the course the students define a language level to be achieved based on the existing language skills in the chosen language. This happens together with the responsible teacher. The expected improvement of the language skills has to be defined in a learning agreement. For international students this language should be German, for German students any other language offered by the language center of the university can be selected. After completion of the module the students should be able to communicate better in an additional foreign language. They are able to prepare documents required for applications in Germany or abroad.
Content:	acc. module description of the selected module of the language center
Assessment:	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 code:	Module from any other Bachelor study course HSRW 2021
Degree:	Biomaterials Science: BMS 7 2021 Electrical and Electronics Engineering: EL 7 2021 Industrial Engineering: IE 7 2021 Mechanical Engineering: ME 7 2021 Mechatronic Systems Engineering: MSE 7 2021
Module coordinator:	Heads of the degree programme
Lecturer:	acc. selected module
Language:	German or English
Place in curriculum:	Elective: The choice of the students has to be confirmed by the study program coordinators to avoid clashes with core subjects and to ensure the fitting to the study program.
Timetabled hours:	Recommended: 4 HPW
Workload:	acc. module description
Credits:	5
Recommended prerequisites:	none
Module objectives:	acc. module description of the selected module
Content:	acc. module description of the selected module
Assessment:	acc. module description of the selected module
Forms of media:	acc. module description of the selected module
Literature:	acc. module description of the selected module

2108 Materials and Testing

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

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

2305 Fundamentals of Electrical Engineering

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

	• Mesh Analysis • Electric power and energy • Superposition principle • Thevenin's theorem, alternative sources • Fundamentals of capacitors • Transient processes at capacitors • Induction law • Inductivities and their relation to capacitors • Transient processes at inductivities • Fundamentals of alternating currents engineering • Calculating with complex numbers in alternating currents engineering, basics of phasor diagrams • Root mean squares and peak values • Calculation of impedance and admittance • Networks in complex notation, application of phasor diagrams • Energy and power in alternating current networks • Polyphase systems • Frequency-dependent behaviour
Assessment:	Attestation within the scope of laboratory; Written examination
Forms of media:	Webex/Moodle
Literature:	1. R.L. Boylestad: Introductory Circuit Analysis, 12th Edition, Pearson, 2010 2. T.L. Floyd D.M. Buchla, Electronics Fundamentals, 8th Edition, Person, 2010 3. G. Hagmann: Grundlagen der Elektrotechnik, 15. Auflage, AULA Verlag, 2011 4. G. Hagmann: Aufgabensammlung zu den Grundlagen der Elektrotechnik, 14. Auflage, AULA Verlag, 2010 5. Course materials from the lecturer 6. Laboratory documents and Exercises from the lecturer

2500 Introduction to Industrial Engineering

Module name/Module code:	Introduction to Industrial Engineering	2500
Degree:	Industrial Engineering:	IE 1 2500
Module coordinator:	Heads of Study Program	
Lecturer:	Prof. Dr.-Ing. D. Untiedt Prof. Dr A. Struck A. Viermann	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Descriptive Statistics and Reporting: Lecture: 1HPW Basics of Communication and Self-Management: Seminar: 1 HPW Introduction to Industrial 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 Industrial 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 Industrial Engineering • The students get a feeling for the study program and the field of Industrial 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 Industrial Engineering • Introduction of different fields in Industrial 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:	Webex/Moodle
Literature:	Reporting and Descriptive Statistics: 1. Devore, J. (2012). *Probability and Statistics for Engineering and the Sciences* (8th edition Ausg.). Boston: Brooks/Cole. 2. Mittal, H. V. (2011). *R Graphs Cookbook.* Brimingham - Mumbai: Packt Publishing Basics of Communication and Self-Management: Different literature related to the different topics as well as additional learning material will be provided during class.

2501 Fundamentals of Economics and Business

Module name/Module code:	Fundamentals of Economics and Business	2501
Degree:	Industrial Engineering:	IE 1 2501
Module coordinator:	Prof. Dr. D. Berndsen	
Lecturer:	Prof. Dr. D. Berndsen	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Fundamentals of General Economics Lecture: Introduction to Business Economics Lecture:	 2 HPW 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:	Fundamentals of General Economics: Students know and understand the fundamental economic relationships in local, national and global market environments. They can identify key economic actors, understand their interests, and their means of influencing market outcomes. They understand the construction principles of economic models and are able to develop elementary solution approaches for economic issues. More specifically, they know basic micro-economic methods and contexts and are able to analyze consumer and producer behavior of goods and factor markets. They understand macro-economic models and can arrive their own basic interpretation of various economic policy proposals. Introduction to Business Economics: 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.
Content:	General Economics • Markets and market participants • Market structures, market typology and market influences • Decision making in markets • Micro- vs. Macro-economics • Macroeconomic models • Economic policy – select types of state interventions and their evaluation Business Economics • Definition and roles of a business • 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
Assessment:	Written examination
Forms of media:	Moodle
Literature:	General Economics 1. McConnell, Stanley / Brue, Stanley / Conley, Flynn (2016): Economics. Principles, Problems & Policies, 20th edition, 978-1259450242, McGraw-Hill 2. Krugman, Paul / Wells, Robin (2015): Economics, 4th edition. ISBN 978-1464143847, Worth Publishers 3. Harford, Tim (2012): The Undercover Economist, Revised and Updated Edition: Exposing Why the Rich Are Rich, the Poor Are Poor - and Why You Can Never Buy a Decent Used Car! ISBN 978-0199926510, Oxford University Press Introduction to Business Economics

