Module Handbook

for the study program

Biomaterials Science B.Sc.

Kleve, Rev. 4 January 2023

Content

Curriculum Biomaterials Science B.Sc

Curriculum BMS		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						
2003	Physics	4	2			1	1		x	x	5	4						
2005	Inorganic Chemistry	4	2			1	1			x	5	4						
2011	Programming	4	2				2		x	x	5	4						
2014	Cross-Cultural Management and Creativity	4	2			2			x		5	4						
2100	Introduction to Biomaterials Science	3	2		1				x		3	3						
2nd Semester																		
2001	Applied Mathematics	8	5			3				x	7		8					
2004	Advanced Physics	4	2			1	1		x	x	5		4					
2006	Organic Chemistry	4	2			1	1			x	5		4					
2103	Physical Chemistry	4	2			1	1			x	5		4					
2106	Metallic Materials and Testing	4	2				2			x	5		4					
2110	Material Analysis	4	2				2			x	5		4					
3rd Semester																		
2008	Statics and Strengths of Materials	4	2			2				x	5			4				
2013	Business Economics and Project Management	4	3				1		x		5			4				
2101	Cell Biology and Microbiology	4	2				2			x	5			4				
2104	Chemistry of Biopolymers	4	2			1	1			x	5			4				
2107	Non-metallic Materials	4	2			1	1			x	5			4				
2112	Colloids and Rheology	4	2			**1**	**1**			x	5			4				
4th Semester																		
2102	Biochemistry	4	2				2			x	5				4			
2105	Biotechnology and biodegradable Materials	4	4							x	5				4			
2109	Materials Technology	4	4							x	5				4			
2111	Applied Materials and Corrosion	4	2			1	1			x	5				4			
	Focus Field (see catalogue individual subjects: Focus Field Subjects)																	
	Focus Field Subject 1	4									5				4			
	Focus Field Subject 2	4									5				4			
5th Semester																		
2015	Group Project	1						1	x		5					1		
2113	Tailored Materials and Surfaces	4	2			1	1			x	5					4		
2114	Biocompatible Materials	4	2			1	1			x	5					4		
2906	FEM and Simulation Methods	4	2			**2**				x	5					4		
	Focus Field (see catalogue individual subjects: Focus Field Subjects)																	
	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							
2511	Technology and Quality 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**	**WS5**	**SS6**	**WS7**
			58	**0**	**1**	**20**	**24**	**3**							**HPW**			

Catalogue Individual Subjects BMS		HPW	Type						Examination form		CP	HPW						
			V	SL	S	Ü	Pra	Pro	Attestation	graded		WS1	SS2	WS3	SS4	WS5	SS6	WS7
Focus Field Subjects *//***/**** **																		
2002	Numerical Mathematics	4	3			1				x	5				4			
2021	Modul from any other study course HSRW										5							
2116	Inorganic and Composite Materials	4	2				2			x	5				4			
2117	Technical Investment Planning	4	2				2		x		5				4			
2118	Materials inspired by Nature	4	2			**1**	1			x	5				4			
2119	Medical Devices	4	2				2			x	5				4			
2120	Recycling and Ecology of Materials	4	2				2			x	5					4		
2121	Material Testing and Failure Analysis	4	2				2			x	5					4		
2122	Nanomaterials	4	2			**1**	1			x	5					4		
2123	Materials Simulation	4	2			2				x	5					4		
2124	Biological Reactions to Materials	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 Kreditpunktanzahl aus dem Vertiefungsfeld bleibt unberührt./ * The faculty reserves the right to determine a minimum and a maximum number of participants for offering a subject in the focus fields / electives. The possibility to obtain the required number of credit points remains unaffected.

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

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

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

Abbreviations

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

2000 Introductory Mathematics

Module name/Module code:	Introductory Mathematics	2000
Degree:	Biomaterials Science: Electrical and Electronics Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BMS 1 2000 EL 1 2000 IE 1 2000 ME 1 2000 MSE 1 2000
Module coordinator:	Prof. Dr. A. Kehrein	
Lecturer:	Prof. Dr. A. Struck, Ch. Neh	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise:	5 HPW 3 HPW
Workload:	120 h attendance 90 h preparation and review 30 h exam preparation	
Credits:	8	
Recommended prerequisites:	High school: Algebra, Exponential function and Logarithm, Trigonometry	
Module objectives:	Students are able to gain knowledge in various ways and learn to organize their work. Students understand basic mathematical concepts and know how to apply standard mathematical methods. They are able to visualize mathematical objects and to interpret mathematical symbols and formulas. They have learned to think, to work and to express themselves with precision. Also they have acquired a feeling for handling numbers. They possess the skills to solve problems on their own and to verify the solutions. They are able to apply numerical as well as graphical solution methods to various tasks. The students will possess general problem solving skills beyond the simple application of standard procedures.	
Content:	• Numbers: irrational numbers and the difficulties associated with their representation on a pocket calculator or computer, complex numbers and the Fundamental Theorem of Algebra • Systems of linear equations: Gaussian elimination • Vector algebra and analytic geometry: linear combinations, scalar and vector products, lines and planes • Limits: concept and computation, continuity, bisection method • Differential calculus: definition of derivative, rules of derivation, tangent, Newton's method, monotonicity and concavity • Integral calculus: inversion of differentiation – indefinite integral, area calculation – definite integral, Fundamental Theorem of Calculus	

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

2001 Applied Mathematics

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

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

2002 Nummerical Mathematics

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

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

2003 Physics

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

2004 Advanced Physics

Module name Module code:	Advanced Physics	2004
Degree:	Biomaterials Science Science Communication & Bionics	BMS 2 2004 SCB_11.2
Module coordinator:	Prof. Dr. G. Bastian	
Lecturer:	Prof. Dr. G. Bastian Prof. Dr. A. Struck	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practical training:	2 HPW 1 HPW 1 HPW
Workload:	60 h presence 60 h preparation and wrap-up 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2003 Physics	
Module objectives:	• Students can understand and explain technical and scientific phenomena on the basis of their acquired theoretical knowledge. • The connection between theory and practical applications is recognized. • Students are able to approach and solve new kinds of problems with the learned methods. • Presentation of own results in exercise classes and lab reports can be done with proper terminology in digital form and English language.	
Content:	• Light, sound, waves • Elektricity and Magnetism • Atomic physics • Nuclear physics • Solid State Physics • Sensor applications	
	Written examination, lab reports (attestation)	
Forms of media:	Whiteboard, Projector	
Literature:	Paul A. Tipler: Physics for Scientists and Engineers, Freeman, 2007	

2005 Inorganic Chemistry

Module name/Module code:	Inorganic Chemistry	2005
Degree:	Biomaterials Science	BMS 1 2005
Module coordinator:	Prof. Dr. A. Fahmi	
Lecturer:	Prof. Dr. A. Fahmi Prof. Dr. Ch. Heß Prof. Dr. N. Shirtcliffe	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practical training:	2 HPW 1 HPW 1 HPW
Workload:	60 h attendance 60 h self-study 30 h exam preparation	
Credits:	5	
Recommended prerequisites:		
Module objectives:	Students will be able to: • Describe the basic chemistry of the elements and compounds. • Recognize periodic trends vertically and horizontally on the periodic table • Describe the use of inorganic materials, especially in wide range of applications. • Describe the role of inorganic chemicals in varieties of reactions and catalysts	
Content:	• Review of elements structures and electron configurations in periodic tables and bonding • Molecular Orbital Theory • Acid-Base and Redox reactions Chemistry • Transition elements (coordination chemistry) and Crystal Field Theory • Structure, Bonding, Electronic and Magnetic Properties • S-block and P- block elements and compounds reaction and key characteristics	
Assessment:	Written examination on campus	
Forms of media:	Moodle	
Literature:	1. Grundlagen der Chemie: John E. McMurry, Robert C. Fay: General Chemistry: Atoms First, Prentice Hall; 2009 2. John E. McMurry, Robert C. Fay: General Chemistry: Atoms First, Prentice Hall; 2009	

	3. Charles E. Mortimer, Ulrich Müller: Chemie, 10.Auflage Thieme; 2010 4. Geoffrey Alan Lawrance: Introduction to Coordination Chemistry 5. François Mathey, Alain Sevin: Molecular Chemistry of the Transition Elements: An Introductory Course 6. F. Albert Cotton,Carlos A. Murillo,Manfred Bochmann, Russell N. Grimes: Advanced Inorganic Chemistry, 6th Edition

