Module Handbook
Nature-Inspired Materials B.Sc.

Kleve, xx.xx.20xx

Content

Study Plan

Modulcode	Modulname	CP	SWS	V	Ü	L	P	Proj	Prüfungsform	
									Testat	Be-notet
Semester 1										
BMS 1 2201	Mathematics 1	6	6	4	2					x
BMS 1 2202	Chemistry of Materials	6	4	Hyb-rid			4			x
BMS 1 2203	Physics and Error Statistics	6	4	2	1	1				x
BMS 1 2204	Fundamentals of Project Management	3	2	1	1				x	
BMS 1 2205	Information competence and scientific working	3	2	1	1				x	
BMS 1 2206	Fundamentals of Business and Management	6	4	3	1				x	
Semester 2										
BMS 2 2207	Mathematics 2	6	6	4	2					x
BMS 2 2208	Organic Chemistry	6	4	2		2				x
BMS 2 2209	Programming for Biomaterials	6	4	2			2			x
BMS 2 2210	Metallic Materials and Testing	6	4	2		2				x
BMS 2 2211	Materials Analysis	6	4	2	1	1				x
Semester 3										
BMS 3 2212	Non-metallic Materials	6	4	2	1		1			x
BMS 3 2213	Chemistry of Biopolymers	6	4	2	1		1			x
BMS 3 2214	Biochemistry	6	4	2			2			x
BMS 3 2215	Physical Chemistry	6	4	2	1		1			x
BMS 3 2216	Personal and Social Competences	6	4	2	2					x
Semester 4										
BMS 4 2217	FEM and Materials Simulation	6	4	2	1	1				x
BMS 4 2218	Corrosion and Surface Chemistry	6	4	2	1		1			x
BMS 4 2219	Materials Technology	6	4	3	1					x
BMS 4 2220	Cell Biology and Microbiology	6	4	3	1					x
	Focus (1)	6	4							x
Semester 5										
BMS 5 2221	Sustainability, Quality and Business Process Management	6	4	2	2				x	
BMS 5 2222	Biocompatible Materials	6	4	2			2			x
BMS 5 2223	Recycling and Ecology of Materials	6	4	2			2			x
	Focus (2)	6	4							x
	Focus (3)	6	4							x
Semester 6										
BMS 6 2224	BMS-Project	5	4			4			x	
	Elective 1	5	4							x
	Elective 2	5	4							x
BMS 6 2225	Internship A	15							x	
Semester 7										
BMS 7 2226	Internship B	15							x	
BMS 7 2227	Bachelor Thesis	12								x
BMS 7 2228	Colloquium	3								x
3 Vertiefungsrichtungen (Focus Fields)										
	Vertiefungsrichtung: *Biomaterials Science with* ***Material Technology***									

BMS 4 2229	(1) Manufacturing Technology and Factory Equipment	6	4							
BMS 5 2232	(2) Material Testing and Failure Analysis	6	4	2			2			
BMS 5 2233	(3) Inorganic and Composite Materials	6	4	2			2			
	Vertiefungsrichtung: *Biomaterials Science with **Management***									
BMS 4 2230	(1) Accounting	6	4	2	2					
BMS 5 2234	(2) General Management	6	4	2			2			
BMS 5 2235	(3) Technology and Innovation Management	6	4	2			2			
	Vertiefungsrichtung: *Biomaterials Science with **Biochemistry***									
BMS 4 2231	(1) Biotechnology and Biodegradable Materials	6	4							
BMS 5 2236	(2) Supramolecular Chemistry and Materials	6	4	2	1		1			
BMS 5 2237	(3) Smart Functional Materials	6	4	2			2			
Wahlfächer (Electives)										
BMS 6 2241	Research-Project	6	4							
BMS 6 2242	Nanomaterials	6	4	2	1	1				
BMS 6 2243	Materials inspired by nature	6	4	2	1	1				
BMS 6 2244	Medical devices	6	4	2			2			
BMS 6 2245	Numerical Mathematics	6	4	2	2					
BMS 6 2246	Foreign Language	6	4							

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
L	Labor / Laboratory
Pra	Praktikum / practical work
Pro	Projekt / project
WSx	Wintersemester / winter semester
SSx	Sommersemester / summer semester

Dependencies

	Recommended	Requires	Required by
Semester 1			
Mathematics 1	Highschool Mathematics: Algebra, Exponential function and Logarithm, Trigonometry	-	Physical Chemistry; Non-metallic Materials; FEM and Materials Simulation
Chemistry of Materials	-	-	Chemistry of Biopolymers; Biochemistry
Physics and Error Statistics	-	-	Physical Chemistry; Material Technology; Manufacturing Technology and Factory Equipment
Fundamentals of Project Management	-	-	Manufacturing Technology and Factory Equipment
Information competence and scientific working	-	-	Personal and Social Competence
Fundamentals of Business and Management	-	-	Sustainability, Quality and Business Process Management; Technology and Innovation Management
Semester 2			
Mathematics 2	Mathematics 1	-	FEM and Materials Simulation
Organic Chemistry	General Chemistry; Chemistry of Materials	-	Cell Biology and Microbiology; Smart Functional Materials
Programming for Biomaterials	Physics and Error Statistics	-	FEM and Materials Simulation
Metallic Materials and Testing	Chemistry of Materials	-	Recycling and Ecology of Materials; Corrosion and Surface Chemistry; Materials Technology; Biocompatable Materials; Materials Testing and Failure Analysis
Materials Analysis	Chemistry of Materials	-	Recycling and Ecology of Materials
Semester 3			
Non-metallic Materials	Organic Chemistry or Chemistry of Materials	-	Biocompatable Materials; Inorganic and Composite Materials
Chemistry of Biopolymers	Organic Chemistry	Chemistry of Materials	
Biochemistry	Organic Chemistry	Chemistry of Materials	Cell Biology and Microbiology; Biocompatible Materials;
Physical Chemistry	Mathematics 2	Mathematics 1; Physics and Error Statistics	Smart Functional Materials
Personal and Social Competences	-	-	General Management
Semester 4			
FEM and Materials Simulation	Physics and Error Statistics	Mathematics 1; Mathematics 2; Programming for Biomaterials	
Corrosion and Surface Chemistry	Physical Chemistry	Metallic Materials and Testing	
Materials Technology	Non-metallic Materials; Materials Analysis	Physic and Error Statistic; Metallic Materials and Testing	
Cell Biology and Microbiology	xxx	xxx	

Focus (1)	Chemistry of Biopoly-mers; Biochemistry	Organic Chemistry	
Semester 5			
Sustainability, Quality and Busi-ness Process Management	-	Fundamentals of Business and Management	
Biocompatible Materials	Organic Chemistry	Biochemistry; Metallic Materials and Testing; Non-metallic Materials	
Recycling and Ecology of Materi-als	Non Metallic Materials; Material Analysis	Metallic Materials and Testing	
Focus (2)		See below	
Focus (3)		See below	
Semester 6			
BMS-Project		Credit point minimum: 60	
Elective 1		As elective	
Elective 2		As elective	
Internship A		Credit point minimum: 90	
Semester 7			
Internship B		Credit point minimum: 90	
Bachelor Thesis		Credit point minimum: 175	
Colloquium		Thesis	
3 Vertiefungsrichtungen (Focus Fields)			
Vertiefungsrichtung: Biomaterials Science with Material Technology			
(1) Manufacturing Technology and Factory Equipment	-	Project Management; Physics and Error Statistics	
(2) Material Testing and Failure Analysis	Metallic Materials and Testing	Fundamentals of Business and Management	
(3) Inorganic and Composite Ma-terials	Metallic Materials and Testing, Non-metallic Ma-terials	Biochemistry	
Vertiefungsrichtung: Biomaterials Science with Management			
(1) Accounting	Material Analysis	Metallic Materials and Testing	
(2) General Management	-	Personal and Social Compe-tences	
(3) Technology and Innovation Management	-	Organic Chemistry; Chemistry of Biopolymers	
Vertiefungsrichtung: Biomaterials Science with Biochemistry			
(1) Biotechnology and Biodegra-dable Materials	Material Analysis	Non-metallic Materials	
(2) Supramolecular Chemistry and Materials	-	Fundamentals of Business and Management	
(3) Smart Functional Materials	Metallic Materials and Testing; Non-metallic Ma-terials	Organic Chemistry; Physical Chemistry	

Modules

Semester 1

Mathematics 1			
Module name	Mathematics 1		
Module code	BMS 1 2201		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr. Achim Kehrein		
Lecturer	Prof. Dr. Achim Kehrein Prof. Dr. A. Struck		
Language	English		
Part of focus field	Core		
Credits	6		
Workload	180 h	Preparation and Review	90 h
		Attendance	90 h
HPW	6	Lecture	4
		Exercise	2
Prerequisites	Required: - Recommended: Highschool Mathematics: Algebra, Exponential function and Logarithm, Trigonometry		
Module objectives	Students will be able to … • gain knowledge in various ways and learn to organize their work • understand basic mathematical concepts • know how to apply standard mathematical methods • visualize mathematical objects • interpret mathematical symbols and formulas • learn to think, to work and to express themselves with precision • acquire a feeling for handling numbers • possess the skills to solve problems on their own and to verify the solutions • apply numerical as well as graphical solution methods to various tasks • 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 differentiation, tangent, Newton's method, monotonicity and concavity • Integral calculus: inversion of differentiation – indefinite integral, area calculation – definite integral, • Fundamental Theorem of Calculus		
Assessment	Lecture: Written examination Exercise: Attestation		

Literature/ Resources	• James Stewart (2011). *Calculus. Metric International Version.* 7th edition. Brooks/Cole • James Stewart, Lothar Redlin, Saleem Watson (2012). *Algebra and Trigonometry*. 3rd international edition. Brooks/Cole [to catch up on high school mathematics] • Rhine-Waal Moodle Course “Preparatory Course: Mathematics”