	4. Nickels, William G. / McHugh, James / McHugh, Susan (2015): Understanding Business. 11th edition, ISBN 978-9814670371, McGraw-Hill 5. Hughes, Robert / Kapoor, Jack R. / Pride, William M. (2014): Business. EMEA edition. ISBN 978-1473704763, Cengage Learning 6. Brealey, Richard A. / Myers, Stewart C. / Allen, Franklin (2016): Principles of Corporate Finance. 12th edition, ISBN 978-1259253331, McGraw-Hill 7. Osterwalder, Alexander et al. (2014): Value Proposition Design: How to Create Products and Services Customers Want (Strategyzer). ISBN 978-1118968055, Wiley 8. Ries, Eric (2011): The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. ISBN 978-0670921607, Portfolio Penguin 9.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

2502 External Accounting

Module name/Module code:	External Accounting	2502
Degree:	Industrial Engineering:	IE 2 2502
Courses (where applicable):	Bookkeeping Financial Accounting	
Module coordinator:	Prof. Dr. D. Berndsen	
Lecturer:	Prof. Dr. D. Berndsen	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Bookkeeping Exercises: 2 HPW Financial Accounting / Reporting Lecture: 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	
Module objectives:	Students will gain the ability to solve problems independently with application-related, fundamental knowledge of bookkeeping and accounting. Students gain a good working knowledge about the purposes, structure and basic processes of bookkeeping and annual closing. They can apply bookkeeping fundamentals and post simple transactions using current basic bookkeeping software. They can distinguish and explain the linkages between the three main financial reporting statements. They know and understand alternative ways of evaluating select assets as well as liabilities. They have basic knowledge of the differing reporting requirements on different legal setups of a business (one person firms vs. partnerships vs. small corporations vs. large corporations). After finishing the module, students fully understand both the operational functions of and the informational expectations on financial accounting. For this they are able to take the perspectives of all main stakeholders of a business.	
Content:	Bookkeeping • Principles of record keeping • Double Entry bookkeeping • Introduction to basic bookkeeping software • Recording transactions • Adjusting the accounts • Accounting cycle • Process of annual closing	

	<u>Financial Accounting / Reporting</u> • Legal setups of a business (extended from semester 1) • Corporations: Legal organization, share types and share transactions • The Balance sheet / Statement of Financial Position • Evaluating Equity, dividends, and retained earnings • Evaluating Inventories • Doubtful provisions on Accounts Receivable • Evaluating Plant Assets, Natural Resources, and Intangible Assets • Reporting Investments • Reporting Liabilities • Profit & Loss accounts and Income Statement • Statement of Cash Flow • From Income Statement to Statement of Cash Flow • Additional reporting requirements on various types of business (examples)
Assessment:	Written examination (2 hours)
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) Open Source bookkeeping software (e.g. GnuCash, Wave Accounting). Optional (tbd): Basic SAP, Microsoft Dynamics or Sage accounting modules for education
Literature:	<u>Bookkeeping</u> 1. Piper, Mike (2010): Accounting Made Simple. ISBN 978-0981454221, Simple Subjects 2. Knight, John (2017): Accounting: Accounting made simple, basic accounting principles, and how to do your own bookkeeping. ISBN 978-1542385527, CreateSpace 3. Weygandt, Jerry J. / Kieso, Donald E. / Kimmel, Paul D. (2013): Financial Accounting, 9th edition, ISBN 978-1118334324, Wiley 4. GnuCash – Software Download (year and server address subject to change) <u>Financial Accounting / Reporting</u> 5. Weygandt, Jerry J. / Kieso, Donald E. / Kimmel, Paul D. (2013): Financial Accounting, 9th edition, ISBN 978-1118334324, Wiley 6. Weygandt, Jerry J. / Kieso, Donald E. / Kimmel, Paul D. (2013): Study Guide to accompany Financial Accounting, 9th edition, ISBN 978-1118855423, Wiley 7. Harrison, Walter T. Jr. / Horngren, Charles T. / Thomas, C. William (2016), Financial Accounting, 11th Edition, ISBN 978-0134127620, Pearson

	8. Schilit, Howard / Perler, Jeremy (2010): Financial Shenanigans: How to Detect Accounting Gimmicks and Fraud in Financial Reports. 3rd edition, ISBN 978-0071703079, 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