2006 Organic Chemistry

Module name/Module code:	Organic Chemistry	2006
Degree:	Biomaterials Science:	BMS 2 2006
Module coordinator:	Prof. Dr. N. Shirtcliffe	
Lecturer:	Prof. Dr. N. Shirtcliffe	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practical training:	2 HPW 1 HPW 1 HPW
Workload:	60 h Attendance 60 h Self-study 30 h Exam preparation	
Credits:	5	
Prerequisites:	2005 Inorganic Chemistry	
Module objectives:	Students will be able to: • Use the concepts and language of organic chemistry • Sketch simple organic chemical reaction mechanisms • Understand the importance of organic chemistry to daily life • To plan and carry out simple organic synthesis in a laboratory	
Content:	Organic Chemistry Functional Groups in Organic Chemistry • Alkanes, alkenes and alkynes • Aromatic groups • Halocarbons • Alcohols, Phenols and thiols • Ether and Epoxy groups • Aldehydes and Ketones • Carboxylic acids and their derivatives • Amines and other nitrogen groups • Heterocycles Stereochemistry • Types of isomer • Optical Isomers Organic reactions and their mechanisms • Radical substitution • Nukleophilic Substitution SN1 and 2 • Elimination • Addition to double bonds • Substitution to aromatics • Oxidation and Reduction • Carbonyl Chemistry	
Assessment:	Written examination	

Literature	1. John E. McMurry: Organic Chemistry 8th Ed. Brooks/Cole; 2011 2. David J, Hart, Christopher M. Hadad, Lesli E. Craine, Har-old Hart: Organic Chemistry 13th Ed. Brooks/Cole; 2011

2008 Statics and Strength of Materials

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

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

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
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.

2013 Business Economics & Project Management

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

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

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

2014 Cross-Cultural Management and Creativity

Module name/Module code:	Cross-Cultural Management and Creativity	2014
Degree:	Biomaterials Science: Electrical and Electronics Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BMS 1 2014 EL 3 2014 IE 2 2014 ME 2 2014 MSE 5 2014
Module coordinator:	A. Viermann	
Lecturer:	A. Viermann D. Ziegler (External Lecturer)	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Cross-Cultural Management: Lecture & Exercise Creativity: Lecture & Exercise	3 HPW 1 HPW
Workload:	60 h attendance 90 h preparation and review and group assignment	
Credits:	5	
Recommended pre-requisites:	none	
Module objectives:	The aim of this module is to support students to build up intercultural competencies (cognitive, affective and communicative) and acquire first basic knowledge and abilities to deal with creative processes in individual, team or organisational settings. For this, the students will • build knowledge and explore human nature in dealing with differences • reflect on the implications of various dimensions of diversity in organizational and business context. • develop an understanding of the term and nature of 'CULTURE' • self-reflect and explore the implications of dealing with change situations (e.g. culture shock) and reflect on coping strategies. • study different cultural models and learn about different dimensions of culture (e.g. Hofstede). On this basis, reflect on and develop an awareness of their own cultural background in comparison to other cultures in terms of values and behaviour. This supports students in becoming more self-reflective, mindful and adaptive when dealing with cultural differences. • experience working within multi-cultural teams and combine theoretical and empirical work while working on topic related projects. • develop awareness of and reflect on the importance of creativity. • be equipped with a repertoire of methods and strategies that support creative processes and know-how to build a supportive work environment and innovative climate in organizations to make best use of creative potentials. • by group work, practice to use the learned creativity methods to solve engineering related challenges	

	• through group work, improve their intercultural collaboration and communication skills as well as presentation abilities.
Content:	<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 • Dealing with change – (culture shock model) • Cultural models and dimensions of culture • Work in intercultural teams on semester assignments, preparing an term paper and presenting the results in class. <u>Creativity:</u> • Definition of terms like creativity, idea and innovation • Impact of creativity on business innovation and the creation of sustainable competitive advantages • Key components of individual creativity and team creativity • Getting to know different classical creativity techniques and new approaches to creativity • Frame conditions for creativity and innovation in organizations
Assessment:	Attestation: Group assignments: preparation, submission and oral presentation (40%) and a written assignment (term paper) (60%)
Forms of media:	Whiteboard, PowerPoint, Projector, Flip-Chart, Moderation kit
Literature:	1. Hofstede, Geert: Cultures and Organizations, (2010,Mcgraw Hill) 2. Trompenaars, Fons: Riding the Waves of Culture, (2012, Brealey Publishing) 3. Lewis, Richard: When cultures collide – Leading across cultures (2006, Brealey Publishing) 4. De Bono, Edward: Serious Creativity, (2015, Vermilion // Trade Paperback) 5. Keeley, Larry Ten Types Of Innovation, (2013, Wiley) 6. Michalko, Michael: Thinkertoys, (2006,Ten Speed Press) 7. Wolff, Jurgen: CREATIVITY NOW, (2012, Pearson Interna-tional) 8. Van Aerssen, B. et al: The Innovator's Dictionary, (2018, Vahlen) V9. on Oech, Roger: A Kick In The Seat Of The Pants, (1986, Warner Books) 10. Supplemental readings, e.g. additional literature, exercises, cases and other learning materials will be provided during class.

2015 Group Project

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

2016 Internship / Semester Abroad

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

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

2017 Bachelor Thesis

Module name/Module code:	Bachelor Thesis 2017
Degree:	Biomaterials Science: 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:	Prof. Dr. Andreas von Bubnoff
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: Electrical and Electronics Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BMS 7 2020 EL 7 2020 IE 7 2020 ME 7 2020 MSE 7 2020
Module coordinator:	Heads of the degree programme	
Lecturer:	acc. selected module of the Language Center	
Language:	English	
Place in curriculum:	Elective: The choice of the students has to be confirmed by the study program coordinators to avoid clashes with core subjects and to ensure the fitting to the study program.	
Timetabled hours:	Recommended:	4 HPW
Workload:	acc. module description	
Credits:	5	
Recommended prerequisites:	none	
Module objectives	At the beginning of the course the students define a language level to be achieved based on the existing language skills in the chosen language. This happens together with the responsible teacher. The expected improvement of the language skills has to be defined in a learning agreement. For international students this language should be German, for German students any other language offered by the language center of the university can be selected. After completion of the module the students should be able to communicate better in an additional foreign language. They are able to prepare documents required for applications in Germany or abroad.	
Content:	acc. module description of the selected module of the language center	
Assessment:	Attestation	
Forms of media:	acc. module description of the selected module of the language center	
Literature:	acc. module description of the selected module of the language center	

2021 Module from any other Bachelor study course HSRW

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

2100 Introduction to Biomaterials Science

Module name/Module code:	Introduction to Biomaterials Science 2100
Degree:	Biomaterials Science: BMS 1 2100
Module coordinator:	Heads of Study Program
Lecturer:	Prof. Dr.-Ing. R. Sicking (Part - Intro to) Prof. Dr. A. Struck (Part - Statistics) A. Viermann (Part - Basics of Communication and Self-Management)
Language:	English
Place in curriculum	Core
Timetabled hours:	Descriptive Statistics and Reporting: Lecture: 1HPW Basics of Communication and Self-Management: Seminar: 1 HPW Biomaterials Introduction: 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 Biomaterials Science: 15 h attendance 15 h preparation
Credits:	3
Recommended prerequisites:	none
Module objectives:	Descriptive Statistics and Reporting: • Students learn to present, summarize, and interpret data in a meaningful way. They learn to present data graphically using standard software packages. The focus lies on enabling the students to handle experimental data in future lab reports. Basics of Communication and Self-Management: • Getting to know and apply helpful first basic knowledge, methods and strategies in order to build up skills and capabilities to succeed in studying, communicating and working together with others. • Supporting with adequate exercises and team building elements the team building processes within the study courses in the first semester. On this base, reflect on the experiences and proceedings in order to learn from it for other transferable settings in teams and oganizations.

	Biomaterials Introduction: • Students will understand the importance of materials science and the interfaces to biological systems • Students will know relevant associations in the field of biomaterials science • Students understand the structure and intention of the BMS-curriculum • Motivate students for the study course BMS • Students will have the opportunity to discuss any organizational aspects which are related to the course Optional there will be an excursion to see materials production or manufacturing in industrial practice.
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 Biomaterials Introduction: • Examples of material and biomaterial production, development and application • Assessment of relevant associations • Internet check of relevant associations • Curriculum and module descriptions of the BMS-course • Link curriculum contents with examples from industrial practice • Time for discussion of organizational issues related to the biomaterials science course
	Attestation: Continuous Assessment
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:

	3. Different literature related to the different topics as well as additional learning material will be provided during class.