Chemistry of Materials			
Module name	Chemistry of Materials		
Module code	BMS 1 2202		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Neil Shirtcliffe		
Lecturer	Prof. Dr. Neil Shirtcliffe		
Language	English		
Part of focus field	Core		
Credits	6		
Workload	180 h	Attendance	60 h
		Self-study	90 h
		Exam Preparation	30 h
HPW	4	Lecture/Practical	4
Prerequisites	Required : - Recommended: -		
Module objectives	Students will be able to … • Describe the basic chemistry of the elements and compounds. • Understand basic Molecular Orbital theory • Carry out a range of practical skills safely • Write a Lab book		
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) • Structure and Bonding Using a variety of experiments to learn skills • Labbook writing • Weighing and measuring • Filtering • Purification • Titration • chromatography		
Assessment	Experimental write-ups/Labbook Written examination		
Literature/ Resources	• Chemistry (7th Edition) by John E. McMurry, Robert C. Fay , et al. | Jan 10, 2015 • John E. McMurry, Robert C. Fay: General Chemistry: Atoms First, Prentice Hall; 2009 • https://openstax.org/details/books/chemistry-2e		

Physics and Error Statistics			
Module name	Physics and Error Statistics		
Module code	BMS 1 2203		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Alexander Struck		
Lecturer	Prof. Dr. Alexander Struck, Prof. Dr. Georg Bastian		
Language	English		
Part of focus field	Core		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	2
		Exercise	1
		Practical	1
Prerequisites	Recommended: - Required: -		
Module objectives	Students are able to … • know how to work with quantities, units and measures • can assess uncertainties in measurements • have experienced how to come from observations to mathematical interpretation of fundamental laws of nature • are able to report experimental and theoretical findings in a proper way.		
Content	• Units and Quantities, SI and IUPAP norms • Kinematics • Forces, Newton postulates • Work, Energie, Power • Conservation laws • Rotatory motion, moment of inertia, pseudoforces • Oscillations and Resonance • Waves • Doppler effect • Current, voltage, resistance and fundamental circuits • Fundamental Optics • Blackbody radiation		
Assessment	Graded exam		
Literature/ Resources	• Tipler, P.: Physics for Scientists and Engineers • Gehrtsen, C. : Physics • Feynman, R. : The Feynman lectures in Physics, Vol. 1		

Fundamentals of Project Management			
Module name	Fundamentals of Project Management		
Module code	BMS 1 2204		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Dirk Berndsen		
Lecturer	Prof. Dr. Dirk Berndsen		
Language	English		
Part of focus field	Core		
Credits	3		
Workload	90 h	Attendance	30 h
		Preparation and Review	60 h
HPW	2	Lecture	1
		Exercise	1
Prerequisites	Recommended: - Required: -		
Module objectives	Students are able to … • know the essential terms, methods and tools of q project management • understand and appreciate the need for project planning • be able to distinguish between project objectives and functional goals, and be able to define and document the objectives of a given project • be able to design a suitable project structure and plan of execution, for different types of given projects, with particular emphasis on product development projects • understand project risks and can come up with rough estimates of those risks using a given set of tools • evaluate given project execution based on a set of pre-defined project performance criteria • be able to communicate and document project results by creating informative target group oriented presentations		
Content	• Projects as the dominant mode of collaborative work in current business environments • Comparison of project and line management • Typical challenges of project management • Different types and contents of projects – project goals and scoping • Project phases • Developing project objectives (SMART) • Documentation: brief description of the project, project proposal • Project organization and roles (PMOs, steering committees, project teams • Embedding projects with existing organizations – continuous project management • Stakeholders • Project planning • Milestones and activities • Project structure plan • Network Techniques • Critical Path Method (CPM) • Programme Evaluation and Review Technique (PERT) • Risk Management		

	• Principles of risk mitigation • Continuous risk assessment • Change management within a given project • Agile project management approaches • Project Documentation and Reports • Reports for different recipients • Planning of project meetings • Stakeholder managements, handling individual expectations and project performance perceptions • Results presentation and discussion
Assessment	Lecture: Written individual attestation, presence only (1h) Exercises: Continuous Assessment, recorded individual participation
Literature/ Resources	• Hayden, Jack (2023): Project Management Mastery: A Comprehensive Guide To Successfully Implementing The Core Principles Of Project Planning And Scope Management From Concept To Completion. London, EB Publishing, ISBN 978-1916726024 • Nieto-Rodriguez, Anthony (2021): Harvard Business Review Project Management Handbook: How to Launch, Lead, and Sponsor Successful Projects. Cambridge, Mass, Harvard Business Review Press, ISBN 978-1647821258 • Project Management Institute (2021): A Guide to the Project Management Body of Knowledge (PMBOK Guide), 7th edition, The Project Management Institute, ISBN 978-1628256642

Information competence and scientific working			
Module name	Information competence and scientific working		
Module code	BMS 1 2205		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	N.N.		
Lecturer	Prof. Dr. Andreas von Bubnoff		
Language	English		
Part of focus field	Core		
Credits	3		
Workload	90 h		
HPW	2	Lecture	1
		Exercise	1
Prerequisites	Recommended: - Required: -		
Module objectives	Students will be able to … • understand the philosophical underpinnings of how scientists generate reproducible and reliable knowledge, and how to assess differences in the quality of scientific studies in terms of study design • assess challenges to the quality of scientific information (such as the reproducibility problems, confirmation and publication bias, poor experimental design, p-hacking, and predatory journals) • understand how science is communicated to fellow scientists and to the public and how academic communication differs from non-academic science communication • understand challenges to accurate science communication among scientists and from scientists to the public and learn strategies how to overcome them		
Content	At its core, scientists, engineers and science communicators have the same goal: They want to know the truth about the world and accurately communicate it to others. This module teaches how to keep the research reliable and how to communicate these findings without getting things wrong.		
Assessment	Attestation: Continuous Assessment		
Literature/ Resources	• Hume, D. (1748): An enquiry concerning human understanding • Russell, B. (1946/2004): History of Western Philosophy • Popper, K. (1959): The Logic of Scientific Discovery • Snow, CP (1959): The Two Cultures and the Scientific Revolution • Kuhn, T.S. (1962): The Structure of Scientific Revolutions • von Bubnoff, A. (2007): Numbers Can Lie (LA Times) • Nuzzo, R. (2014): Scientific Method: Statistical errors. • von Bubnoff, A. (2016): Experimental Quality • Giuseppe Biondi-Zoccai, ed. (2016): Umbrella Reviews: Evidence Synthesis with Overviews of Reviews and Meta-Epidemiologic Studies • Harris, R. (2017): Rigor Mortis: How Sloppy Science Creates Worthless Cures, Crushes Hope, and Wastes Billions • Montgomery, S.L. (2017): The Chicago Guide to Communicating Science • Pinker, S. (2021): Rationality.		

Fundamentals of Business and Management			
Module name	Fundamentals of Business and Management		
Module code	BMS 1 2206		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr. Dirk Berndsen		
Lecturer	Prof. Dr. Dirk Berndsen		
Language	English		
Part of focus field	Core		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	3
		Exercise	1
Prerequisites	Recommended:- Required: -		
Module objectives	Students are able to … • know and understand fundamental economic concepts and relationships in local, national and global market environments • be able to identify key economic actors, understand their interests, and their means of influencing market outcomes, with a focus on business • have a basic understanding of macroeconomic models and economic policy proposals based on them, as well as non-economic societal goals • understand the makeup of different business models and can recognize the strategic rationales for various types of observable business behaviour • acquire a good initial overview and insight into the environment and inner workings of a business organization, focused on manufacturing firms • understand the financing needs of different types of business, and know the most common ways to address them • understand how the performance of an enterprise can be measured and reported • know the basic structure and contents of standard financial reports (Balance Sheets, Income and Cash Flow Statements) as well as non-financial stakeholder reporting • 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 • can make basic evaluations of a business' performance and sustainability based on information gathered from various reports		
Content	• Markets – participants, structures, market typology and market influences • Decision making in markets, market outcomes and externalities • Economic policy – goals, select types of state interventions and their evaluation • Definition and roles of a business • Business models (with special emphasis on manufacturing firms) and value creation • Business objectives, strategy, sustainability and stakeholder impact • Legal environment and legal setups		

	• Financing the business – key concepts, basics of corporate performance management • Financial statements - balance sheet, income statement, statement of cash flow • Non-financial reporting (i.e. CSR,EIA), codes of conduct and compliance • Overview business organization, functions and processes • 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 • End-to-end business performance assessment (sustainability) and improvements management
Assessment	Lecture: Written examination, presence only
Literature/ Resources	• Grayson, David / Coulter, Chris / Lee, Mark (2022): The Sustainable Business Handbook: A Guide to Becoming More Innovative, Resilient and Successful. ISBN 978-1398604049, Kogan Page • Nickels, William G. / McHugh, James / McHugh, Susan (2021): Understanding Business. 13th edition, ISBN 978-9814670371, McGraw-Hill • Pride, William M. / Hughes, Robert / Kapoor, Jack R. (2022): Foundations of Business, 7th edition. ISBN 978-0357717943, Cengage Learning • Osterwalder, Alexander et al. (2015): Value Pro-position 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