2503 Internal Accounting

Module name/ Module code:	Internal Accounting	2503
Degree:	Industrial Engineering:	IE 3 2503
Courses (where applicable):	Cost Accounting Managerial Accounting	
Module coordinator:	Prof. Dr. D. Berndsen	
Lecturer:	Prof. Dr. D. Berndsen	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Cost Accounting Lecture + Exercises: Managerial Accounting Lecture + Exercises:	 2 HPW 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	
Module objectives:	Students will gain the ability to solve problems independently with application-related, fundamental knowledge of cost accounting and managerial accounting. They become acquainted with accounting as the core foundation for strategic and operational decision support, planning, budgeting, and analysis of a business' performance. More specifically, they understand the cost side of management decisions on a business' product mix, making or buying products, pricing strategy and tactics. They are able to structure basic price calculations for an industrial firm. Students know the principles of the planning and budgeting process and understand the role of accounting in it. They can also identify the most common approaches to ratio analysis and gain basic knowledge of additional indicators on a business' performance. They can interpret standard KPI reports and arrive at informed conclusions on them.	
Content:	Cost Accounting • Cost behavior • Fixed and Variable costing • Direct and Indirect costing • Cost allocation and absorption costing • Cost Volume Profit analysis • Break Even analysis • Activity based costing and Target costing • Price calculation • Make or Buy decisions • Product mix decisions • Marginal costing and margin management	

	<u>Managerial Accounting</u> • Working capital management • Capital structuring decisions • Financial leverage • Liquidity management • Ratio analysis • Key performance indicators • Integrated performance management systems (e.g. Balanced Scorecard)
Assessment:	Written examination (2 hours)
Forms of media:	Webex/Moodle
Literature:	<u>Cost Accounting</u> 1. Blocher, Edward et al. (2015): Cost Management: A Strategic Emphasis. 7th edition. ISBN 978-1259253096, McGraw-Hill 2. Rundshagen, Volker (2016): Cost Accounting. Short Stories and Basic Concepts. ISBN 978-3737590525, epubli 3. Datar, Srikant / Rajan, Madhav V. (2017): Horngren's Cost Accounting. A Managerial Emphasis. 16th edition, ISBN 978-0134475585, Pearson <u>Managerial Accounting</u> 4. Proctor, Ray (2012): Managerial Accounting for Business Decisions: Decision Making and Performance Improvement. 4th edition, ISBN 978-0273764489, Pearson 5. Seal, Will / Rohde, Carsten (2014): Management Accounting, 7th edition, ISBN 978-0077157500, McGraw-Hill <u>Both Module Segments</u> 6. Bhimani, Alnoor et al (2015): Management and Cost Accounting. 6th edition, ISBN 978-1292063461, Prentice-Hall 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

2504 Quality and Project Management

Module name/Module code:	Quality and Project Management 2504
Degree:	Industrial Engineering: IE 3 2504
Module coordinator:	Prof. Dr.-Ing. D. Untiedt
Lecturer:	Prof. Dr.-Ing. D. Untiedt Prof. Dr.-Ing. A. Klein
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 3 HPW Practical work: 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	-
Module objectives:	Students know the essential terms, methods and tools of quality and project management. 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. After finishing this module, students will appreciate the need for project planning and are able to distinguish between project objectives and functional goals. They are able to define and document the objectives of a project. Depending on the type of project, they are able to design a suitable project structure and plan of execution. They are able to estimate project risks using a set of tools to analyse the project execution based on time and content and to communicate and document results by creating informative target group oriented presentations.
Content:	<u>Project Management</u> • Projects as a modern form of working • Comparison of Project and Line Management • Challenges of Project Management • Differentiation and contents of projects • Project phases • Developing project objectives (SMART) • Documentation: brief description of the project, project proposal • Project organisation • Embedding projects in existing organisations • Typical project organisation form • Role descriptions of project committees • Stakeholder Management • Analysis of influence and demand

	• Developing a strategy and action plan for targeted contact • Project Planning • Milestones and activities • Project structure plan • Network Techniques • Critical Path Method (CPM) • Programme Evaluation and Review Technique (PERT) • Risk Management • Strategies for handling risks • Continuous risk assessment • Change Management within the project • Project Documentation and Reports • Reports for different recipients • Planning of project meetings • Handling expectations <u>Quality management (not quality assurance)</u> • 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) • Business process management • Quality Function Deployment (House of Quality) • Statistical Process Control <u>Environmental management and occupational health and safety management:</u> • Environmental Management DIN EN ISO 14001 • Work safety BS OSHAS 18001 • Sustainability
Assessment:	Attestation / Written examination
Forms of media:	Webex/Moodle
Literature:	<u>Project Management</u> Pinto, Jeffrey K.: Project Management – Achieving competitive Advantage, 2nd Edition, Pearson, 2010 <u>Quality management</u> 1. Sanders, Donald A., Scott, C. Frank: Passing Your ISO 9000/QS-9000 Audit, CRC Press LLC, 1997 2. May, Constantin, Schimek, Peter: TPM Total Productive Management, 2nd edition, CETPM Publishing, 2009

	3. Hoyle, David: ISO 9000 Quality Systems Handbook, 6th edition, Routledge, 2009 4. Kelly, John M: IMS: The Excellence Model, BSI Business Information, 2004 5. Lindsay, Evans: The Management and Control of Quality, 8th edition, South-Western, Cengage Learning, 2011 6. DIN ISO EN 9000ff, raw documents (extracts) 7. BS OHSAS 18001; raw documents (extracts) 8. DIN ISO EN 14000 f, raw documents (extracts)

2505 Production and Logistics

Module name/Module code:	Production and Logistics 2505
Degree:	Industrial Engineering: IE 3 2505
Module coordinator:	Prof. Dr.-Ing. A. Klein
Lecturer:	Prof. Dr.-Ing. A. Klein
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 3 HPW Exercises: 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:	Continuous Assessment
Forms of media:	Webex/Moodle
Literature:	1. OM6 – Operations + Supply Chain Management, David A. Collier and James R. Evans, Cengage Learning, 2017 ISBN: 978-1-305-66479-1 2. 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