2101 Cell Biology and Microbiology

Module name/Module name::	Cell Biology and Microbiology	2101
Degree:	Biomaterials Science:	BMS 3 2101
Module coordinator:	Prof. Dr. N. Shirtcliffe	
Lecturer:	Prof. M. Palmada Fenès Prof. J. Fensterle	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practical training:	2 SWS 1 SWS 1 SWS
Workload:	60 h Attendance 60 h Self-study 30 h Exam preparation	
Credits:	5	
Prerequisites:		
Module objectives:	On successful completion of this module, students should • know important principles of cellular processes and their related structures; • understand the major principles of energy generation in biological systems; • classify major microbial groups and know their practical relevance; • be able to challenge beneficial and adverse effects of microorganisms; • be able to apply the principles of sterile working; • and write scientific lab protocols in an adequate manner	
Content:	Lecture: Cell biology: • anatomy of pro- and eukaryotic cells; • structure and function of subcellular components and cell organelles; • growth and metabolism (respiration, fermentation, photosynthesis); • protein synthesis; • movement and motility; • cells and tissues Microbiology: • introduction: Microbial evolution, microorganisms and humans, historical milestones; • structure and function of prokaryotes: morphology, cell wall, structures and locomotion, physiological basics; • taxonomy of microorganisms; growing microorganisms, killing microorganisms, detecting and analysing microorganisms; • selected examples	

	Lab course: Cell biology: • accurate pipetting of liquids, serial dilution, sterile technique; • basic techniques in mammalian cell culture; • transfection of mammalian cells; • direct fluorescent labelling of organelles Microbiology: • basic techniques in microbiology; • gram's staining; • measuring bacterial growth phases and generation time; • assessing an antibiotic´s minimal inhibitory concentration (MIC); • transformation of bacteria; • selection and screening of transformed bacteria
Assessment:	Written digital examination
Literature	Alberts: Molecular Biology of the Cell Brock: Biology of Microorganisms

2102 Biochemistry

Module name/Module code:	Biochemistry	2102
Degree:	Biomaterials Science:	BMS 4 2102
Module coordinator:	Prof. Dr. A. Fahmi	
Lecturer:	Prof. Dr. A. Fahmi	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Practical Training:	2 HPW 2 HPW
Workload:	60 h attendance 60 h self-study, preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2006 Organic Chemistry	
Module objectives:	Biochemistry • The course is designed for the undergraduate students to emphasis the unique chemistry that occurs in the environment of a cell to facilitate basic understanding of the life's processes at a molecular level. • The student should obtain an in-depth knowledge of the structures of amino acids, carbohydrates, lipids and nucleic acids. • The student also will gain a deeper understanding of biochemical macromolecular structure, function and metabolism. Broadly, it encompasses the chemical nature and structure of biomolecules and how they interact with each other, simple cellular reactions and the generation of energy for cellular activity, communication and co-ordination between and within cells, and the replication and expression of genetic material.	
Content:	Biochemistry: • This is an introductory course that addresses basic concepts of the chemical processes in living organisms. • It deals with the chemistry, structures and functions of cellular components such as proteins, carbohydrates, lipids, nucleic acids and other biomolecules. • Among the vast number of different biomolecules, many are complex and/or large molecules (called polymers based on subunit called monomers), types of monomers, linkages and types of biochemical polymers that are formed for vast of biological functions. • Few examples will explain the mechanism of enzymatic catalysis and regulation of carbohydrate, lipid,	

	nucleic acid and amino acid metabolism, and highlights their health and biotechnological implications.
Assessment:	Written examination
Forms of media:	Whiteboard, Projector
Literature:	1. Lehninger Principles of Biochemistry; Biochemistry, Donald Voet, Judith G. Voet Harper's Illustrated Biochemistry

2103 Physical Chemistry

Module name/Module code:	Physical Chemistry	2103
Degree:	Biomaterials Science:	BMS 2 2103
Module coordinator:	Prof. Dr. N Shirtcliffe	
Lecturer:	Prof. Dr. N. Shirtcliffe Prof. Dr. F. Platte	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practical training:	2 HPW 1 HPW 1 HPW
Workload:	60 h Attendance 60 h Self-study 30 h Exam preparation	
Credits:	5	
Prerequisites:	2000 Introductory Mathematics 2005 Inorganic Chemistry	
Module objectives:	The students will gain an initial understanding of kinetics and thermodynamics and will be able to describe and use the basic forms of optical spectroscopy	
Content:	Physical Chemistry: • Material Structure Atoms, Elements and bonding Types of chemical bond • Chemical equilibria • Acids and bases pH strong and weak acids and bases • Redox reactions Oxidation and reduction redox equations corrosion • Electrochemistry Standard electrode potentials Electrolysis and batteries Introduction to chemical thermodynamics • Gibbs Free energy • Relationships between enthalpy, entropy • Thermodynamic and Kinetic control Introduction to Kinetics • Reaction rate • Rate laws • activation energy, rate of reaction Spectroscopy • basics • basic quantum mechanics • optical spectroscopy • Elemental analysis	
Assessment:	Written examination	

Literature	1. Peter Atkins, Julio de Paula, Physical Chemistry for the Life Sciences, 2nd ed. Oxford University Press, 2011 2. John E. McMurry, Robert C. Fay: General Chemistry: Atoms First, Prentice Hall; 2009

2104 Chemistry of Biopolymers

Module name/Module code:	Chemistry of Biopolymers	2104
Degree:	Biomaterials Science:	BMS 3 2104
Module coordinator:	Prof. Dr. N. Shirtcliffe	
Lecturer:	Prof. Dr. P. Simon	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lectures: Exercise: Practical training:	2 HPW 1 HPW 1 HPW
Workload:	60 h Attendance 60 h Homework 30 h Exam Preparation	
Credits:	5	
Recommended prerequisites:	2006 Organic Chemistry	
Module objectives:	The lecture will enable the students • to employ principle concepts and terms of macromolecular chemistry • to recognize the most important types of synthetic polymers • to derive suitable synthesis strategies • to estimate the importance of polymers in daily life. • to compare the advantages and disadvantages of the different methods of polymer analysis • to perform simple polymer synthesis in laboratory scale • to study the different gels and other associative structures that can exist	
Content:	1 Historical overview 2 Distribution functions and the background theory 3 Determination of molar masses and distributions 4 Principle strategies for polymer synthesis 4.1 Step growth processes 4.1.1 Polycondensation 4.1.2 Polyaddition 4.2 Chain growth processes 4.2.1 Living Processes 4.2.2 Anionic Polymerization 4.2.3 Cationic Polymerization 4.2.4 Radical Polymerization 4.2.5 Polyinsertion	
Assessment:	Written digital examination, Lab reports	
Forms of media:	Webex/Moodle, laboratory equipment on campus	
Literature:	Paul C. Hiemenz, Timothy P. Lodge: Polymer Chemistry 2nd ed. CRC-Press 2007	

2105 Biotechnology and Biodegradable Materials

Module name/Module code:	Biotechnology and Biodegradable Materials 2105
Degree:	Biomaterials Science: BMS 4 2105
Module coordinator:	Prof. Dr. N. Shirtcliffe
Lecturer:	Prof. Dr. N. Shirtcliffe
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 4 SWS
Workload:	60 h Attendance 60 h Self-study 30 h Exam preparation
Credits:	5
Prerequisites:	2006 Organic Chemistry 2101 Cell Biology and Microbiology
Module objectives:	Upon Studying this course students will be able to: • Recognize the structure of the most important bio-degradable polymers and how they are degraded. • Describe representative examples of biodegradable materials • Describe the chemistry of oxodegredation • Describe the chemistry of some natural materials. • Understand how bioresorbable implants function • link this with biotechnology with the formation of products, such as PLA, combinative Silk • Also with enzymes that attack various bonds
Content:	A short introduction to genetics allows the students to understand Biotechnology. • The goal is to give the students the tools to converse with biologists. • The laboratory introduces sterilization and carrying out experiments under microbiologically clean conditions. • The students will also learn how to culture bacteria and simple cell culture procedures. • They will also understand some ways of carrying out genetic modification in order to express desired products • The ethical and safety questions in bioengineering will be considered and the students will be able to understand some of the moral implications of genetic research as well as to work safely on simple experiments. Biodegradable Materials: • Chemistry of oxo- and hydro-degradation. • Anaerobic degredation of polymers • Enzymatic degredation of biopolymers • The types and sources of biopolymers