Semester 2

Mathematics 2			
Module name	Mathematics 2		
Module code	BMS 2 2207		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr. Achim Kehrein		
Lecturer	• Prof. Dr. Achim Kehrein • Prof. Dr. Alexander Struck		
Language	English		
Part of focus field	Core		
Credits	6		
Workload	180 h	Attendance	90 h
		Preparation and Review	90 h
HPW	6	Lecture	4
		Exercise	2
Prerequisites	Required: - Recommended: Mathematics 1		
Module objectives	Students are able to … • understand mathematical concepts and methods beyond high-school level, in particular, matrices, infinite series, multivariate functions, and ordinary differential equations • practice to communicate in precise mathematical terms and their problem-solving skills		
Content	• Integral calculus: substitution rule, integration by parts, partial fraction decomposition, improper integrals • 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		
Assessment	Lecture: Written examination Exercise: Attestation		
Literature/ Resources	• James Stewart (2016): *Calculus*. Metric International Version. 8th edition. Brooks/Cole • [Video Lectures] Mattuck, Arthur, Haynes Miller, Jeremy Orloff, and John Lewis. *18.03SC Differential Equations,Fall 2011*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed 08 May, 2013). License: Creative Commons BY-NC-SA • [Video Lectures] 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

Organic Chemistry			
Module name	Organic Chemistry		
Module code	BMS 2 2208		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Neil Shirtcliffe		
Lecturer	Prof. Dr. Neil Shirtcliffe		
Language	English		
Part of focus field	Core		
Credits	6		
Workload	180	Attendance	60 h
		Self-study	90 h
		Exam preparation	30 h
HPW	4	Lecture	2
		Practical	2
Prerequisites	Required: - Recommended: General Chemistry, Chemistry of Materials		
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 • plan and carry out simple organic synthesis in a laboratory • understand some of the analytical techniques required in organic chemistry		
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 • Nucleophilic Substitution SN1 and 2 • Elimination • Addition to double bonds • Substitution to aromatics • Oxidation and Reduction • Carbonyl Chemistry Analytical Chemistry • Infrared		

	• NMR • MP and RI
Assessment	Written examination
Literature/ Resources	• John E. McMurry: Organic Chemistry 9th Ed. Brooks/Cole; 2015; (10th Edition Open Online https://openstax.org/details/books/organic-chemistry) • David J, Hart, Christopher M. Hadad, Lesli E. Craine, Harold Hart: Organic Chemistry 13th Ed. Brooks/Cole; 2011

Programming for Biomaterials			
Module name	Programming for Biomaterials		
Module code	BMS 2 2209		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Matthias Krauledat		
Lecturer	• Prof. Dr. Matthias Krauledat • Prof. Dr. Ronny Hartanto • Prof. Dr. Georg Bastian		
Language	English		
Part of focus field	Core		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	2
		Practical	2
Prerequisites	Required: - Recommended: Physics and Error Statistics		
Module objectives	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 • assess similarities and differences between different programming languages		
Content	Algorithmic Concepts • Input and Output • Recursion and Iteration Program structures in high-level programming languages such as Python • Syntax and Semantics • Expressions and statements • Variables, lists and tuples • Operators • Data Visualization • Basic Control flow: Conditional statements, Loops • Program structures: scripts and functions • Recursion • Objects • Getting started in other programming languages		
Assessment	Lecture: Written examination Practical Training: Attestation		
Literature/ Resources	• James R. Parker (2021) “Python. An Introduction to Programming”. 2nd edition. Mercury Learning & Information. • Magnus Lie Hetland (2017) “Beginning Python: From novice to professional”. 3rd edition. New York: Apress • Mark Lutz (2011) “Programming Python”. 4th edition. O’Reilly • John V Guttag (2013) “Introduction to computation and programming using Python”. MIT Press		

Metallic Materials and Testing			
Module name	Metallic Materials and Testing		
Module code	BMS 2 2210		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr.-Ing. Raimund Sicking		
Lecturer	Prof. Dr.-Ing. Raimund Sicking		
Language	English		
Part of focus field	• Biomaterials Science (B.Sc.): Core • Science and Engineering (B.Sc.): Product Creation		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	2
		Practical	2
Prerequisites	Required: - Recommended: Chemistry of Materials		
Module objectives	Students will be able to … • define and draw crystal structures and different classes of metals • explain crystal defects and their role for plastic deformation 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 • consider the main corrosion phenomena		
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 including metallographic preparation • Jominy test and displacive transformation (martensite formation) in steels • Classification of steels In addition specific application examples are presented.		

Assessment	Lecture: Written examination Lab: Lab reports
Literature/ Resources	• M. F. Ashby, D. R. H. Jones: Engineering Materials 2 – An Introduction to Microstructures and Processing, 4th ed., 2013, ISBN-13 978-0-08-096668-7 • D. R. Askeland, W. J. Wright: The Science and Engineering of Materials, enhanced 7th edition, 2022, ISBN 978-0-357-44786-4 • G. Gottstein: Physical Foundations of Materials Science, 1st Edition, 2004, ISBN 978-3-642-07271-0 • Bunge, H.J., Pöhlandt, K., Tekkaya, A.E., Banabic, D.; Pöhlandt, Klaus (Eds.): Formability of Metallic Materials, Plastic Anisotropy, Formability Testing, Forming Limits, XV, 2000, ISBN 978-3-540-67906-6 • Y. Leng, Materials Charakterization – Introduction to Microscopic and Spectroscopic Methods, 2nd ed., 2013, ISBN 978-3-527-33463-6 • V. John, Testing of Materials, 1st ed., 1992, ISBN 978-0-333-56814-9

Materials Analysis			
Module name	Materials Analysis		
Module code	BMS 2 2211		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr. Christoph Heß		
Lecturer	Prof. Dr. Christoph Heß		
Language	English		
Part of focus field	• Biomaterials Science (B.Sc.): Core • Science and Engineering (B.Sc.): Product Creation		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	2
		Exercise	1
		Practical	1
Prerequisites	Recommended: Chemistry of Materials Required: -		
Module objectives	Students are able to … • understand the scientific principles which important test methods for materials are based on • understand and explain important test methods for materials and identify appropriate test methods for a given analytical task • apply gained theoretical skills practically in laboratory environment by properly running a variety of tests on different materials with the help of appropriate analytical equipment • consider specific German, European and global standards for the analytical task in focus		
Content	• Metallographic sample preparation: grinding, etching, polishing, phase identification • Mechanical testing: tensile, compression, bending, hardness, toughness, creep, fatigue • Non-destructive test methods: eddy current, ultrasound, surface inspection systems (SIS), roughness • Spectroscopy: FT-IR, Raman, UV-VIS, XPS, XRF, EDX, Auger, OES • Thermal, thermomechanical and rheological analysis: DSC, TGA, HDT, VICAT, MFI, MVR • Microscopy: Optical, SEM, TEM, AFM • German, European and global test standards		
Assessment	Lecture: Written examination Exercise: Attestation Practical Training: Reports		
Literature/ Resources	• Callister W.D.: Materials Science and Engineering - An Introduction • Brooks C.: Failure Analysis of Engineering Materials		

	• Ohser J., Mücklich F.: Statistical Analysis of Microstructures in Materials Science • Grellmann W., Seidler S.: Polymer Testing

Semester 3

Non-metallic Materials			
Module name	Non-metallic Materials		
Module code	BMS 3 2212		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr. Christoph Heß		
Lecturer	Prof. Dr. Christoph Heß		
Language	English		
Part of focus field	• Biomaterials Science (B.Sc.): Core • Science and Engineering (B.Sc.): Product Creation		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	90 h
		Exam Preparation	30 h
HPW	4	Lecture	2
		Exercise	1
		Practical	1
Prerequisites	Required: - Recommended: Organic Chemistry or Chemistry of Materials		
Module objectives	Students are able to … • specify basic chemical structures of polymers, ceramics and glasses • conclude on characteristic properties of polymers, ceramics and glasses from the respective structure • select suitable materials for a given application task • modify specific properties of a material by adjustment of its formulation or processing parameters • understand and explain the most important processing technologies for non-metallic materials • select appropriate processing technologies for a given product application • consider process-induced changes of material properties and evaluate process limitations • assess processing methods in regard of product quality and economic efficiency		
Content	• Thermoplastic and thermosetting polymers • Physical properties of ceramics and glasses: Hardness, strength, thermal properties • Fundamentals of polymer processing: Material flow, processing equipment, products, recycling, disposal • Fundamentals of polymer compounding: Twin screw extrusion, blending, additives, fillers • Processing technologies for polymers: Profile extrusion, injection molding, blown film extrusion, sheet film extrusion, blow molding, thermoforming, compression molding, resin infusion, resin transfer molding • Ceramic process, sintering of materials		

	• Processing of glass and glass-ceramics • Rapid prototyping • Process-induced changes of material: Orientation, degradation, shrinking, anisotropic properties • Fundamentals of rheology: Newtonian and non-Newtonian fluids, viscoelasticity, dynamic mechanical analysis (DMA), storage and loss modulus
Assessment	Lecture: Written examination Exercise: Attestation Practical Training: Reports
Literature, Resources	• Rosen S. L.: Fundamental Principles of Polymeric Materials. • Halary J. L., Laupretre F., Monnerie L.: Polymer Materials: Macroscopic Properties and Molecular Interpretations. • Callister W. D.: Materials Science and Engineering: An Introduction. • Gedde U. W., Hedenqvist M. S., Hakkarainen M., Nilsson F., Das O.: Applied Polymer Science. • Ehrenstein G., Pongratz S.: Resistance and Stability of Polymers, Vols. 1 and 2. • Munz D., Fett T.: Ceramics – Mechanical Properties, Failure Behaviour, Materials Selection. • Carter C.B., Norton M. G.: Ceramic Materials - Science and Engineering.