2506 Game Theory and Operations Research

Module name/Module code:	Game Theory and Operations Research	2506
Degree:	Industrial Engineering:	IE 5 2506
Courses (where applicable):	Game Theory Operations Research	
Module coordinator:	Prof. Dr. D. Berndsen	
Lecturer:	External lecturer	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Game Theory Lecture + Exercises: 2 HPW Operations Research 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:	2002 Numerical Mathematics	
Module objectives:	Game Theory is a set of concepts aimed at decision making in situations of competition and conflict, as well as cooperation and inter-dependence. It can thus be used to describe many aspects of business decision making in a formal way. Business executives regularly play "games" both within the firm and outside it – with competitors, customers, regulators, and even capital markets. Game Theory provides mathematical support for their related business decisions, always made under uncertainty. Seen from this angle, it becomes a subset of Operations Research problems. Operations Research employs mathematical models of various business decisions, usually seeking optimum solutions based on a limited set of decision variables. The methods can be employed to provide an unambiguous foundation to both operational and strategic business decisions. Students taking this elective will • develop a better understanding on essential business decision problems, • be able to re-formulate business decisions and strategies in mathematical terms • use well-established and well-researched solution pathways to find optimum or best attainable solutions, maximizing business benefit • grow their capability to analyze complex systems and pinpoint their challenges • develop their ability to analyze risks and reach strategic recommendations based on decision models	

	• improve their skills in case-driven research, observation, data analysis and presentation.
Content:	Game Theory • Overview strategic form games • Dominance and rationalizability • Nash equilibrium • Correlated equilibrium • Half dominance • Trembling hand perfection • Risk dominance • Overview extensive form games • Bayesian games and mechanism design Operations Research • Modeling with Linear Programming • Duality and Sensitivity in Linear Programming • The Simplex Method • Transportation Model • Network Models • Multiobjective Optimization and Goal Programming • Heuristic Programming • Traveling Salesperson Problem • Queuing Systems • Select Applications (Exercises)
Assessment:	Individual Exercises, Continuous Assessment
Forms of media:	Webex/Moodle
Literature:	1. Dixit, Avinash K. / Skeath, Susan / Reiley, David H. Jr. (2015): Games of Strategy. 4th edition, ISBN 978-0393919684, W.W. Norton 2. Tadelis, Steven (2013): Game Theory. An Introduction. ISBN 978-0691129082, Princeton University Press 3. Taha, Hamdy A. (2016): Operations Research. An Introduction. 10th edition, ISBN 978-0134444017, Pearson 4. Marlow, W.H. (2012): Mathematics for Operations Research. ISBN 978-0486677231, Dover Books 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 • Electronic case study materials • Sample exams • Catalogue of possible questions for exam preparation

2507 General Management

Module name/Module code:	General Management	2507
Degree:	Industrial Engineering:	IE 4 2507
Module coordinator:	Prof. Dr.-Ing. D. Untiedt	
Lecturer:	Prof. Dr.-Ing. D. Untiedt	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercises: Practical work:	2 HPW 1 HPW 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2503 Internal Accounting 2505 Production and Logistics	
Module objectives:	Students know the main methods and instruments of General Management. They have the ability to use them effectively. In general three management functions for any kind of company can be distinguished with respect to General Management: • Marketing Management • Finance Management and • Operations management. Students know the main tools, methods and instruments of general management. They have the ability to use them effectively. They are able to formulate strategies and implementation plans on all strategy levels and in specific contexts.	
Content:	• Fundamentals of General Management • Strategy • Operations Management • Finance and Controlling • Organisation and Management • Human Resource Management • Change Management • Marketing The theoretical knowledge gained in the sector of General Management will be simulated and deepened by an IT based business game.	

Assessment:	Attestation / Written examination
Forms of media:	Whiteboard, PowerPoint, Flip-Chart, Moderation kit, Business Simulation Game
Literature:	Daft, Richard L.: Management. 12th Edition, Cengage Learning, 2016

2508 Marketing and Sales

Module name/Module code:	Marketing and Sales	2508
Degree:	Industrial Engineering:	IE 4 2508
Courses (where applicable):	B2B Sales Fundamentals of Marketing	
Module coordinator:	Prof. Dr. D. Berndsen	
Lecturer:	Prof. Dr. D. Berndsen	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Fundamentals of Marketing Lecture + Exercises: 2 HPW B2B Sales 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	
Module objectives:	An economy based on the division of labour requires the exchange of goods and services among businesses. This module enables students to understand, apply and analyse the processes and structures necessary for this exchange from the specific perspective of a business selling a product or service to other businesses. Students become acquainted with the fundamental concepts of Marketing as the expression of a market-going strategy aimed at increasing sales by creating customer benefit. • They know about the data foundation of Marketing measures in assessing customer preferences and requirements. • They understand basic methods of market-oriented research, in particular as applied in b2b markets. • They are fluent in the arsenal of marketing measures as collected by the standard 4P approach. • They can create their own basic applied Marketing Strategies for new product introductions. Students fully understand the specific role of the Sales function in a b2b context. • They can identify the expectations on a Salesperson, their various roles and typical organizational setups for the sales function. • They are familiar with techniques of data-driven Marketing and Sales. • They can assess Sales Performance and connect it to the overall goals of the business.	