	• Bone and shell • The structure of nacre and diotoms etc.; how they form and function • Chemistry of lignin and cellulose • Protein structure • Synthesis and degradation of biopolymers and energy cost/production • Biodegradable implants • How genes effect the properties of proteins and therefore those of the whole organism. • Basic chromatography and different types of chromatography preparative and analytical will be considered with a focus on biotechnology, extracting natural starting materials and analyzing the breakdown products of polymers.
Assessment:	written or oral examination
Literature	1. Basic Biotechnology by Colin Ratledge (Editor), Bjorn Kris-tiansen, Paperback: 584 pages, Publisher: Cambridge University Press 2. Cartoon Guide to Genetics, Larry Gonick, HarperCollins, 14.08.1991

2106 Metallic Materials and Testing

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

Forms of media:	Board/PowerPoint/Projector/Laboratory
Literature:	1. Bunge, H.J., Pöhlandt, K., Tekkaya, A.E., Banabic, D.Banabic, D.; Pöhlandt, Klaus (Eds.):Formability of Metallic Materials, Plastic Anisotropy, Formability Testing, Forming Limits, XV, ISBN 978-3-540-67906-6, 2000 2. R.B. Ross: Metallic Materials Specification Handbook, 4th Edition, ISBN 978-0412369407, Springer US, 1991 3. G. Gottstein: Physical Foundations of Materials Science, 1st Edition, ISBN 978-3-642-07271-0 4. George M. Crankovic: Metals Handbook: Materials Characterization, 9th Edition, ISBN 978-0871700162, ASM Intl., 1989 5. M. F. Ashby, D. R. H. Jones: Engineering Materials 2 – An Introduction to Microstructures, Processing and Design, 3rd edition, ISBN-13 978-0-7506-6381-6

2107 Non-metallic Materials

Module name/Module code:	Non-metallic Materials 2107
Degree:	Biomaterials Science: BMS 3 2107 Mechanical Engineering: ME 3 2107
Module coordinator:	Prof. Dr. C. Heß
Lecturer:	Prof. Dr. C. Heß
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:	2006 Organic Chemistry (BMS) or 2007 Chemistry of Materials (ME)
Module objectives:	• Specify basic chemical structures of polymers, ceramics and glass • Conclude on characteristic properties of polymers, ceramics and glass from the respective structure • Select suitable materials for a given engineering application task • Optimize specific mechanical or thermal properties of a material by suitable adjustment of formulation or processing parameters • Understand and explain the most important processing technologies for synthetic materials • Select suitable processing technologies for a given industrial task • Consider probable changes of material properties during processing and evaluate process limitations • Assess processing methods in regard of product quality and economic efficiency
Content:	• Different types of polymers (synthetic polymers, natural polymers, thermoplastics, thermosets, elastomers) • Structure and composition of polymers, ceramics and glass • Manufacture of polymers (radical polymerization, polyaddition, polycondensation) • Manufacture of ceramics and glass (ceramic process, sintering) • Homopolymers, copolymers, terpolymers, tacticity • Branched polymers, crosslinked polymers, curing, semicrystalline and amorphous polymers • 3-dimensional structure of macromolecules, superstructures • Phase transitions in polymers (glass transition, crystallization, melting)

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

2109 Materials Technology

Module name/Module code:	Materials Technology	2109
Degree:	Biomaterials Science:	BMS 4 2109
Module coordinator:	Prof. Dr.-Ing. R. Sicking	
Lecturer:	Prof. Dr.-Ing. R. Sicking	
Language:	English	
Place in curriculum	Core	
Timetabled hours:	Lecture:	4 HPW
Workload:	60 h Attendance 60 h Self-study 30 h Exam preparation	
Credits:	5	
Recommended prerequisites:	2106 Metallic Materials and Testing 2107 Non-metallic Materials 2110 Materials Analysis	
Module objectives:	*Students will be able to:* • Know the most important manufacturing processes for semi-finished metals like casting, rolling and extrusion • To give an overview of the value creation chain from raw material to the final product for aluminium and steel • Show the link between process, microstructure and macroscopic properties and can select a process accordingly. • To explain the primary forming by powder metallurgy and sintering of ceramics • Understand special demands to materials for mobility applications including light weight constructions • To distinguish between different important light weight construction materials. In addition, appropriate joining technologies can be selected. • To answer basic questions concerning material selection Optional there will be an excursion to see materials production or manufacturing in industrials practice.	
Content:	• Smelting of aluminium and steel • Casting, rolling and extrusion of metals • Microstructure development during the production process, • Influence on microstructure and properties by primary forming and semi-finished forming processes • Sintering of ceramics and powder metals • Overview on chipping manufacturing and forming processes • Heat Treatment of steels	

	• Steels for transport applications, high strength steels, TRIP steels • Aluminum alloys for light weight constructions • Reinforced materials for strength, stiffness and fire resistance • Carbon fibres and Kevlar®: Production and properties • Carbon nano fibres: production and properties • Rubber tires and their manufacturing • Joining techniques for mobile applications
Assessment:	Written or oral examination
Forms of media:	Board/PowerPoint/Projector
Literature:	1. M. F. Ashby, D. R. H. Jones: Engineering Materials 2 - An Introduction to Microstructures, Processing and Design, 2006, ISBN-13 978-0-7506-6381-6, Elsevier 2. B. Ilschner, R. F. Singer: Werkstoffwissenschaften und Fertigungstechnik – Eigenschaften, Vorgänge, Technologien; 5. Ed., 2010, ISBN 978-3-642-01733-9, Springer-Verlag 3. A. C. Reardon (Editor): Metallurgy for the Non-Metallurgist, 2nd edition, 2011, ISBN-13 978-1-61503-821-3, ASM International 4. E. Hornbogen, H. Warlimont: Metalle – Struktur und Eigenschaften der Metalle und Legierungen, 5. Ed., 2006, ISBN-13 978-3-540-34010-2 5. D. Altenpohl: Aluminium von Innen, 5. Ed., 1994, ISBN 3-87017-235-5, Aluminium Verlag 6. G. W. Ehrenstein: Faserverbund-Kunststsoffe – Werkstoffe – Verarbeitung – Eigenschaften; 2nd Ed., 2006, ISBN 978-3-446-22716-3, Hanser 7. C. B. Carter, M. G. Norton: Ceramic Materials - Science and Engineering, 2nd Ed., 2013, ISBN 978-1-4614-3522-8, Springer-Verlag 8. F. Henning, E. Moeller (Hrsg.): Handbuch Leichtbau - Methoden, Werkstoffe, Fertigung; 1st Ed., 2011, ISBN 978-3-446-42267-4, Carl Hanser Verlag

2110 Material Analysis

Module name/Module code:	Material Analysis 2110
Degree:	Biomaterials Science: BMS 2 2110
Module coordinator:	Prof. Dr. C. Heß
Lecturer:	Prof. Dr. C. Heß
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:	2005 Inorganic chemistry
Module objectives:	Students are able to • Understand basic scientific principles on which important analyzing methods are based • Apply gained knowledge in the laboratory in order to properly test and analyze a variety of materials • Understand and explain basic analyzing methods and identify appropriate methods for a given analyzing task. • Consider specific German, European and international standards for the task in focus
Content:	• Vibrational spectroscopy (IR, Raman) • Electron emission spectroscopy (UV) • Spectroscopy of inner electrons (XPS, XRF, EDX, Auger) • Magnetic testing methods • Metallographic sample preparation (grinding, etching, polishing, phase identification) • Thermal analysis (DSC, TGA) • Microscopic techniques (SEM, TEM, AFM) • Industrial surface inspection systems (SIS) • German, European and international standards for testing and analyzing
Assessment:	Lecture: Written examination Prcatical work: Reports
Forms of media:	Whiteboard, PowerPoint, Projector, Laboratory
Literature:	1. Callister, WD: Materials Science and Engineering - An Introduction, 2000 2. Charles Brooks: Failure Analysis of Engineering Materials 3. Joachim Ohser and Frank Mücklich: Statistical Analysis of Microstructures in Materials Science