Chemistry of Biopolymers			
Module name	Chemistry of Biopolymers		
Module code	BMS 3 2213		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Neil Shirtcliffe		
Lecturer	N.N.		
Language	English		
Part of focus field	Core		
Credits	6		
Workload	180 h	Attendance	60 h
		Self-study; Homework	90 h
		Exam Preparation	30
HPW	4	Lectures	2
		Exercise	1
		Practical	1
Prerequisites	Required: Chemistry of Materials Recommended: Organic Chemistry		
Module objectives	Students are able to … • employ principle concepts and terms of macromolecular chemistry • recognize the most important types of synthetic polymers • derive suitable synthesis strategies • estimate the importance of polymers in daily life • compare the advantages and disadvantages of the different methods of polymer analysis • perform simple polymer synthesis in laboratory scale • study the different gels and other associative structures that can exist • consider the rheology of polymers from simple solutions (capillary viscometer) to melt rheology (only a small introduction to this theme)		
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 5 Physical chemistry of polymers including “simple” rheology		
Assessment	Written digital examination, Lab reports		
Literature/ Resources	Paul C. Hiemenz, Timothy P. Lodge: Polymer Chemistry 2nd ed. CRC-Press 2007		

Biochemistry			
Module name	Biochemistry		
Module code	BMS 3 2214		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Lily Chambers		
Lecturer	Prof. Dr. Lily Chambers		
Language	English		
Part of focus field	Core		
Credits	6		
Workload	180 h	Attendance	60 h
		Self-study, Preparation and Review	90 h
		Exam Preparation	30 h
HPW	4	Lecture	2
		Practical	2
Prerequisites	Required: Chemistry of Materials Recommended: Organic Chemistry		
Module objectives	Students are able to … • understand the core chemistry and biology that occurs within a cell to facilitate basic understanding of the living processes at a molecular level • obtain an in-depth knowledge of the structure and functions of amino acids, carbohydrates, lipids and nucleic acids • gain a deeper understanding of the biochemical nature of biomolecules and how they interact with each other, simple cellular reactions and the generation of energy for cellular activity along with communication and coordination between and within cells		
Content	• 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 large macromolecules such as proteins, carbohydrates, lipids, nucleic acids. • Structure and function of biological membranes and transport. • Biosignalling and the evolution of cell signals • It introduces the mechanism of enzymatic catalysis and regulation and their health and biotechnological implications such as food preservation		
Assessment	Written examination		
Literature/ Resources	• Lehninger: Principles of Biochemistry; • Donald Voet, Judith G. Voet: Biochemistry		

Physical Chemistry			
Module name	Physical Chemistry		
Module code	BMS 3 2215		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Neil Shirtcliffe		
Lecturer	Prof. Dr. Neil Shirtcliffe		
Language	English		
Part of focus field	Core		
Credits	6		
Workload	180 h	Lecture	60 h
		Self-study	90 h
		Exam Preparation	30 h
HPW	4	Lecture	2
		Exercise	1
		Practical	1
Prerequisites	Required: Mathematics 1, Physics and Error Statistics Recommended: Mathematics 2		
Module objectives	Students are able to … • understand the core kinetics and thermodynamics and will be able to describe and use the basic forms of optical spectroscopy		
Content	<u>Physical Chemistry</u>: • Material Structure Atoms, Elements and bonding <u>Types of chemical bond:</u> • 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 <u>Introduction to chemical thermodynamics:</u> • Gibbs Free energy • Relationships between enthalpy, entropy • Thermodynamic and Kinetic control <u>Introduction to Kinetics:</u> • Reaction rate • Rate laws • Activation energy, rate of reaction • Diffusion <u>Physical Chemistry of Colloids:</u> • Surface energy • Interparticle forces • Double layer <u>Spectroscopy:</u> • Basics • Basic quantum mechanics • Optical spectroscopy • Elemental analysis (not the ones in OC)		
Assessment	Written examination		

Literature/ Resources	• Peter Atkins, Julio de Paula, Physical Chemistry, 12th ed. Oxford University Press, 2018. • John E. McMurry, Robert C. Fay: General Chemistry: Atoms First, Prentice Hal, 2009.

Personal and Social Competences			
Module name	Personal and Social Competences		
Module code	BMS 3 2216		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Dipl.-Kffr. (FH) Anja Viermann		
Lecturer	Dipl.-Kffr. (FH) Anja Viermann		
Language	English		
Part of focus field	All		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	2
		Exercise	2
Prerequisites	Required: - Recommended: -		
Module objectives	Students are able to … • develop and expand a framework of personal and social competencies and to make them aware of the need for continuous, lifelong further personal development in this field. Core competencies that form an important basis for employability and success in any future professional context as an individual or as a member of a team or organization		
Content	<u>Social Competence:</u> Communication Competence: • "The First impression" • Filters forming perception, thinking, reactions and behaviour • Active Listening & Levels of Communication • Basic insights: Negotiation, Dealing with conflicts, presentation techniques Cooperation Competence: • Teamwork: Team Roles & Team Process • First insights into methods of Facilitation Diversity & Intercultural Competence: • Human nature dealing with differences • Impact and potential of diversity; incl. bias effects • Diversity in organizational and business context • Term and nature of 'CULTURE'; culture building processes • Impact of culture on any form of human group forming process as common base of collective values & beliefs, thinking, perception and (re)action patterns and rules (Group, Organizational and National Culture) <u>Personal Competence:</u> Self-Competence • Mindfulness • Self-awareness - Self- reflection; incl. dealing with feedback • Dealing with stress Flexibility & Adaptability Competence • Change: human mechanisms & coping strategies		

	• Adaptation to different roles, responsibilities, and context and change priorities and direction, if needed • Ambiguity tolerance Creativity & Innovation Competence • Term and importance of creativity & innovation • Repertoire of methods and strategies that support creative processes and know-how and to build a supportive work environment and innovative climate to make best use of creative potentials. Analytical & Critical Thinking • Exploring, application and critical reflection on scientific models, concepts and approaches (e.g. Hofstede: Cultural Dimensions, Oberg: Cultural Shock Model). • Adopt systemic thinking by exploring and integrating different perspectives and interdependencies Integrity and Work Ethics • Appreciate transparency, honesty and work ethic and apply them in relationships and in their own work • Admit faults and seek guidance if needed • open-minded and accountable for own actions • Be reliable and trustworthy • motivation and commitment to task
Assessment	Attestation: • Active participation in learning & "experiential spaces" in classroom in presence (attendance) 50% • Working in diverse team on semester assignments (partly outside of class): preparation, submission written assignment (term paper); presentation in class (50%)
Literature/ Resources	• Hofstede, Geert et al.: Cultures and Organizations; Software of the Mind, 2010, Mcgraw-Hill. • Trompenaars, Fons: Riding the Waves of Culture, 2012, BrealeyPublishing. • Lewis, Richard: When cultures collide – Leading across cultures, 2006, Brealey Publishing. • De Bono, Edward: Serious Creativity, 2015, Vermilion // TradePaperback. • Keeley, Larry Ten Types Of Innovation, 2013, Wiley. • Michalko, Michael: Thinkertoys, 2006,Ten Speed Press. • Wolff, Jurgen: CREATIVITY NOW, 2012, Pearson International. • Van Aerssen, B. et al: The Innovator's Dictionary, 2018, Vahlen • Von Oech, Roger: A Kick In The Seat Of The Pants, 1986, Warner Books. Supplemental readings, e.g. additional literature, exercises, cases and other learning materials will be provided during class

Semester 4

FEM and Materials Simulation			
Module name	FEM and Materials Simulation		
Module code	BMS 4 2217		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Alexander Struck		
Lecturer	Prof. Dr. Alexander Struck		
Language	English		
Part of focus field	Core		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	2
		Exercise	1
		Practical	1
Prerequisites	Required: Mathematics 1, Mathematics 2, Programming for Biomaterials Recommended: Physics and Error Statistics		
Module objectives	Students are able to … • have an overview of simulation methods for materials science • assess simple simulation problems on different time and length scales • operate important software tools		
Content	• Introduction to modelling and simulation in materials science • Microscopic simulations: Molecular dynamics • Lattice methods for fluid simulations • Macroscopic Simulations: Transport equations, partial differential equations • Introduction to finite element /finite volume simulations of solids and mechanical properties		
Assessment	Graded exam		
Literature/ Resources	*(tba)*		

Corrosion and Surface Chemistry			
Module name	Corrosion and Surface Chemistry		
Module code	BMS 4 2218		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Neil Shirtcliffe		
Lecturer	Prof. Dr. Neil Shirtcliffe		
Language	English		
Part of focus field	Core		
Credits	6		
Workload	180 h	Attendance	60 h
		Self-study	90 h
		Exam preparation	30 h
HPW	4	Lecture	2
		Exercise	1
		Practical	1
Prerequisites	Required: Metallic Materials and Testing Recommended: Physical Chemistry		
Module objectives	Students are able to … • identify and use some electrochemical methods, CV, EIS… • identify different corrosion modes • consider some specific materials problems related to corrosion and surface chemistry and understand the challenges in the choice of material. • understand the relations between surface chemistry, electrochemistry and colloid chemistry • consider some ways in which to analyse complex materials, colloids and corrosion.		
Content	• How corrosion happens, driving forces and modes. • Growth of nanocrystals and particles • Electrochemistry • Interfacial energy • Electrical Double layer • Properties of colloids, such as particle size, stability, rheology and Zeta potential. • Measuring the properties of colloids • Surface agents in relation to all these aspects (corrosion inhibitors, particle stabilisers, growth modifiers)		
Assessment	Written or oral examination		
Literature/ Resources	• Corrosion Science and Engineering Pietro Pedeferri (https://doi.org/10.1007/978-3-319-97625-9) • Corrosion and Corrosion Control Revie and Uhlig Wiley • Introduction To Modern Colloid Science (Oxford Science Publications) Paperback – Illustrated, 17 Feb. 1994 Robert Hunter		