	• They can create a basic set of rules for Customer Relationship Management.
Content:	<u>Fundamentals of Marketing</u> • Marketing origins and goals • Data foundations – Customer preferences, competitive landscape, market specific constraints • Marketing in the digital environment • Collecting and interpreting market data • Marketing Management - overview • Product. Product and Service innovation, customer-oriented design, and lifecycle management • Price. Individual customer pricing, Trade Terms • Promotion. Brand, Marketing Communications, Influencers and Customer Relationships in b2b markets. • Place. Channel options, channel strategy and Sales function roles <u>B2B Sales</u> • Sales function role specified • Sales process • Sales objectives, managing and motivating Salespeople • Sales organization • B2B customer relationships as joint value creation • Key Account Management • Team Selling • Lead Management • Lead requirements and benefits analysis • Developing customer relationships • Sales performance indicators
Assessment:	Continuous assessment and written examination (2 hours)
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>Fundamentals of Marketing</u> 1. Kotler, Philip / Keller, Kevin Lane (2015): Marketing Management. 15th edition, ISBN 978-1292092621, Prentice-Hall 2. King, Kim Ann (2015): Complete Guide to B2B Marketing: New Tactics, Tools, and Techniques to Compete in the Digital Economy. ISBN 978-0134084527, Pearson <u>B2B Sales</u> 1. Johnston, Mark W. / Marshall, Grew W. (2013): Sales Force Management: Leadership, Innovation, Technology. 11th edition ISBN 978-0415534628, Routledge 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

2509 Fundamentals of Law, Investment and Financing

Module name/Module code:	Fundamentals of Law, Investment and Financing 2509
Degree:	Industrial Engineering: IE 5 2509 Mechanical Engineering: ME 5 2509
Courses (where applicable):	Fundamentals of Business Law Investment and Financing
Module coordinator:	Prof. Dr. D. Berndsen
Lecturer:	Prof. Dr. D. Berndsen Prof. Dr. H. Wilde
Language:	English
Place in curriculum:	Core: IE Focus Field Subject: ME
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:	Fundamentals of Business Law • 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 Investment and Financing • 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:	Webex/Moodle
Literature:	Business Law 1. Marson, James / Ferris, Katy (2015): Business Law. 4th edition, ISBN 978-0198727347, Oxford University Press 2. DiMatteo, Larry A. (2016): International Business Law and the Legal Environment: A Transactional Approach. 3rd edition ISBN 978-1138850989, Taylor & Francis Investment and Financing

	1. Brealy, Richard A / Myers, Stewart C. / Allen, Franklin (2016): Principles of Corporate Finance. 12th edition, ISBN 978-1259253331, McGraw-Hill 2. 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/Module code:	Technology and Innovation Management 2510
Degree:	Electrical and Electronics Engineering: EL 7 2510 Industrial Engineering: IE 7 2510 Mechanical Engineering: ME 7 2510 Mechatronic Systems Engineering: MSE 7 2510
Module coordinator:	Prof. Dr.-Ing. D. Untiedt
Lecturer:	Prof. Dr.-Ing. D. Untiedt
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	45 h attendance 75 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	-
Module objectives:	Students know the essential terms, methods and tools of technology and innovation management. They are able to arrange technologies and to evaluate these using suitable methods. They are aware of the importance of technologies for businesses and society. They know the methods and tools of technology forecasting, planning and evaluation and are able to apply these to practical problem cases. Students know the importance of innovations for businesses. They are acquainted with the relationships between innovation process, stakeholders and the internal and external business environments. They are able to apply suitable methods and instruments of innovation management in an objective-oriented manner in everyday operation. For this, a clear understanding is gained of the innovation process, its success factors and its management and controlling instruments. After completing the module, students should be able to create technology portfolios and to apply roadmaps. Furthermore they should have basic knowledge in the areas of projections and scenarios. In particular they are able to evaluate technological innovations with regard to chances and risks.
Content:	Technology and Life cycle management • Fundamentals of Technology management • Scope of duties of Technology management • Technology forecasting • Technology planning • Protection of intellectual property • Technology evaluation • Formulation of Technology strategies Innovation management • Basics concepts of Innovation management • Innovation processes and structures

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

2512 Entrepreneurship

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

2513 Global Economy and Trade

Module name/Module code:	Global Economy and Trade	2513
Degree:	Industrial Engineering: Mechanical Engineering:	IE 4 2513 ME 4 2513
Courses (where applicable):	Global Economy International Trade Law	
Module coordinator:	Prof. Dr. D. Berndsen	
Lecturer:	Prof. Dr. D. Berndsen External lecturer	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Global Economy Lecture + Exercises: International Trade Law Lecture + Exercises:	 2 HPW 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>