	4. D. J. O'Connor, Brett A. Sexton, Brett A. and Roger C.: Surface Analysis Methods in Materials Science Korad Herrmann Hardness Testing - Principles and Applications, ASM In-ternational, ISBN-13 978-1-61503-832-9 5. W. Grellmann, S. Seidler: Kunststoffprüfung, 2. Aufl., 2011, ISBN 978-3-446-42722-8, Carl-Hanser-Verlag 6. C. R. Brundle, C. A. Evans, S. Wilson Encyclopedia of Material Characterization, 1992, Butter-worth-Heinemann, ISBN 0-7506-9168-9

2111 Applied Materials and Corrosion

Module name/Module code:	Applied Materials and Corrosion	2111
Degree:	Biomaterials Science:	BMS 4 2111
Module coordinator:	Prof. Dr. N. Shirtcliffe	
Lecturer:	Prof. Dr. N. Shirtcliffe	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practical training:	2 HPW 1 HPW 1 HPW
Workload:	60 h Attendance 60 h Self-study 30 h Exam preparation	
Credits:	5	
Prerequisites:	2006 Organic Chemistry 2103 Physical Chemistry 2106 Metallic Materials 2107 Non-metallic Materials	
Module objectives:	The students will be able to • Consider some specific materials problems related to biomaterials and understand the challenges in the choice of material. • Analyse some special cases in which various materials are used together to attain the properties required. • Consider some ways in which to analyse complex materials.	
Content:	How materials fail, including corrosion and other forms of degredation. • Materials for hygene, sterilisability, bioreactors • Multilayer structures, barrier properties, swelling, adhesion. • Materials for food packaging • Growth of nanocrystals • Solar cells and semiconductors • Materials for food, seals wear products.	
Assessment:	Written or oral examination	
Literature	1. Applied Materials Science: Applications of Engineering Materials in Structural, Electronics, Thermal, and Other Industries 1st Edition by Deborah D. L. Chung CRC Press 2001. 2. Zhong Lin Wang and Z. C. Kang Functional and Smart Materials Structural Evolution and Structure Analysis 3. Hee-Gweon Woo and Hong Li: Advanced Functional Materials	

2112 Colloids and Rheology

Module name/Module code:	Colloids and Rheology	2112
Degree:	Colloids and Rheology	BMS 3 2112
Module coordinator:	Prof. Dr. Ch. Heß	
Lecturer:	Colloids: Prof. Neil Shirtcliffe Rheology: Prof. Ch. Heß	
Language:	English	
Place in curriculum:	Core subject	
Timetabled hours:	Lecture: Exercise: Practical training:	2 HPW 1 HPW 1 HPW
Workload:	60 h attendance 60 h self-study, preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:		
Module objectives:	Rheology The students expected to • conduct measurement to define rheological properties • analyse and interpret of rheological properties of different types of materials • choose a rheometer system • use rheometer system efficiently • use rheological measurements to describe materials properties • use rheological tests to solve processing problems • to design rheology tests for Colloidal Dispersions and formulate rheology modifiers Colloids: • The students will be able to: • Classify the types and stability of colloids, e.g. Sus-pensions (Solid in liquid), emulsions (liquid in liquid e.t.c. • Describe the properties of fine Particles and aggregates of macromolecules using the high interfacial area and interfacial energy. • To be able to quantify the structure and stability of colloids. • To recognise the factors affecting dispersability, flocking and sedimentation in both aqueous and non-aqueous media. • Describe and use methods to determine the propoerties of colloids, such as particle size, stability, rheology and Zeta potential.	
Content:	Rheology: • Introduction to Rheology: Basic principles, definitions and descriptions	

	• Rheological measuring instruments: describe di-verse measuring principles, measuring geometries. • Rheology Fundamentals: Stress and Strain Fundamentals, Elastic Solids and Viscous Models, Linear Viscoelasticity, the "structured fluids" model for describing rheology, Shear and extensional flow modes, Shear stress, shear strain, shear rate and viscosity, Newtonian and Non-Newtonian flow behaviour and shear viscosity and shear-thinning behaviour. • Structure effects: yield stress, thixotropy and de-scribing viscoelasticity, elastic and viscous modulus, phase angle and tan delta, Viscoelasticity and deformation timescale effects and FT-Rheology. Colloids: • An introduction into the properties and importance of different surface and dispersed systems and how this reaches into many areas of production and daily life. Using examples from areas such as medicine, food, ceramics and biology. • The properties of charged surfaces, their stability and how this can be influenced by adsorbtion of surface active species. This includes properties of emulsions, polymers in solution and at surfaces, wetting and aggregation. • The concept of amphiphiles, with their surface active properties and emergent phase behavior, micellar, liquid crystaline and microemulsions. Other aggregates, such as vesicles are also considered • The interactions between particles and their effect on colloidal stability are considered. The role of surface activity of additives on colloidal stability is described using systems such as foams and emulsions as examples. • The role of surface energy on wetting, filtration and sintering is discussed as is the more general aspect of how surface and interfacial properties influence the bulk properties of dispersions.
Assessment:	Written examination
Forms of media:	Moodle
Literature:	Rheology: 1. Christopher W. Macosko: Rheology: Principles, Measurements, and Applications (Advances in Interfacial Engineering) 2. Nhan Phan-Thien: Understanding Viscoelasticity: Basics of Rheology (Ad-vanced Texts in Physics) 3. Marianna Kontopoulou: Applied Polymer Rheology: Polymeric Fluids with Industrial Applications Colloids:

	4. Jan Mewis and Norman J. Wagner: Colloidal Suspension Rheology (Cambridge Series in Chemical Engineering) 5. Ian D. Morrison and Sydney Ross: Colloidal Dispersions: Suspensions, Emulsions, and Foams

2113 Tailored Materials and Surfaces

Module name/Module code:	Tailored Materials and Surfaces	2113
Degree:	Biomaterials Science:	BMS 5 2113
Module coordinator:	Prof. Dr. N. Shirtcliffe	
Lecturer:	Prof. Dr. N. Shirtcliffe	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practical Training:	2 HPW 1 HPW 1 HPW
Workload:	60 h Attendance 60 h Self-study 30 h Exam preparation	
Credits:	5	
Prerequisites:	2006 Organic Chemistry 2103 Physical Chemistry 2106 Metallic Materials and Testing 2107 Non-metallic Materials	
Module objectives:	The students will be able to • Explain how the techniques in the content work • Solve simple practical problems where a modification is required or a problem arises with a treatment • consider some ways in which to analyse complex materials and how they work.	
Content:	• Surfaces of materials including pure surfaces, bonding to surfaces, reactions at surfaces, states of surface atoms. • Chemical bonding to surfaces (thiols, silanes, click e.t.c) • Surface modification with plasma, corona • Deeper surface modifications, through anodization, nitriding etc. • Paint chemistry • Evaporation, electroless deposition, electrodeposition • Sol-Gel chemistry • Thermal spray coatings and other thick layer coating processes • Lithography lithography and microcontact printing • Surface characterization techniques	
Assessment:	written digital examination	
Literature	Handbook of Surfaces and Interfaces of Materials Edited by: Hari Singh Nalwa, M.Sc, Ph.D. ISBN: 978-0-12-513910-6	