Materials Technology			
Module name	Materials Technology		
Module code	BMS 4 2219		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr.-Ing. Raimund Sicking		
Lecturer	Prof. Dr.-Ing. Raimund Sicking		
Language	English		
Part of focus field	• Biomaterials Science (B.Sc.): Core • Science and Engineering (B.Sc.): Product Creation		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	3
		Exercise	1
Prerequisites	Required: Physic and Error Statistic, Metallic Materials and Testing Recommended: Non-metallic Materials, Materials Analysis		
Module objectives	Students are able to … • give an overview of the value creation chain from raw material to the final product for aluminium and steel • know the most important manufacturing processes for semi-finished metals like casting, rolling and extrusion • show the link between process, microstructure and macroscopic properties and can select a process accordingly • explain the primary forming by powder metallurgy and sintering of ceramics • understand special demands to materials for mobility applications including light weight constructions • analyse some special cases in which various materials are used together to attain the properties required • distinguish between different important light weight construction materials. In addition, appropriate joining technologies can be selected • answer basic questions concerning material selection • refer to prominent examples for the important role of specific materials in important applications		
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 • 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: Production, properties and applications • Rubber tires and their manufacturing • Joining techniques for mobile applications		

	• Optional there will be an excursion to see materials production or manufacturing in industrials practice
Assessment	Lecture: Written or oral examination
Literature/ Resources	• M. F. Ashby, D. R. H. Jones: Engineering Materials 2 – An Introduction to Microstructures and Processing, 4th ed., 2013, ISBN-13 978-0-08-096668-7, Elsevier • B. Ilschner, R. F. Singer: Werkstoffwissenschaften und Fertigungstechnik – Eigenschaften, Vorgänge, Technologien; 5. Ed., 2010, ISBN 978-3-642-01733-9, Springer-Verlag • A. C. Reardon (Editor): Metallurgy for the Non-Metallurgist, 2nd edition, 2011, ISBN-13 978-1-61503-821-3, ASM International • D. Altenpohl: Aluminium von Innen, 5. Ed., 1994, ISBN 3-87017-235-5, Aluminium Verlag • G. W. Ehrenstein: Faserverbund-Kunststsoffe – Werkstoffe – Verarbeitung – Eigenschaften; 2nd Ed., 2006, ISBN 978-3-446-22716-3, Hanser • C. B. Carter, M. G. Norton: Ceramic Materials - Science and Engineering, 2nd Ed., 2013, ISBN 978-1-4614-3522-8, Springer-Verlag • F. Henning, E. Moeller (Hrsg.): Handbuch Leichtbau - Methoden, Werkstoffe, Fertigung; 1st Ed., 2011, ISBN 978-3-446-42267-4, Carl Hanser Verlag • Z. L. Wang and Z. C. Kang, Functional and Smart Materials: Structural Evolution and Structure Analysis; 1998, ISBN 978-0-306-45651-0

Cell Biology and Microbiology			
Module name	Cell Biology and Microbiology		
Module code	BMS 4 2220		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. N. Shirtcliffe		
Lecturer	Prof. Dr. L. Chambers		
Language	English		
Part of focus field	Core		
Credits	6		
Workload	180 h	Attendance	60 h
		Self-study	90 h
		Exam Preparation	30 h
HPW	4	Lecture	2
		Exercise	1
		Practical	1
Prerequisites	Required: Recommended:		
Module objectives	Students are able to … • 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; • write scientific lab protocols in an adequate manner		
Content	<u>Lecture</u> 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 <u>Lab course</u> 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);
Assessment	Lecture: Written examination
Literature/ Re-sources	• Alberts: Molecular Biology of the Cell • Brock: Biology of Microorganisms • Campbell, Reece, Mitchell: Biology

Semester 5

Sustainability, Quality and Business Process Management			
Module name	Sustainability, Quality and Business Process Management		
Module code	BMS 5 2221		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr.-Ing. Alexander Klein		
Lecturer	Prof. Dr.-Ing. Alexander Klein		
Language	English		
Part of focus field	• Biomaterials Science (B.Sc.): Core • Science and Engineering (B.Sc.): Business Operations		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	3
		Exercise	1
Prerequisites	Required: Fundamentals of Business and Management Recommended: -		
Module objectives	Students are able to … • know the theoretical models, concepts and methods of sustainable development and sustainable management • can address the targets and conflicts of sustainability in a business environment • know industry standards for quality and sustainability management • can apply quality management and quality assurance methods in the context of product development and production planning • are able to select and evaluate quality management systems • understand the principles and structures of business processes and business process management • are able to develop and optimize business processes • know software solutions for sustainability, quality management and assurance and business process management		
Content	• Examples and use cases (case studies) • Sustainability definition • ESG reporting • Fair and green supply chains, labels • Means to improve sustainability • Circular economy • Quality definitions • Perceived quality • Continuous improvement • Auditing • Benchmarking • APQP, quality assurance, inspection planning including Design FMEA and Process FMEA • Quality function deployment		

	• Metrology basics • Statistical process control • Six sigma basics • Important standards for QM, Safety management, health management, Environment, such as DIN EN ISO 9001, 14001, 45001, 50001 • Business process definition and business process modelling notation • Tools and proven approaches for business process improvements • Digital workflows
Assessment	Graded exam
Literature/ Resources	• Bell, Simon, 2018. Routledge Handbook of Sustainability Indicators. Routledge. ISBN 9781315561103 • DIN EN ISO 9001 • DIN EN ISO 14001 • DIN ISO 45001 • DIN EN ISO 50001 • AIAG & VDA, 2022. FMEA Handbook. • Goldratt, Eliyahu M. und Jeff Cox, 2014. The goal: a process of ongoing improvement. 4., rev. ed., 30. anniversary ed. Great Barrington, Mass.: North River Press. ISBN 9780884271956

Biocompatible Materials			
Module name	Biocompatible Materials		
Module code	BMS 5 2222		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr. Christoph Heß		
Lecturer	Prof. Dr. Christoph Heß		
Language	English		
Part of focus field	• Biomaterials Science (B.Sc.): Core • Science and Engineering (B.Sc.): Product Creation		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	2
		Practical	2
Prerequisites	Required: Biochemistry, Metallic Materials and Testing, Non-metallic Materials Recommended: Organic Chemistry		

Module objectives	Students are able to …
	• demonstrate a broad understanding on the multidisciplinary field of biomaterials.
	• design the properties of a biomaterial (bulk and surface) by consideration of its
	  • functionality
	  • stability, resorbability
	  • manufacture and processing
	  • interaction with living tissue
	• understand the clinical context of biomaterials 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 intended to be used in direct contact with living tissue in biological systems as well as biological reactions to materials. • Furthermore the course demonstrates the vital research and development work that is done in order to identify biofunctional and biocompatible materials which can be used to replace or augment damaged organs, vessels or tissues. • Beside structural properties and performance of synthetic, metallic and ceramic biomaterials, the course also deals with general ethical and economic aspects for the 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	Lecture: Written examination Practical Training: Reports		

Literature/ Resources	• Ratner B. D., Hoffman A. S., Schoen F. J., Lemons J. E.: *Biomaterials Science: An Introduction to Materials in Medicine* • Park J. B., Bronzino J. D.: *Biomaterials: Principles and Applications* • Baura G. D.: *Medical Device Technologies – A System Based Overview Using Engineering Standards* • Rodriguez-Gonzales F. A.: *Biomaterials in Orthopaedic Surgery* • Hasirci V., Hasirci N.: *Fundamentals of Biomaterials*

Recycling and Ecology of Materials			
Module name	Recycling and Ecology of Materials		
Module code	BMS 5 2223		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr.-Ing. Raimund Sicking		
Lecturer	Prof. Dr.-Ing. Raimund Sicking		
Language	English		
Part of focus field	All		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Reading	90 h
		Review	30
HPW	4	Lecture	2
		Practical	2
Prerequisites	Required: Metallic Materials and Testing Recommended: Non-metallic Materials, Materials Technology		
Module objectives	Students are able to … • explain the recycling cycle beginning from the product development to re-use, recovery and recycling under consideration of legal as well as material based boundary conditions • recognise the importance of life-cycle analysis/engineering and that of sustainable product development • perform the choice of materials with regard to their recyclability considering mechanical and thermal separation methods including chemical aspects • understand the social meanings of recycling and consider this against material cost and the use of finite resources • develop structured presentations on the issue of recycling according to scientific standards • evaluate new ideas against the practise of large scale recycling and sorting based on prepared excursions • (with regard to the ecology of materials) identify ecological aspects for the design of substances and materials • allocate materials properties and applicability for the materials • ecologically evaluate a bio product and the ecological compatibility for different materials		
Content	• Motivation • The current legal guidelines (EU regulations) • Use of materials • REACH • 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 harmful 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 • The students will participate in the lecture with their own contributions on the different contents and goals
Assessment	Written or oral exam
Literature/ Resources	• E. Worrell, M. A. Reuter • Handbook of Recycling – State-of-the-art for practitioners, analysts, and scientists; Elsevier, 2014, ISBN: 978-0-12-396459-5 • V. Goodship: Management, Recycling and Reuse of Waste Composites; CRC Press, 2010, ISBN-13: 978-1439827659 • Vincent Rich: The International Scrap and Recycling Industry Handbook, CRC Press, 2001, ISBN-13: 978-1855732483 • John Scheirs: Polymer Recycling: Science, Technology and Applications, John Wiley & Sons, 1998), ISBN-13: 978-0471970545 • Matthias Finkbeiner: Towards Life Cycle Sustainability Management, Springer Netherlands, 1st Edition, 2011, ISBN-13: 978-9400718982 • Publications from several magazines and current internet sources