	1. Cowen, Tyler / Tabarrok, Alexander (2015): Modern Principles of Economics. 3rd edition, ISBN 978-1464128745, Freeman 2. Hill, Charles W. L. / Hult, G. Tomas M. (2015): Global Business Today. 9th edition, ISBN 978-9814738255, McGraw-Hill 3. Jorgenson, Dale W. et al., Hg. (2016): World Economy. Growth or Stagnation? ISBN 978-1316507742, Cambridge University Press <u>International Trade Law</u> 1. Carr, Indira / Stone, Peter (2013): International Trade Law. ISBN 978-0415659239, Routledge 2. 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/Module code:	Technical Investment Planning and Purchasing 2514
Degree:	Industrial Engineering: IE 4 2514 Mechanical Engineering: ME 4 2514
Module coordinator:	Prof. Dr.-Ing. D. Untiedt
Lecturer:	Prof. Dr.-Ing. D. Untiedt External lecturer (Purchasing)
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lecture: 1 HPW Practical work: 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:	Continuous Assessment
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

2515 Supply Chain Management

Module name/Module code:	Supply Chain Management	2515
Degree:	Industrial Engineering:	IE 5 2515
Module coordinator:	Prof. Dr.-Ing. A. Klein	
Lecturer:	Prof. Dr.-Ing. A. Klein	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lecture: Practical work:	2 HPW 2 HPW
Workload:	60 h attendance 45 h preparation and review (3 h per week) 45 h exam preparation	
Credits:	5	
Recommended prerequisites:	2503 Internal Accounting 2509 Fundamentals of Law, Investment and Financing	
Module objectives:	Supply Chain Management (SCM) is both an art and a science; SCM is a discipline focused on planning and forecasting, purchasing, product assembly, moving, storage, distribution, sales, and customer service – in short, all of the activities that take place to get the right product into the right hands, in the right quantity, at the right time. The SCM elective introduces students to core concepts of supply chain management, such as vendor and distribution strategies, supply chain planning, and procurement. Upon completion of the Elective, students demonstrate a good understanding of the key supply chain processes, their functional role and related performance indicators. Students • can analyze and document a firm's supply chain requirements, in particular for an industrial firm operating in a b2b environment. • are familiar with basic optimization techniques for supply chain processes. • can formulate both supplier and distribution strategies • understand the processes of supplier selection and supplier relationship management • demonstrate research, observation, analytical and presentation skills.	
Content:	• Supply chain management vs. Operations management • Key process overview • Essential data for optimized supply chain processes • Integrated customer relationship management • Customer service management • Demand planning and demand management • Order fulfillment • Logistics and logistics partner management • Manufacturing flow management • Supplier relationship management	

	• Vendor managed inventory • Supplier relationships in product development and commercialization • Returns management • Operational risk management
Assessment:	Written examination
Forms of media:	Webex/Moodle
Literature:	1. Chopra, Sunil / Meindl, Peter (2015): Supply Chain Management: Global Edition: Strategy, Planning, and Operation. 6th ed., ISBN 978-1292093567, Pearson 2. Lysons, Kenneth / Farrington, Brian (2016): Procurement and Supply Chain Management. 9th edition, ISBN 978-1292086118, Pearson 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

2516 Enterprise Resource Planning

Module name/Module code:	Enterprise Resource Planning 2516
Degree:	Industrial Engineering: IE 5 2516 Mechanical Engineering ME 5 2516
Module coordinator:	Prof. Dr. D. Berndsen
Lecturer:	Prof. Dr. D. Berndsen
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lecture: 2 HPW Practical work: 2 HPW
Workload:	60 h attendance 45 h preparation and review (3 h per week) 45 h exam preparation
Credits:	5
Recommended prerequisites:	2505 Production and Logistics 2011 Programming
Module objectives:	Students taking this course shall • understand why companies above a certain size and complexity of business need ERP systems to management their resources in an effective and efficient way. • know the core functions of ERP systems as well as optional features such as HR management, data analysis tools etc. • comprehend the complexity of ERP implementation projects and the intransparency of the ERP market and know proven approaches to cope with these problems • be able to make a differentiated assessment on the functions and configurations for different types of businesses (e.g. retail company vs. manufacturing plant)
Content:	Enterprise Resource Planning • ERP system core functions • Optional functions of ERP systems • Business process management and electronic workflows • User roles in ERP systems and management of proprietary data • Difference between master data (Stammdaten) and transaction data (Bewegungsdaten) • Data architectures, data structures • IT system “coordinates” (horizontal and vertical integration); integration along the product life stages from development over manufacturing planning, production, sales, distribution and after sales service • Porter value creation model • Interfaces and connectivity to other IT tools (e.g. manufacturing execution systems (MES), accounting tools, strategic workforce planning, advanced

	planning and optimization (APO), advanced planning and scheduling (APS) etc.) • Cooperation between ERP software manufacturer and implementation (integration) service provider • Reference process for ERP implementation (and ERP upgrade) projects as well as principles and tools for ERP project management
Assessment:	Individual Exercises, Continuous Assessment
Forms of media:	Webex/Moodle
Literature:	1. The Architecture of SAP ERP - Understand of successful software works; Jochen Böder; Tredition Verlag Hamburg 2013; ISBN 978-3-8495-6814-6 2. Production planning and control with SAP ERP; Jörg Thomas Dickersbach; Galileo press Bonn 2011; ISBN 978-1-59229-360-5 3. ERP and Data Warehousing in Organizations; Gerald Grant; IRM press, Hershey, PA, 2003; ISBN 1-931777-65-9 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