2114 Biocompatible Materials

Module name/Module code:	Biocompatible Materials	2114
Degree:	Biomaterials Science:	BMS 5 2114
Module coordinator:	Prof. Dr. C. Heß	
Lecturer:	Prof. Dr. C. Heß	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practical Training	2 HPW 1 HPW 1 HPW
	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2106 Metallic Materials and Testing 2107 Non-metallic Materials	
Module objectives:	Students are able to • Demonstrate a broad understanding on the multidisciplinary field of biomaterials • Design the properties of biomaterials (bulk and surface) in regard of ○ Degradability/Degradation ○ Interfacial reactions ○ Manufacture and processing ○ Characterization ○ Interaction between biomaterial and living tissue • Understand the clinical context of biomaterials that are used in medical health care for implants or other devices • Identify ethical aspects and limitations for the selection of biomaterials that are intended to be used for specific healthcare applications	
Content:	• The comprehensive fundamental course addresses basic concepts of materials that are interfacing in dimensions with living tissue and interact with different biological systems in a possibly safe, reliable and physiologically acceptable manner. • The course demonstrates the vital development work that is done in order to identify biofunctional materials which can be used to replace or augment damaged organs, vessels or tissues, in order to improve both quality and span of life. • Beside structural properties, biocompatibility and performance of synthetic, metallic and ceramic biomaterials, the course also deals with general ethical as well as economic aspects for the specific application of biomaterials in medical healthcare. • Finally the course provides an overview of national and international regulations on compliance and performance	

	requirements for the use of biomaterials in clinical resp. healthcare environment.
Assessment:	Continuous Assessment
Forms of media:	Moodle
Literature:	1. Buddy D. Ratner , Allan S. Hoffman, Frederick J. Schoen and Jack E. Lemons: Biomaterials Science, Second Edition: An Introduction to Materials in Medicine 2. Joon B. Park and Joseph D. Bronzino: Biomaterials: Principles and Applications 3. G. D Baura: Medical Device Technologies – A System Based Overview Using Engineering Standards, 1. Aufl., 2012, ISBN 978-0-12-374976-5, Elsevier 4. F. A. Rodriguez-Gonzales: Biomaterials in Orthopaedic Surgery, 1. Aufl., 2009, ISBN-13 978-1-61503-009-5, ASM International 5. E. Wintermantel, S.-W. Ha: Medizintechnik – Life Science Engineering, 5. Aufl., 2009, ISBN 978-3-540-93935-1, Springer-Verlag

2116 Inorganic and Composite Materials

Module name/Module code:	Inorganic and Composite Materials	2116
Degree:	Biomaterials Science:	BMS 4 2116
Module coordinator:	Prof. Dr. C. Heß	
Lecturer:	Prof. Dr. C. Heß	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lecture: Practical training:	2 HPW 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2106 Metallic Materials and Testing 2107 Non-metallic Materials	
Module objectives:	Inorganic Materials Students are able to • describe and evaluate properties and features of ceramic materials • understand and analyze loading scenarios and failure mechanisms • distinguish ceramics from metallic and synthetic materials by their characteristic properties • identify, explain and compare technologies for the manufacture and processing of ceramic materials • select and evaluate appropriate manufacturing technologies for ceramics with respect to their specific technological and economical challenges Composite Materials Students are able to • distinguish, describe and evaluate the properties of reinforced, laminated and sandwich-structured composites • understand and analyze mechanical, thermal and chemical loading scenarios as well as failure mechanisms • identify, explain and compare technologies and mechanisms to strengthen materials by addition of reinforcements • plan and apply methods for the evaluation of composite materials and device characterization	
Content:	Inorganic Materials • The course deals with material characteristics and fundamentals for the manufacture of ceramics.	

	• The lecture further covers concepts for construction with ceramics, including specific mechanical and thermal properties as well as fracture mechanisms. • Ceramic materials are juxtaposed against metallic and synthetic materials. By using examples from engineering and industrial needs, application domains and limitations of ceramic materials are analyzed. • The topics are consolidated by lab work. Composite Materials • The course deals with the various possibilities to strengthen materials by application of composite technology (fiber reinforcement, lamination, formation of sandwich structures). • The properties of different material combinations as well as constructive and manufacturing aspects are discussed. • The lecture further covers the different functionalities of matrix resp. reinforcement material in composites. • Composites are juxtaposed against the respective monolithic materials in order to assess the specific effects of reinforcements. • Examples of industrial applications illuminate the increasing importance but also limitations of composite materials. • A focus is put on manufacturing methods for fiber reinforced resp. laminated composites. • The topics are consolidated by lab work.
Assessment:	Lecture: Written examination Prcatical work: Reports
Forms of media:	Whiteboard, PowerPoint, Projector, Laboratory
Literature:	1. Carter, C. Barry, Norton, M. Grant: Ceramic Materials Science and Engineering Ceramic Materials: Science and Engineering (Apr 4, 2007) 2. Jan Wurm: Glass Structures: Design and Construction of Self-supporting Skins (Aug 17, 2007) 3. erope Kalpakjian,Steven R. Schmid,Ewald Werner: Werkstofftechnik, 2011, ISBN 978-3-86794-006-0

2117 Technical Investment Planning

Module name/Module code:	Technical Investment Planning 2117
Degree:	Biomaterials Science: BMS 4 2117
Module Coordinator:	Prof. Dr.-Ing. Dipl.-Wirt. Ing. R. Schmetz
Lecturer:	Prof. Dr.-Ing. Dipl.-Wirt. Ing. R. Schmetz
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lecture: 2 HPW Practical training: 2 HPW
Workload:	60 h attendance 90 h preparation, review and execution
Credits:	5
Recommended prerequisites:	None
Module Objectives:	After completion of the module students are able to • analyse technical investment planning tasks and recognise restrictions • analyse the present situation of the items or processes which should be replaced or improved, and recognise any weaknesses • search for suitable solutions and improvements • perform technical and economical evaluations of the best solution(s) • perform detailed technical investment plannings of the best solution(s) including calls and searches for offers • discuss results, document them due to a close professional standard and present them to a well-informed audience
Content:	Some real technical investment planning examples from the past and one distinct actual real technical investment planning task are made available to the students. Basic methodical technical investment planning knowledge is taught. Then students do group work to perform analyses of tasks, create requirement and functional specifications, call or search for offers and evaluate technical investment alternatives according to technical and economical, but also ecological points of view. At the end all main results are documented and presented.
Assessment:	Continuous Assessment (rewarded by attestation)
Forms of Media:	Group work, Excursions to the planning items or processes at companies or other locations, Analysis tasks at companies and other locations, Presentation, Whiteboard, Projector
Literature:	1. Course materials and real technical investment planning examples from the past from lecturer 2. Suitable literature depending on the actual project task

2118 Materials inspired by Nature

Module name/Module code:	Materials inspired by Nature	2118
Degree:	Biomaterials Science:	BMS 4 2118
Module coordinator:	Prof. Dr. A. Fahmi	
Lecturer:	Prof. Dr. A. Fahmi	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lecture: Exercise Practical training:	2 HPW 1 HPW 1 HPW
Workload:	45 h attendance 60 h self-study 45 h exam preparation	
Credits:	5	
Recommended prerequisites:	Biochemistry, organic chemistry, inorganic chemistry and biopolymers.	
Module objectives:	Students will be able to: • recognize the most important types of materials inspired by nature • identify structures on different dimensions and length scale • describe natural phenomena based on different interactions between biological components • perform simple synthesis of functional materials by imitating unique characteristics of natural materials	
Content:	• Fundamentals of design and fabrication of materials inspired by nature • Principles of electrospinning materials assembly of macromolecules • Fundamentals of principles of biomineralization • Fundamentals of molecular recognition • Application of self-healing materials in different industry sectors • Introduction into materials self-assembly and self-organization of macromolecules • Introduction into measurement methods for pattern and structure recognition	
Assessment:	Written examination	
Forms of media:	Whiteboard, Projector	
Literature:	1. Wolfgang Pompe, Gerhard Rodel, Hans-Jurgen Weiss, Michael Mertig , ISBN: 978-3-527-41015-6 Bio-Nanomaterials: Designing Materials Inspired by Nature 2. N. Katsube, W. O. Soboyejo, M. Sacks: Functional Biomaterials, 2001, ISBN: 978-0-87849-871-0	

	3. John E. McMurry: Organic Chemistry With Biological Applications 2nd Ed. Brooks/Cole; 2011 4. Sujata V. Bhat, Bhimsen A. Nagasampagi, Meenakshi Sivakumar: Chemistry of Natural Products, 1st ed. Springer 2005

2119 Medical Devices

Module name/Module code:	Medical Devices	2119
Degree	Biomaterials Science:	BMS 4 2119
Module coordinator:	Prof. Dr.-Ing. I. Volosyak	
Lecturer:	Prof. Dr.-Ing. I. Volosyak	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lectures: Practical training:	2 HPW 2 HPW
Workload:	60 h attendance 50 h preparation and review 40 h exam preparation	
Credits:	5	
Recommended prerequisites:	none	
Module objectives:	Students know the fundamentals of electric potential within the human body that can be measured by ECG or EEG for example. They know a selection of sensors supporting different diagnostic processes, by which they are able to select and specify sensor systems for these areas of application. They master basic methods of image processing as used in tomography, for example. The students understand the fundamentals of electrical potentials in the human brain that can be detected with non-invasive and invasive methods. They can derive, from first principles, real architectures for modern Brain-Computer Interfaces. They are aware of the legal and other requirements for medical products and based on this, they are able to estimate which constructive measures are necessary. A brief introduction to implantology allows students to recognise the limits and possibilities of implanting electronic components for supporting sensory and actuatory functions.	
Content:	• The body as an electric system • ECG, EEG • Brain-Computer Interfaces • Sensor systems for medical applications • Introduction to image-processing systems • Requirements for medical products • Implantable electronics	
Assessment:	Written examination	
Forms of media:	Whiteboard, PowerPoint, Projector	
Literature:	1. W. Saltzmann: Biomedical Engineering, Cambridge University Press, 2009, 00/WBK 33	