Semester 6

BMS-Project			
Module name	BMS-Project		
Module code	BMS 6 2224		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Neil Shirtcliffe		
Lecturer	Individual supervisors		
Language	English		
Part of focus field	Core		
Credits	5		
Workload	150 h	Attendance	15 h
		Project Workload	135 h
HPW	4	Project	4
Prerequisites	Required: 60 Credit point minimum Recommended: -		
Module objectives	Students work on a theme in Biomaterials Science for a Supervisor. This can be individual or in exceptional cases with permission of course leaders in small groups of maximum 3 students. For this course students carry out specific tasks to carry the project forward and make an appropriate report. Themes and styles can vary from a classical Natural Science research theme to Engineering or Management themes. From carrying out experimental work to a literature report. The supervisor and module coordinator define the desired outcome. A typical report is 20-30 pages long including figures.		
Content	Contents are project-specific		
Assessment	Graded: Continuous Assessment		
Literature/ Resources	• Selected state-of-the-art papers relevant to project • Best practice guides • Internal Journal		

Internship A	
Module name	Internship A
Module code	BMS 6 2225
Degree	Biomaterials Science (B.Sc.)
Module coordinator	Heads of the degree programme
Lecturer	Professors
Language	English
Part of focus field	Core
Credits	15
Workload	450 h
HPW	-
Prerequisites	Have achieved 90CP from the BMS 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 • 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 • 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 based on a written internship report
Literature/ Resources	-

Semester 7

Internship B	
Module name	Internship B
Module code	BMS 7 2226
Degree	Biomaterials Science (B.Sc.)
Module coordinator	Heads of the degree programme
Lecturer	Professors
Language	English
Part of focus field	Core
Credits	15
Workload	450 h
HPW	-
Prerequisites	Have achieved 90CP from the BMS 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 • 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 • 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 based on a written internship report
Literature/ Resources	-

Bachelor Thesis	
Module name	Bachelor Thesis
Module code	BMS 7 2227
Degree	Biomaterials Science (B.Sc.)
Module coordinator	Heads of the degree programme
Lecturer	Supervisor of the bachelor thesis
Language	English
Part of focus field	Core
Credits	12
Workload	360 h
HPW	-
Prerequisites	175 CP in the BMS Curriculum
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)
Literature/ Resources	-

Colloquium	
Module name	Colloquium
Module code	BMS 7 2228
Degree	Biomaterials Science (B.Sc.)
Module coordinator	Heads of the degree programme
Lecturer	Supervisor of the bachelor thesis
Language	English
Part of focus field	Core
Credits	3
Workload	90 h
HPW	-
Prerequisites	207 CP in the BMS curriculum
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
Literature/ Resources	• M. Powell: Presenting in English – how to give successful presentations, Heinle Cengage Learning, 2011 • S. Krantman: The Resume Writer's Workbook, fourth edition, South-Western Cengage Learning, 2013

Focus Fields

Biomaterials Science with Material Technology

(1) Manufacturing Technology and Factory Equipment

(2) Material Testing and Failure Analysis

(3) Inorganic and Composite Materials

Biomaterials Science with Management

(1) Accounting

(2) General Management

(3) Technology and Innovation Management

Biomaterials Science with Biochemistry

(1) Biotechnology and Biodegradable Materials

(2) Supramolecular Chemistry and Materials

(3) Smart Functional Materials

Focus Field: Biomaterials Science with Material Technology

Manufacturing Technology and Factory Equipment			
Module name	Manufacturing Technology and Factory Equipment		
Module code	BMS 4 2229		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr.-Ing. Alexander Klein		
Lecturer	Prof. Dr.-Ing. Alexander Klein		
Language	English		
Part of focus field	• Biomaterials Science (B.Sc.): Core • Science and Engineering (B.Sc.): Business Operations		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	3
		Exercise	1
Prerequisites	Required: Project Management, Physics and Error Statistics Recommended: -		
Module objectives	Students are able to … • know common manufacturing technologies and their basic advantages and disadvantages, mainly for cutting, deforming and selected shaping technologies • know the most important process parameters of selected manufacturing technologies and have an understanding of the challenge to find good process parameters to achieve a good total utility of the process with oftentimes conflicting goals • have a good basic knowledge about the types of machines used for the manufacturing technologies. • understand the quality requirements of machine tools and other related pieces of production equipment and metrology equipment needed for quality assurance • know the basic functions of CAM tools (computer aided manufacturing) and its role in industrial manufacturing (and the CAD/CAM chain) as well as other software tools in manufacturing • can select suitable manufacturing processes and machines for specific manufacturing tasks considering production volume and product quality • can define a suitable automation concept and select the necessary automation equipment • know common intra logistic means and storage systems and can plan the internal material storage and transport in a factory		
Content	• Manufacturing technologies overview according to DIN 8580 • Core equipment: Machine tools including tooling and devices (fixtures) and machining centres • Secondary value creation equipment (e.g. tool reconditioning, tool and die making)		

	• Intra logistics hardware (AGVs, conveyors, cranes, miscellaneous vehicles) • Storage systems • Production related building infrastructure • Automation solutions and robots • Quality assurance equipment (soft- and hardware) • Linked systems and flexible manufacturing systems • Software and IT structures for production • (CAM, APS, MES, material flow simulation, vehicle routing etc.) • Examples and use cases (case studies)
Assessment	Graded exam
Literature/ Resources	• DIN 8580 • Bartenschlager, Jörg, Josef Dillinger, Walter Escherich, Werner Günter, Eckhard Ignatowitz, Stefan Oesterle, Ludwig Reissler, Andreas Stephan, Reinhard Vetterund Falko Wieneke, 2016. Metal engineering textbook. 1st English edition. Haan-Gruiten: Verlag Europa-Lehrmittel. ISBN 3808512431 • Kalpakjian, Serope, Steven R. Schmidund K. S. Vijay Sekar, 2014. Manufacturing engineering and technology. 7. ed. in SI units. Singapore [u.a.]: Pearson. ISBN 9789810694067 • Brecher, Christian und Manfred Weck, 2023. Machine Tools Production Systems 1: Machine Types and Application Fields. 1st ed. 2024. Berlin, Heidelberg: Springer Berlin Heidelberg, Imprint: Springer. ISBN 9783662681190. • Brecher, Christian und Manfred Weck, 2021. Machine Tools Production Systems 2: Design, Calculation and Metrological Assessment. 1st ed. 2021. Berlin, Heidelberg: Springer Berlin Heidelberg, Imprint: Springer. ISBN 9783662608630. • Brecher, Christian und Manfred Weck, 2022. Machine Tools Production Systems 3: Mechatronic Systems, Control and Automation. 1st ed. 2022. Wiesbaden: Springer Fachmedien Wiesbaden, Imprint: Springer. ISBN 9783658346225. • Collier, David A. und James R. EVANS, [2017]. OM6: Operations + supply chain management. [6th edition]. Boston, MA: 4LTR Press ; Cengage Learning. ISBN 9781305664791

Material Testing and Failure Analysis			
Module name	Material Testing and Failure Analysis		
Module code	BMS 5 2232		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr.-Ing. Raimund Sicking		
Lecturer	M.Sc. Ph. Sommer (external lecturer)		
Language	English		
Part of focus field	Biomaterials Science with Material Technology		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	60 h
		Exam Preparation	60 h
HPW	4	Lecture	2
		Practical	2
Prerequisites	Required: Fundamentals of Business and Management Recommended: Metallic Materials and Testing		
Module objectives	Students are able to … • explain 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 • perform different kinds of sample preparation, calibration of devices, examination methods and measurement evaluations for exemplary cases • assess different measurement methods (such as spectroscopy, optical and electron microscopy, scattering methods, ultrasound and magnetic particle test and others) based on own experience in conduction		

Content	<u>Material Testing</u>
	• 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
	
	<u>Failure Analysis</u>		

	• 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
Literature/ Resources	• 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 • R. B. Ross: Metallic Materials Specification Handbook, 4th edition, ISBN 978-0412369407, Springer US, 1991 • 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 • George M. Crankovic: Metals Handbook: Materials Characterization, 9th edition, ISBN 978-0871700162, ASM Intl., 1989 • VDI Guideline 3822:2011 Failure analysis. “Fundamentals and performance of failure analysis” • Verein Deutscher Eisenhüttenleute: The Appearance of Cracks und Fractures in Metallic Materials. Verlag Stahleisen 2008

Inorganic and Composite Materials			
Module name	Inorganic and Composite Materials		
Module code	BMS 5 2233		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr. Christoph Heß		
Lecturer	Prof. Dr. Christoph Heß		
Language	English		
Part of focus field	• Biomaterials Science (B.Sc.): Biomaterials Science with Material Technology • Science and Engineering (B.Sc.): Product creation		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	2
		Practical	2
Prerequisites	Required: Chemistry of Materials, Biochemistry Recommended: Metallic Materials and Testing, Non-metallic Materials		
Module objectives	Students are able to … *Inorganic Materials* • describe and evaluate properties and features of ceramic materials • understand and analyze stress 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 specific technological and economical demands *Composite Materials* • distinguish, describe and evaluate the properties of reinforced, laminated and sandwich-structured composites • understand and analyze mechanical, thermal and chemical stress 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 the characterization of composite products		
Content	*Inorganic Materials* • The course deals with material characteristics and fundamentals for the manufacture of ceramics. • It 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. • Application domains and limitations of ceramic materials are analyzed by using examples from engineering and industrial needs. • 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 illustrate the increasing importance but also the limitations of composite materials. • A specific focus is put on manufacturing methods for fiber reinforced resp. laminated composites. The topics are consolidated by lab work.
Assessment	Lecture: Continuous Assessment Practical: Reports
Literature/ Resources	• Barry Carter C., Grant Norton M.: *Ceramic Materials: Science and Engineering* • Long A. C. (Ed.): *Composites forming technologies* • Srinivasan K.: *Composite Materials – Production, Properties, Testing and Applications* • 4. Wurm J.: *Glass Structures: Design and Construction of Self-supporting Skins*