2517 Controlling and Information Engineering

Module name/Module code:	Controlling and Information Engineering	2517
Degree:	Industrial Engineering:	IE 4 2517
Courses (where applicable):	Controlling Business Information Engineering	
Module coordinator:	Prof. Dr. D. Berndsen	
Lecturer:	Prof. Dr. D. Berndsen	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Controlling Lecture + Exercises: 2 HPW Information Engineering 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:	2502 External Accounting 2503 Internal Accounting	
Module objectives:	The elective targets students interested in data-driven decision-making, overall business management and the provision of relevant internal and external information underpinning business decisions. A firm's Controlling function helps navigate the business, engages in the gathering and interpretation of data for decision support throughout the organization. Controlling is also about the 'people side' of numbers, focusing specifically on management and control rather than auditing, assurance or accountancy alone. Business-oriented Information Engineering is widening the scope of usable information for the Controlling function by adapting a firm's IT systems. It develops strategies and methods to generate, distribute, analyze and use the information in a firm's systems. It seeks in part to automate some routine queries and decisions, but also to aid the discovery of new data and data patterns essential for better business decision making. In taking the elective, students will • develop a better understanding on essential business decision data, • be able to identify ways to keep, obtain, combine and analyze essential decision data • understand decision rules for data-driven business management • know strategic performance measurement concepts and models • know essential Information Engineering techniques • know relevant business intelligence software / systems and their key functionalities	

	• practice ways of making data-driven decisions understandable to a variety of stakeholders in a business • improve their skills in case-driven research, observation, data analysis and presentation.
Content:	<u>Controlling</u> • "Controlling" as business performance management concept • Business performance measurement • Data foundations • Decision preparation • Decision impact analysis • Cost analysis • Forecasting • Strategic analysis • Operational and strategic recommendations • Internal communication • Improvement initiatives – project definition, project design, deliverables management <u>Business Information Engineering</u> • Relevant data for business decisions • Data sourcing • Data analysis strategy and process • Data analysis techniques: Entity analysis, Function analysis and process dependency, Process logic analysis, Entity type lifecycle analysis, Matrix cross-checking, Normalization, Cluster analysis, Data flow analysis • Fundamentals of large dataset analysis • Deep data, algorithmic discovery and machine learning • Results interpretation • Presentation
Assessment:	Group Case Work, Continuous Assessment
Forms of media:	MS Powerpoint slides via projector, added notes (electronic pen during lecture), Whiteboard Printouts of case materials and exercise sheets. Basic pocket calculator Networked devices (PCs, laptops, tablets, mobiles)
Literature:	1. Proctor, Ray (2012): Managerial Accounting for Business Decisions: Decision Making and Performance Improvement. 4th edition, ISBN 978-0273764489, Pearson Hope, Jeremy / Player, Steve (2012): Beyond Performance Management: Why, When, and How to Use 40 Tools and Best Practices for Superior Business Performance. ISBN 978-1422141953, Harvard Business Review 2. Parmenter, David (2015): Key Performance Indicators: Developing, Implementing, and Using Winning KPIs. ISBN 978-1118925102, Wiley

	3. Turban, Efraim / Sharda, Ramesh / Delen, Dursun (2014): Business Intelligence and Analytics. Systems for Decision Support. 10th edition, ISBN 978-1292009209, Pearson 4. Nussbaumer Knaflic, Cole (2015): Storytelling with Data. A Data Visualization Guide for Business Professionals. ISN 978-1119002253, Wiley 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

2518 Service and Business Process Engineering

Module name/Module code:	Service and Business Process Re-Engineering 2518
Degree:	Industrial Engineering: IE 4 2518
Courses (where applicable):	Service Processes Business Process Re-Engineering
Module coordinator:	Prof. Dr. D. Berndsen
Lecturer:	Prof. Dr. D. Berndsen
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Service Processes Lecture 1 HPW Business Process Re-Engineering Lecture 1 HPW Exercises: 2 HPW
Workload:	60 h attendance 45 h preparation and review (3 h per week) 45 h exam preparation
Credits:	5
Recommended prerequisites:	
Module objectives:	Business Process Engineering has provided essential tools for raising business productivity across the entire value chain, improving business core processes, and overall competitiveness. This course centers on one specific set of business processes, an industrial firms' b2b Services, either sold independently, as complimentary products to manufactured goods, or provided throughout an ongoing customer relationship. The Services process area is consistently used as an example and reference point to develop student skills applicable to any business process re-engineering or optimization project. Emphasis in this course lies with the practical techniques of process description, analysis, and improvement modeling.
Content:	Service Processes • Services vs. Sales in a b2b setting • Services objectives • Services as an independent product • Services as complement to industrial products • Customer Services / After Sales Services • Service strategies • Service organization • Customer requirements, expectations, and performance measurement Business Process Engineering