	2. M. Culjat, Medical Devices: Surgical and Image-Guided Technologies, Wiley, 2013, 00/VUT 13 and online: https://hsb-rhein-waal.digibib.net/search/katalog/record/(DE-1383)EBC947726 3. Ivan Volosyak, Recent advances in VEP-based BCI systems, Shaker, 2019, 00/WBK 115 *Further reading:* 4. G. D. Baura, Medical Device Technologies, Academic Press, 2012, 00/VUT 4 and online (2020): https://hsb-rhein-waal.digibib.net/search/katalog/record/(DE-Elsevier)9780128119846 5. L. Street: Introduction to Biomedical Engineering Technology, 2nd edition, CRC Press, 2011, 00/VUT 9-2 6. J. Enderle: Introduction to Biomedical Engineering, Academic Press, 2011, 00/WBK 56-3 7. R. Northrop: Analysis and Application of analog electronic circuits to biomedical instrumentation, CRC Press, 2012, 00/VUT 10-2 8. J. Wolpaw, E. Wolpaw, Brain-Computer Interfaces: Principles and Practice, Oxford University Press, 2012, 00/TVU33

2120 Recycling and Ecology of Materials

Module Name/ Module code:	Recycling and Ecology of Materials	2120
Degree:	Biomaterials Science:	BMS 5 2120
Course Leader:	Prof. Dr.-Ing. R. Sicking	
Teacher:	Prof. Dr.-Ing. R. Sicking	
Language:	English	
Place in Curriculum	Focus Field Subject	
Teaching Type/SWS:	Lecture: Practical training:	2 HPW 2 HPW
Workload:	60 h Contact 60 h preparation and reading 30 h Revision	
Credits:	5	
Requirements (recommended):	2005 Inorganic Chemistry 2106 Metallic Materials and Testing	
Module Goals:	The students will have knowledge of the recycling cycle beginning from the product development to reuse, recovery and recycling. They will recognise the importance of life-cycle analysis/engineering and that of sustainable product development. The students will develop the ability to critically question the choice of materials depending upon their recyclability. They will recognize mechanical and thermal separation methods including chemical aspects. The students will understand the social meanings of recycling and consider this against material cost and the use of finite resources. This knowledge will be practised through the use of practical examples and exercises; ideally with the use of an excursion to a typical industrial site where the themes are important. With regard to the ecology of materials the students are able to identify ecological aspects for the design of substances and materials. Furthermore they are able to allocate material properties and applicability for the materials. They have knowledge about the ecological compatibility for different materials. The students are able to ecologically evaluate a bio product. The students will participate in the lecture with their own contributions on the different contents and goals.	
Content:	• Motivation • The current legal guidelines (EU regulations) • Use of materials • Life-Cycle Engineering/Analysis • The importance of sustainable use of materials	

	• Basics of recycling technology • Physical separation • Chemical separation • Specifics of the recycling of different materials (metals, polymers, ceramics) • Recycling liquids and gasses • The reuse of materials and its limits • Alternative materials and recycling • Ecological basics for the design with materials and substances • Overview of industrial application of substances with regard to the “objects of protection” air, water, soil • Handling harmfull substances • Methods for pollution-free environment • Basics of product and product-integrated environmental protection • Basics of recycling management and its application • Ecological consequences when using different substances / materials
Examination Method:	oral examination
Media:	Webex/Moodle
Literature:	1. V. Goodship: Management, Recycling and Reuse of Waste Composites; CRC Press, 2010, ISBN-13: 978-1439827659 2. Vincent Rich: The International Scrap and Recycling Industry Handbook, CRC Press, 2001, ISBN-13: 978-1855732483 3. John Scheirs: Polymer Recycling: Science, Technology and Applications, John Wiley & Sons, 1998), ISBN-13: 978-0471970545 4. Matthias Finkbeiner: Towards Life Cycle Sustainability Management, Springer Netherlands, 1st Edition, 2011, ISBN-13: 978-9400718982 5. H. Martens: Recyclingtechnik: Fachbuch für Lehre und Praxis; Spektrum Akademischer Verlag; 2010; ISBN-13: 978-3827426406 6. Publications from several magazines

2121 Material Testing and Failure Analysis

Module name/Module code:	Material Testing and Failure Analysis	2121
Degree:	Biomaterials Science Mechanical Engineering	BMS 5 2121 ME 4 2121
Module coordinator:	Prof. Dr.-Ing. R. Sicking	
Lecturer:	Ph. Sommer M. Sc. (external lecturer)	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lecture: Practical training:	2 HPW 2 HPW
Workload:	60 h attendance 45 h preparation and review 45 h exam preparation	
Credits:	5	
Recommended prerequisites:	2106 Metallic Materials and Testing	
Module objectives:	Students learn the fundamentals of material testing procedures to enable them to select and apply the optimal mechanical or destruction-free testing process after analysis and determination of features of materials. Furthermore, they gain knowledge of different kinds of sample preparation, calibration of devices, examination methods and measurement evaluation. Students will independently conduct different measurement methods (such as spectroscopy, optical and electron microscopy, scattering methods, ultrasound and magnetic particle test and others).	
Content:	Material Testing • Mechanical test methods - Quasi-static test methods: traction, pressure and bend test, test at high temperatures and long periods of exposure (creep) - Dynamic test methods: Charpy impact test • Test method for cyclic deformation: fatigue and fracture development • Destruction-free test methods - Magnetic and electromagnetic test methods - Ultrasound method - Radiographic method • Examination of chemical composition of materials with integral and local solid state method • X-ray diffraction for examining crystal structure • Back scattering electron diffraction for measuring crystal texture • Light microscopic method • Scanning electron microscopy and energy dispersive X-Ray measurements • Transmission electron microscopy	

	• Laser microscopy Failure Analysis VDI 3822 guideline Failure analysis. “Fundamentals and performance of failure analysis.” Fractography (forced fractures, fatigue fractures) Various root causes of failures Design related influences Material related influences Manufacturing related influences Heat treatment faults Wrong conditions of use Exercises on real failed components
Assessment:	Written examination on campus
Forms of media:	Webex/Moodle Practical Training in person (Issum)
Literature:	1. Bunge, H.J., Pöhlandt, K., Tekkaya, A.E., Banabic, D.Banabic, D.; Pöhlandt, Klaus (Eds.): Formability of Metallic Materials, Plastic Anisotropy, Form-ability Testing, Forming Limits, XV, ISBN 978-3-540-67906-6, 2000 2. R. B. Ross: Metallic Materials Specification Handbook, 4th edition, ISBN 978-0412369407, Springer US, 1991 3. E. Hornbogen, G. Eggeler, E. Werner: Werkstoffe: Aufbau und Characteristics von Keramik-, Me-tall-, Polymer- und Verbundwerkstoffen, (Materials: Structure and Features of Ceramic, Polymeric and Composite Materials), 9th completely rev. ed., ISBN 978-3540718574, Springer, 2008 4. George M. Crankovic: Metals Handbook: Materials Characterization, 9th edition, ISBN 978-0871700162, ASM Intl., 1989 5. VDI Guideline 3822:2011 Failure analysis. “Fundamentals and performance of failure analysis” 6. Verein Deutscher Eisenhüttenleute: The Appearance of Cracks und Fractures in Metallic Materials. Verlag Stahleisen 2008