Focus Field: Biomaterials Science with Management

Accounting			
Module name	Accounting		
Module code	BMS 4 2230		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr. Dirk Berndsen		
Lecturer	Prof. Dr. Dirk Berndsen		
Language	English		
Part of focus field	• Biomaterials Science (B.Sc.): Biomaterials Science with Management • Science and Engineering (B.Sc.): Management, Business Operations		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	2
		Exercises	2
Prerequisites	Required: Metallic Materials and Testing Recommended: Material Analysis		
Module objectives	Students are able to … • understand and apply the fundamental principles of accounting • recognize and navigate basic financial statements including the income statement, balance sheet, and cash flow statement • analyze financial statements using various financial accounting ratios • understand the basic concepts of cost accounting • analyze and interpret cost accounting data • use cost accounting information to make better business decisions • apply cost accounting techniques to real-world scenarios – in particular business decisions, process optimization and project management • understand the role of accounting and financial vs. non-financial information in business decision-making processes • make basic assessments of the wider impact and sustainability of business models, decisions and practices		
Content	• Introduction to Accounting Principles and Standards • Recording Business Transactions • Introductions to Financial Statements • Financial Statement Analysis • Basic Cost Accounting • Cost-Volume-Profit Analysis • Job Costing and Process Costing • Activity-Based Costing (ABC) • Standard Costing and Variance Analysis • Project Costing • Accounting for Corporate Social Responsibility (CSR), Environment Impact Assessment (EIA), and Strategic Environmental Assessment (SEA) • Fundamentals of Managerial Accounting • Applying Non-Financial Business Performance Indicators		

	• Applying Accounting for Business Sustainability
Assessment	Lecture: Written examination, presence only (2h)
Literature/ Resources	• Knight, John (2019): Accounting: Accounting made simple, basic accounting principles, and how to do your own bookkeeping. ISBN 978-1542385527, CreateSpace • Weygandt, Jerry J. / Kimmel, Paul D. (2022): Financial Accounting with IFRS, 5th edition, ISBN 978-1119787051, Wiley • Weygandt, Jerry J. / Kimmel, Paul D. / Mitchell, Jill E. (2020): Managerial Accounting: Tools for Business Decision Making, 9th edition, ISBN 978-1119709589, Wiley • Rimmel, Gunnar (2020): Accounting for Sustainability. ISBN 978-0367478957, Routledge

General Management			
Module name	General Management		
Module code	BMS 5 2234		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr.-Ing. Dirk Untiedt		
Lecturer	Prof. Dr.-Ing. Dirk Untiedt		
Language	English		
Part of focus field	• Biomaterials Science (B.Sc.): Biomaterials Science with Management • Science and Engineering (B.Sc.): Management, Business Operations		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	2
		Practical	2
Prerequisites	Required: Personal and Social Competences Recommended: -		

Module objectives	Students are able to …
	• know the main methods and instruments of General Management. They have the ability to use them effectively
	• distinguish in general three management functions for any kind of company with respect to General Management:
	  • Marketing Management
	  • Finance Management and
	  • Operations management.
	• know the main tools, methods and instruments of general management
	• use them effectively
	• formulate strategies and implementation plans on all strategy levels and in specific con-texts		

Content	• Fundamentals of General Management • Strategy • Operations Management • Finance and Controlling • Organisation and Management • Human Resource Management • Change Management • Marketing • The theoretical knowledge gained in the sector of General Management will be simulated and deepened by a business simulation game.		
Assessment	Lecture: Attestation/ Written Examination Practical Training: Business Simulation		
Literature/ Resources	*tba*		

Technology and Innovation Management			
Module name	Technology and Innovation Management		
Module code	BMS 5 2235		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr.-Ing. Dirk Untiedt		
Lecturer	Prof. Dr.-Ing. Dirk Untiedt		
Language	English		
Part of focus field	• Biomaterials Science (B.Sc.): Biomaterials Science with Management • Science and Engineering (B.Sc.): Management		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	2
		Practical Training	2
Prerequisites	Required: Fundamentals of Business and Management, Organic Chemistry, Chemistry of Biopolymers Recommended: -		

Module objectives	Students are able to …
	• know the main methods and instruments of General Management
	• use them effectively
	• distinguish with respect to General Management in general three management functions for any kind of company:
	  • Marketing Management
	  • Finance Management and
	  • Operations management.
	• know the main tools, methods and instruments of general management
	• use them effectively
	• formulate strategies and implementation plans on all strategy levels and in specific contexts		

Content	• Fundamentals of General Management • Strategy • Operations Management • Finance and Controlling • Organisation and Management • Human Resource Management • Change Management • Marketing The theoretical knowledge gained in the sector of General Management will be simulated and deepened by an IT based business game.		
Assessment	Lecture: Attestation/ Graded Examination		
Literature/ Resources	*tba*		

Focus Field: Biomaterials Science with Biochemistry

Biotechnology and Biodegradable Materials			
Module name	Biotechnology and Biodegradable Materials		
Module code	BMS 4 2231		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Neil Shirtcliffe		
Lecturer	Prof. Dr. Neil Shirtcliffe		
Language	English		
Part of focus field	Biomaterials Science with Biochemistry		
Credits	6		
Workload	180 h	Attendance	60 h
		Self-study	60 h
		Exam Preparation	30 h
HPW	4	Lecture	4
Prerequisites	Required: Non-metallic Materials Recommended: Material Analysis		
Module objectives	Students are able to … • describe the full process for generating transgenetic proteins • be familiar with the basics of biotechnology for creating materials • 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		
Content	A short introduction to genetics allows the students to understand Biotechnology with a focus on generating bioderived materials. • A goal is to give the students the tools to converse with biologists. • 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: • Anaerobic degredation of polymers • Enzymatic degredation of biopolymers • The types and sources of biopolymers • Chemistry of lignin and cellulose • Protein as a material • 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/ Resources	• Basic Biotechnology by Colin Ratledge (Editor), Bjorn Kris-tiansen, Paperback: 584 pages, Publisher: Cambridge University Press • Cartoon Guide to Genetics, Larry Gonick, HarperCollins, 14.08.1991

Supramolecular Chemistry and Materials			
Module name	Supramolecular Chemistry and Materials		
Module code	BMS 5 2236		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Neil Shirtcliffe		
Lecturer	N.N.		
Language	English		
Part of focus field	Biomaterials Science with Biochemistry		
Credits	6		
Workload	180 h	Attendance	60 h
		Self-study; Homework	90 h
		Exam Preparation	30
HPW	4	Lectures	2
		Exercise	1
		Practical	1
Prerequisites	Required: Accounting, Fundamentals of Business and Management Recommended: -		
Module objectives	Students are able to … • show understanding of the underlying principles of complementarity, preorganisation, and cooperative interactions with respect to supramolecular chemistry, and be able to rationalise the characteristics of binding in a given supramolecular complex with respect to these three key concepts • describe, show understanding of and rationalise a range of supramolecular assemblies, including their formation, their behaviour, and their applications in the context of supramolecular chemistry • explain the principles of solvent effects on supramolecular complexes, why and how solvents affect the strength of supramolecular interactions, and design potential supramolecular hosts taking these principles into account. • comment critically on and synthesise a summary of the key messages from a recent research paper describing applications for supramolecular complexes		
Content	Supramolecular chemistry deals with the interactions between molecules and has become one of the fundamental areas of chemical research. The aims of the module are to introduce and develop the students' knowledge of the chemistry of molecular assemblies and intermolecular bonds, or "chemistry beyond the molecule". The module will introduce the concepts of non-covalent chemistry, host-guest chemistry, molecular recognition, self-assembly and self-organisation. Introduction to supramolecular chemistry – nature of supramolecular interactions, solvation effects, cooperativity, host-guest interactions, chelation, macrocyclic effect, characterisation of supramolecular systems. Cation-binding – Why bind cations?, What binds cations Anion binding – Why bind anions, What binds cations Neutral guest binding – Hydrogen bonds, Hydrophobic effect. Solid state Host-Guest systems – clathrates, calixarenes, molecular crystals.		

	Self Assembly – pi-electron donor-acceptor systems, transition metal directed assemblies, hydrogen bond assemblies, anion directed assemblies. Characterising supramolecular systems Biological Mimics Supramolecular Chemistry of Life – porphyrins, plant photosynthesis, enzymes. Interfaces and Liquid Assemblies – non-covalent networks, supramolecular Polymers.
Assessment	Usually continuous assessment
Literature/ Resources	Jonathan W. Steed, Jerry L. Atwood: Supramolecular Chemistry, Wiley 2009 Print ISBN: 9780470512333 |Online ISBN:9780470740880 |DOI:10.1002/9780470740880

Smart Functional Materials			
Module name	Smart Functional Materials		
Module code	BMS 5 2237		
Degree	• Biomaterials Science (B.Sc.) • Science and Engineering (B.Sc.)		
Module coordinator	Prof. Dr. Christoph Heß		
Lecturer	Prof. Dr. Christoph Heß		
Language	English		
Part of focus field	• Biomaterials Science (B.Sc.): Biomaterials Science with Biochemistry • Science and Engineering (B.Sc.): Product Creation		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	2
		Practical	2
Prerequisites	Required: Chemistry of Materials, Organic Chemistry, Physical Chemistry Recommended: Metallic Materials and Testing, Non-metallic Materials		
Module objectives	Students are able to … • understand the scientific principle of the functionality of various smart materials. • identify potential fields of application for smart functional materials • select appropriate functional materials for a given application and consider their limitations		
Content	• Nanostructured materials • Sol-gel structures, hydrogels • Piezoelectric materials • Shape memory materials • Magneto- and electrorheological materials		
Assessment	Lecture: Continuous Assessment		
Literature/ Resources	• Beer P. D.: Supramolecular Chemistry • Gauenzi, P.: Smart Structures • Gandhi M. V., Thompson B. S.: Smart Materials and Structures • Haghi A. K., Zaikov G. E.: Handbook of Research on Nanomaterials, Nanochemistry & Smart Materials		