	• Lean enterprise management • The process improvement overview • Process innovations and process maturity • Re-engineering Processes – objectives and project scoping • Process development project organization – stakeholders, roles, team dynamics • Managing process change • Creating a process ecosystem • Process-Oriented Architecture (POA) • Managing process improvements • The process improvement organization • Business Process Modeling Techniques • Business Process Modeling Notations, Visualization • Process improvement aptitudes • Process improvement templates and instructions • Case examples / Exercises
Assessment:	Continuous Assessment
Forms of media:	MS Powerpoint slides via projector, added notes (electronic pen during lecture) Whiteboard Printouts of case materials, process map examples and exercise sheets. Networked devices (PCs, laptops, tablets, mobiles)
Literature:	1. Miettinen, Satu, ed. (2016): Industrial Service Design. ISBN 978-1472485779, Routledge 2. Gonzales Prida-Diaz, Vicente / Crespo Marquez, Adolpho (2014): After–sales Service of Engineering Industrial Assets: A Reference Framework for Warranty Management, ISBN 978-3319037097, Pearson 3. Boutros, Tristan / Purdie, Tim (2013): The Process Improvement Handbook: A Blueprint for Managing Change and Increasing Organizational Performance. ISBN 978-0071817660, McGraw-Hill 4. Von Rosing, Mark / von Scheel, Henrik / Scheer, August Wilhelm (2014): The Complete Business Process Handbook: Body of Knowledge from Process Modeling to BPM, Volume 1. ISBN 978-0127999593, Morgan Kaufmann 5. 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

2701 Engineering Drawing and Design

Module name/Module code:	Engineering Drawing and Design	2701
Degree:	Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	IE 2 2701 ME 2 2701 MSE 2 2701
Module coordinator:	Prof. Dr.-Ing. S. Danjou	
Lecturer:	Prof. Dr.-Ing. S. Danjou	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practical Training:	2 HPW 1 HPW 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Prerequisites:	none	
Module objectives:	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

2705 Engineering Design

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

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

2706 Manufacturing Technology

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

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

2708 Thermodynamics

Module name/Module code:	Thermodynamics	2708
Degree:	Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	IE 5 2708 ME 3 2708 MSE 3 2708
Module coordinator:	Prof. Dr.-Ing. 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:	Moodle
Literature:	Michael J. Moran, Howard Shapiro: Fundamentals of Engineering Thermodynamics, SI-Version, ISBN 978-0-470-54019-0 Further Readings: Robert Balmer: Modern Engineering Thermodynamics, ISBN 978-0-12-374996-3 Yunus A. Cengel, Michael A. Boles: Thermodynamics An Engineering Approach: 7thedition in SI-Units, ISBN 978-007-131111-3 Claus Borgnakke, Robert E. Sonntag: Fundamentals of Thermodynamics, International Student Version, 7thedition, ISBN 978-0-470-17157-8

2709 Fundamentals of Process Engineering

Module name/Module code:	Fundamentals of Process Engineering	2709
Degree:	Industrial Engineering: Mechanical Engineering:	IE 4 2709 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: 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 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; 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.	
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
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/Module code:	Fluid Mechanics	2710
Degree:	Mechanical Engineering: Industrial Engineering: Mechatronic Systems Engineering:	ME 4 2710 IE 4 2710 MSE 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: 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:		
Module objectives:	On completion of this module the student is able to... – understand the principles of Fluid Mechanics, – identify the importance and role of Fluid Mechanics within the Mechanical Engineering profession, – understand how physical principles such as conservation of mass, momentum, and energy determine fluid behaviour and lead to mathematical descriptions of key features; – understand the advantages and limitations of Fluid Mechanics models, equations and formulae; – use the principles of Fluid Mechanics to solve engineering problems involving such quantities as velocity, pressure, forces (e.g. friction, drag, lift), power requirements, and efficiency. In the laboratory framework, students learn how to measure the pressure losses of a piping system, how to operate a Venturi meter to determine the flow velocity in a tube, how to determine the velocity of fall using Stokes' law, and how to operate a sedimentation basin.	
Content:	• Fluid Properties – Density, viscosity, compressibility • Fluids at rest (Hydrostatics) – Pressure in liquids at rest – Stability of submerged and floating objects – Rotating containers • Fluids in motion – Pathlines, streaklines and streamlines – Viscous and inviscid flows – Laminar and turbulent flows • Integral forms of the fundamental laws	

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

2712 Design of Plants

Module name/Module code:	Design of Plants	2712
Degree:	Industrial Engineering: Mechanical Engineering:	IE 5 2712 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: Practical Training:	2 HPW 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:	Webex/Moodle and on campus Presentations
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/Module code:	Control of Plants in Process Engineering	2713
Degree:	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 safety systems, alarm monitoring, resource efficiency indicators 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 • Resource efficiency indicators • Safety Systems • Alarm management • Process monitoring • Plant asset management
Assessment:	Continuous Assessment
Forms of media:	Webex/Moodle
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

2902 System Theory and Controls

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

	– Time-variant and time-invariant systems – Causal and non-causal systems • Description of linear continuous systems – Time domain: step response, impulse response, convolution integral – Frequency domain: Laplace transformation, transfer functions • Characteristics of systems – Proportional, integral, derivative and its combinations – Block diagram transformation – Closed-loop transfer function: Reference and disturbance transfer function • Frequency domain characteristics – Nyquist-Plot – Bode-diagram • Stability of linear continuous control systems – Definition of stability and stability condition – Hurwitz criterion/Routh criterion/Nyquist criterion – Gain and phase margin • Design method for linear continuous control systems
Assessment:	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

2904 Modelling and Simulation

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

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