2122 Nanomaterials

Module name/Module code:	Nanomaterials	2122
Degree:	Biomaterials Science:	BMS 5 2122
Module coordinator:	Prof. Dr. A. Fahmi	
Lecturer:	Prof. Dr. A. Fahmi	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lecture: Exercise: Practical training:	2 HPW 1 HPW 1 HPW
Workload:	60 h attendance 45 h self-study 45 h exam preparation	
Credits:	5	
Recommended prerequisites:	none	
Module objectives:	The students will be able to • Describe the fabrication processes and equipment involved in nano-scale technology, nano-materials and nano-devices. • understand the principles of molecular self-assembly and the role of weak non-covalent forces in determining structure, energetics and dynamics in complex molecular sys-tems; • An understanding of methods for producing and characterising nanoparticles and thin films of organic, inorganic and hybrid nanomaterials. • understand phase behaviour, structures and properties of nanopartilces and ordered nanodomains in terms of the principles of nanofabrication; • Hands-on training in synthesising nanomaterials (e.g. nanoparticles, films), nanofabrication and characterisation.	
Content:	• Introduction to Nanomaterials: definition of nanomaterials in compare with bulk. • Classification and properties of nanomaterial: Quantum size effects, Anomalous crystal structure, Physical properties of nanomaterials, Anomalous phase transition, Thermal properties of nano-materials, Charge and quantum transport in nano-materi-als, Chemical Reactivity of the Nanomateri-als. • Nanostructured materials fabrication methods at different dimensions and length scale: different types of nanoparticles, nanowires, nanofibers, nanosheets, thin film and three dimensional structured materials • Nano Scale Synthesis & Fabrication (Top Down And Bottom Up Approach): Self-Assembly: Princi-	

	ples of Self-Assembly, Self-Assembly of Nano materials Lithography: printing and photo/electron techniques. • Nanomaterials Characterization techniques: principle of microscopy, spectroscopy and scattering instrumentation for characterisation of nanomaterials: Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), X-ray Diffraction (XRD) , Atomic Force Microscopy (AFM), Investigation of the Surface Charge Nanomaterials by Zeta-Potential, Nano Tensile Tests, Structural Characterisation of Nanomaterials
Assessment:	Written examination on campus
Forms of media:	Webex/Moodle
Literature:	1. D. Vollath: Nanomaterials: An Introduction to Synthesis, Properties and Applications 2. Guozhong Cao and Ying Wang: Nanostructures and Nanomaterials: Synthesis, Properties, and Applications: Synthesis, Properties, and Applications (2nd Edition) (World Scientific Series in Nanoscience and Nanotechnology) 3. Geoffrey A. Ozin, et al: Nanochemistry

2123 Materials Simulation

Module name/Module code:	Materials Simulation	2123
Degree	Biomaterials Science:	BMS 5 2123
Module coordinator:	Prof. Dr. A. Struck	
Lecturer:	Prof. Dr. A. Struck	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lecture: Exercise:	2 HPW 2 HPW
Workload:	60 h atttendance 60 h self-study 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	none	
Module objectives:	Materials Simulation: • Evaluation of methods for materials simulation on different length and time scales. • Understanding numerical and statistical methods to calculate materials properties from atomistic models	
Content:	• Basics of molecular dynamics • Use and construction of special force fields for molecular dynamics simulation of material properties • Algorithms for solution of coupled differential equations in molecular dynamics • Typical boundary conditions • Effects of microscopic interactions on macroscopic properties • Introduction to Monte-Carlo-methods • Basics of macroscopic materials simulation, mechanical, thermal, electrical characteristics of materials	
Assessment:	Written examination or oral examination	
Forms of media:	Whiteboard, Projector	
Literature:	M. Griebel, S. Knapek, and G. Zumbusch. *Numerical Simulation in Molecular Dynamics*. Springer, Berlin, Heidelberg, 2007 Schlick: Molecular Modeling and Simulation: An Interdisciplinary Guide. 2nd edition. Springer. 2010 Allen, Tildesley: Computer Simulation of Liquids. Oxford University Press. 1989 Kurt Binder:	

	Monte Carlo methods in statistical physics, Springer, Berlin [u.a.] 1979, ISBN 3-540-09018-5, und Applications of the Monte Carlo method in statistical physics, Berlin, Springer 1984, ISBN 3-540-12764-X R. Haberlandt, S. Fritzsche, G. Peinel: Molekulardynamik. Grundlagen und Anwendungen, Vieweg und Teubert Verlag Richard Lesar: Introduction to Computational Materials Science, Cambridge University Press, 2013 (ISBN:9780521845878) Press, Teukolsky, Vetterling, Flannery: Numerical Recipes. 3rd Edition. Cambridge, 2007

2124 Biological Reactions to Materials

Module name/Module code:	Biological Reactions to Materials	2124
Degree:	Biomaterials Science:	BMS 5 2124
Module coordinator:	Prof. Dr. N. Shirtcliffe	
Lecturer:	Prof. Dr. N. Shirtcliffe	
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 Homework 30 h Exam Preparation	
Credits:	5	
Recommended prerequisites:	none	
Module objectives:	This course introduces the responses of the body to implant materials. Students learn which effects can occur and some ways how these can be addressed	
Content:	Immune System Response to Foreign Bodies Vroman Effect Complement Immune System Antibody attack Macrophages Foreign Body Giant Cells Blood Clotting Cascade and its interaction at surfaces	
Assessment:	continuous Assessment	
Forms of media:	Moodle	
Literature:	Biological Interactions on Materials Surfaces Understanding and Controlling Protein, Cell, and Tissue Responses Editors: Puleo, David A., Bizios, Rena (Eds.)	

2511 Technology and Quality Management

Module name:	Technology and Quality Management	2511
Module code:	Biomaterial Sciences:	BMS 7 2511
Module coordinator:	Prof. Dr.-Ing. R. Sicking	
Lecturer:	Dr. J. Lambers (External lecturer)	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Practical training:	2 HPW 2 HPW
Workload:	45 h attendance 75 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	-	
Module objectives:	Students know the essential terms, methods and tools of technology and quality 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. 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 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 Quality management (not quality assurance) • Disambiguation against quality assurance (QA), purpose of QM	

	• DIN ISO 9001 series • Process capability, sigma levels • Six sigma methods (e.g. DMAIC) and basic idea of six sigma approach • APQP (advanced product quality planning) including FMEA • Corporate governance, whistleblowing, (basics only) • Business process management • Quality Function Deployment (House of Quality) • Statistical Process Control Environmental management and occupational health and safety management: • Environmental Management DIN EN ISO 14001 • Work safety BS OSHAS 18001 • Sustainability
Assessment:	Written examination
Forms of media:	Webex/Moodle
Literature:	Technology management: 1. Schuh, G.; Klappert, S.: Technologiemanagement (Technology Management). Springer, 2010 2. Betz, F.: Managing Technological Innovation – Competitive Advantage from Change. 3rd edition, John Wiley & Sons, 2011 Quality management: 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) Further Readings: 9. Burgelmann, R.: Strategic Management of Technology and Innovation. 5th revised edition, McGraw-Hill Higher Education, 2008 10. Arnold, H.; Erner, M.; Möckel, P.; Schläffer, Chr. (Eds.): Applied Technology and Innovation Management. Springer, 2010 11. 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	

2906 FEM and Simulation Methods

Module name/Module code:	FEM and Simulation Methods	2906
Degree:	Biomaterials Science:	BMS 5 2906
Module coordinator:	Prof. Dr.-Ing. H. Schütte	
Lecturer:	Prof. Dr.-Ing. H. Schütte	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lectures: Practical Training:	2 SWS 2 SWS
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Rec. prerequisites:	none	
Module objectives:	Students are able to decide when Finite Element Analyses can be used in a sensible way. They master the theoretical backgrounds and are able to construct suitable calculation models. Hereby, they are able to allow abstractions in a result-oriented manner, to design the simulation process efficiently. Because of their fundamental knowledge of mechanics and physics, students are able to define material characteristics and boundary conditions and to transfer them to finite models. They are able to evaluate models regarding the design of finite elements. Students assess results, present them and evaluate them critically regarding their significance. Students are able to conduct, document, pre- sent and defend calculations independently.	
Content:	• Concept of Finite Element Analysis • Theoretical Background of FEM • Comparison with analytical and numerical methods • Sequence of finite element calculations • element types and shape functions • degrees of freedom and coupling of elements • Linear and non-linear calculations • geometry Clean-up • Preprocessing • Solution • Post Processing • Optimization	
Assessment:	Written examination (homework assignment)	
Forms of media:	Webex/Moodle , ANSYS	
Literature:	H. Lee: Finite Element Simulations With ANSYS Workbench 16, ISBN 978-1585039838 SDC Publication, 2016	

	Erdogan Madenci, Ibrahim Guven: The Finite Element Method and Applications in Engineering Using ANSYS, Corrected and 4th printing, ISBN 978-0-387-28289-3, Springer, 2007