Electives

- Research-Project
- Nanomaterials
- Materials Inspired by Nature
- Medical Devices
- Numerical Mathematics
- Foreign Language

Electives

Research-Project			
Module name	Research-Project		
Module code	BMS 6 2241		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Neil Shirtcliffe		
Lecturer	Individual Supervisors		
Language	English		
Part of focus field	Electives		
Credits	6		
Workload	180 h	Attendance	60 h
		Project Workload	120 h
HPW	4		
Prerequisites	Required: - Recommended: -		
Module objectives	Students are able to … • carry out specific tasks to carry the project forward and make an appropriate report.		
Content	Students work individually on a theme in Biomaterials Science for a Supervisor. Themes and styles can vary from a classical Natural Science research theme to Engineering or Management themes. From carrying out experimental work to a literature report. The supervisor and module coordinator define the desired outcome. A typical report is 20-30 pages long including figures. Alternatively it can be submitted as a paper to the Journal Acta Rhenus Bicornis using the template of that Journal. Contents are project-specific		
Assessment	Graded: Continuous Assessment		
Literature/ Resources	1. Selected state-of-the-art papers relevant to project 2. Best practice guides 3. Internal Journal		

Nanomaterials			
Module name	Nanomaterials		
Module code	BMS 6 2242		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Amir Fahmi		
Lecturer	Prof. Dr. Amir Fahmi		
Language	English		
Part of focus field	Electives		
Credits	6		
Workload	180 h	Attendance	60 h
		Self-study	90 h
		Exam Preparation	30 h
HPW	4	Lectures	2
		Exercise	1
		Practical	1
Prerequisites	Required: - Recommended: -		
Module objectives	Students are able to … • describe the fabrication processes and equipment involved in nano-scale technology, nano-materials and nano-devices. Describe nanomaterials properties at different dimensions and the impact in varieties of applications. • explain the principles of molecular self-assembly and the role of weak non-covalent forces in determining structure, energetics and dynamics in complex molecular structures in different systems; • clarify and classify methods for producing and characterising bulding blocks such as nanoparticles and thin films of organic, inorganic and hybrid nanomaterials. • describe phase behaviour, structures and properties of nanopartilces and ordered nanodomains in terms of the principles of nanofabrication at different dimensions and length scales; 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 nanomaterials, Charge and quantum transport in nanomaterials, Chemical Reactivity of the Nanomaterials. • Nanostructured materials fabrication methods at different dimensions and length scale: different types of nanoparticles, nanowires, nanofibers, nanosheets, thin film and three dimensional structured materials • Nanoscale Synthesis & Fabrication (Top Down and Bottom Up Approach): Self-Assembly: Principles of Self-Assembly, Self-Assembly of Nanomaterials Lithography: printing and photo/electron techniques. • Nanomaterials Characterization techniques: principle of microscopy, spectroscopy and scattering instrumentation for characterisation of nanomateri-		

	als: 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	Exam
Literature/ Resources	• D. Vollath: Nanomaterials: An Introduction to Synthesis, Properties and Applications • 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) • Geoffrey A. Ozin, et al: Nanochemistry

Materials Inspired by Nature			
Module name	Materials inspired by nature		
Module code	BMS 6 2243		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. Amir Fahmi		
Lecturer	Prof. Dr. Amir Fahmi		
Language	English		
Part of focus field	Electives		
Credits	6		
Workload	180 h	Attendance	60 h
		Self-study	90 h
		Exam Preparation	30 h
HPW	4	Lectures	2
		Exercise	1
		Practical	1
Prerequisites	Required: - Recommended: -		
Module objectives	Students are able to … • recognize the most important types of materials inspired by nature • identify biomimetic 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 assembly of macromolecules • Introduction into measurement methods for pattern and structure recognition		
Assessment	Exam		
Literature/ Resources	• Wolfgang Pompe, Gerhard Rodel, Hans-Jurgen Weiss, Michael Mertig: Bio-Nanomaterials: Designing Materials Inspired by Nature; ISBN: 978-3-527-41015-6 • N. Katsube, W. O. Soboyejo, M. Sacks: Functional Biomaterials, 2001, ISBN: 978-0-87849-871-0 • John E. McMurry: Organic Chemistry With Biological Applications 2nd Ed. Brooks/Cole; 2011 • Sujata V. Bhat, Bhimsen A. Nagasampagi, Meenakshi Sivakumar: Chemistry of Natural Products, 1st ed. Springer 2005		

Medical Devices			
Module name	Medical Devices		
Module code	BMS 6 2244		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr.-Ing. I. Volosyak		
Lecturer	Prof. Dr.-Ing. I. Volosyak		
Language	English		
Part of focus field	Electives		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lecture	2
		Practical	2
Prerequisites	Required: - Recommended: Materials Technology; Recycling and Ecology of Materials		
Module objectives	Students are able to … • know the fundamentals of electric potential within the human body that can be measured by ECG or EEG for example. • 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. • master basic methods of image processing as used in tomography, for example. • understand the fundamentals of electrical potentials in the human brain that can be detected with non-invasive and invasive methods. • derive, from first principles, real architectures for modern Brain-Computer Interfaces. • Be aware of the legal and other requirements for medical products and based on this, they are able to estimate which constructive measures are necessary. • 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	Lecture: Written examination Practical Training: Attestation		
Literature/ Resources	• W. Saltzmann: Biomedical Engineering, Cambridge Uni-versity Press, 2009, 00/WBK 33 • M. Culjat, Medical Devices: Surgical and Image-Guided Technologies, Wiley, 2013, 00/VUT 13 and online • Ivan Volosyak, Recent advances in VEP-based BCI sys-tems, Shaker, 2019, 00/WBK 115		

	Further reading: • G. D. Baura, Medical Device Technologies, Academic Press, 2012, 00/VUT 4 and online (2020) • L. Street: Introduction to Biomedical Engineering Technology, 2nd edition, CRC Press, 2011, 00/VUT 9-2 • J. Enderle: Introduction to Biomedical Engineering, Ac-ademic Press, 2011, 00/WBK 56-3 • R. Northrop: Analysis and Application of analog elec-tronic circuits to biomedical instrumentation, CRC Press, 2012, 00/VUT 10-2 • Bronzino, Joseph D.: The Biomedical Engineering Hand-book, CRC Press, 2006 • G. Schalk, A practical Guide to Brain-Computer Interfac-ing with BCI2000, Springer, 2010 • J. Wolpaw, E. Wolpaw, Brain-Computer Interfaces: Principles and Practice, Oxford University Press, 2012, 00/TVU33

Numerical Mathematics			
Module name	Numerical Mathematics		
Module code	BMS 6 2245		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Prof. Dr. A. Kehrein		
Lecturer	Prof. Dr. A. Kehrein Prof. Dr. A. Struck		
Language	English		
Part of focus field	Electives		
Credits	6		
Workload	180 h	Attendance	60 h
		Preparation and Review	120 h
HPW	4	Lectures	2
		Exercise	2
Prerequisites	Required: Mathematics 1, Mathematics 2 Recommended: -		
Module objectives	Students are able to … • Understand 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. • how to do computations effectively within the machine limitations. • understand some standard methods of numerical mathematics but, more importantly, how to adapt or even develop numerical methods to fit the problem at hand. • become active learners and look for applications of the new methods on their own. • become independent in checking the correctness of their results.		
Content	• Presentation of numbers in a computer: INT and FLOAT; roundoff errors • Loss of significant digits, error propagation • Interpolation: Lagrange polynomials and splines • Numerical differentiation: use of Taylor approximations, order of a numerical method, truncation error • Numerical integration: midpoint rule, trapezoid rule, Romberg scheme • Fixed-point iteration • Iterative solution of non-linear systems, in particular Newton's Method • Numerical solution of differential equations: forward and backward Euler, stability, implicit vs. explicit schemes		
Assessment	Lecture: Written examination Exercise: Attestation		
Literature/ Resources	• Forman S. Acton (2005) *Real Computing Made Real – Preventing Errors in Scientific and Engineering Calculations*. Mineola. Dover Publications. 00/TKX 19´ • Cleve Moler (2004) *Numerical Computation with Matlab*, Society for Industrial and Applied Mathematics (pdf available from https://de.mmath-works.com/moler/chapters.html)		

	• Gilbert Strang (2007) *Computational Science and Engineering*. Wellesley. Wellesley-Cambridge Press. 00/TKX 3 • Richard Burden and Douglas Faires (2011) *Numerical Analysis*. 9th international edition. Brooks/Cole. 00/TKX 17 • Parviz Moin (2010) *Fundamentals of Engineering Numerical Analysis*. 2nd edition. Cambridge. Cambridge University Press. 00/WAT 1 • 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

Foreign Language			
Module name	Foreign Language		
Module code	BMS 6 2246		
Degree	Biomaterials Science (B.Sc.)		
Module coordinator	Bret Ellis (015905378080)+		
Lecturer	acc. selected module of the language centre		
Language	English		
Part of focus field	Electives		
Credits	5		
Workload	xxx	xxx	xxx
HPW	4	Lectures	
		Exercise	
Prerequisites	Required: … Recommended: …		
Module objectives	Students are able to … • xxx		
Content	xxx		
Assessment	xxx		
Literature/ Resources	xxx		