ADVANCED MATERIALS

Module Guide and Study Plan

Winter semester 2008/2009

Stand: 07.07.2008

Contents

MATERIALS SCIENCE

Materials Science I

Module assigned to 1st semester

Identification Code	2288870100
ECTS-Points	5
Credit Hours	4
Language	English
Length of the Module	1 semester
Date and Capacity	Winter term 60 students
Responsible Lecturer	Prof. Dr. Ulrich Herr
Further Lecturer	Prof. Dr. Ulrich Herr
Study Programme	Master degree in Advanced Materials Master degree in Energy Science and Technology compulsory
Prerequisites	BSc degree
Study Objectives	Students should - understand the basics of materials science - be able to apply this knowledge to optimize materials properties, especially mechanical properties.
Module Contents	1. Introduction - structure and bonding - classification of materials 2. Crystal structure - symmetry classes, lattices - reciprocal lattice, diffraction - band structure 3. Defects in solids - point defects, dislocations, grain and phase boundaries - microstructure of materials 4. Characterization of the microstructure - microscopic methods (optical, SEM, FIM) - diffraction techniques (XRD, TEM) - scanning probe techniques (introduction) 5. Phase diagrams - thermodynamics of solutions - chemical potential, phase equilibrium - basic types of phase diagrams - important examples 6. Transport - diffusion: macroscopic and microscopic description - diffusion at surfaces and interfaces - electromigration - thermotransport 7. Phase Transformations - thermodynamics and kinetics - diffusive transformations - non-diffusive transformations

	8. Mechanical properties - elastic properties - plastic deformation - viscous flow and creep - fracture
Literature	- W.D. Callister: *Materials Science and Engineering - An Introduction* (Wiley) - Atkins: *Physical Chemistry - for chemical potential, thermodynamics of mixtures and thermodynamics of phase transformations* - M. Ohring: *Engineering Materials Science* (Academic Press) - M.F. Ashby, D.R.H. Jones: *Engineering Materials 1&2* (Butterworth Heinemann) - C. Barrett and T.B. Massalski: *Structure of Metals* (Pergamon)
Teaching Methods	Materials Science I (L), 3 h/week Materials Science I (E), 1 h/week lecture with demonstrations, exercises
Estimation of working load	42 h lecture (presence) 14 h exercises (presence) 50 h preparation and postprocessing lecture 28h solution of exercises, postprocessing 16 h exam preparation lecture total 150 h
Examinations	written examination of 120 min., precondition: successful participation in exercises
Grade Composition	exam result
Usability	MSc course of studies Advanced Materials MSc course of studies Energy Science and Technology Materials Science II

Materials Science II

Module assigned to 2nd semester

Identification Code	2288870230
ECTS-Points	5
Credit Hours	4
Language	English
Length of the Module	1 semester
Date and Capacity	summer term 60 students
Responsible Lecturer	Prof. Ulrich Herr
Further Lecturer	Prof. Ulrich Herr
Study Programme	Master degree in Advanced Materials Master degree in Energy Science and Technology compulsory
Prerequisites	BSc degree
Study Objectives	Students should be able to - describe the process of fatigue and the basic causes of fatigue failure - classify metallic, ceramic and polymeric materials based on atomic-level structures, characteristic microstructures and macroscopic properties - understand and interpret the influence of materials processing on the microstructure and properties of metallic alloys, ceramics and polymers - relate the structure of a composite material to improvements in strength and toughness - understand the physical basis for the observed thermal, electrical and magnetic properties of solid materials be able to select appropriate materials and processing routes for the realization of engineering design goals, based on property and performance characteristics
Module Contents	The concepts of materials science are applied to a variety of materials types, including both conventional and novel classes of materials. Topics include materials processing and optimization, heat treatment, structure-property relationships and the stability of micro- and nanostructure. Syllabus: 1. Selected metallic alloys 2. Ceramics and glass 3. Polymers 4. Electrical Properties 5. Semiconductors 6. Magnetic Properties 7. Nanostructured Materials

Literature	- W. D. Callister: *Materials Science and Engineering: An Introduction* 6th ed., Wiley, London, 2003. - M. Ohring: *Engineering Materials Science* Academic Press, London, 1995. - M. F. Ashby, D. R. H. Jones: *Engineering Materials 1, 2nd ed.* Butterworth-Heinemann, Oxford, 1996 - M. F. Ashby, D. R. H. Jones: *Engineering Materials 2, 2nd ed.* Butterworth-Heinemann, Oxford, 1998.
Teaching Methods	Materials Science II (L), 3 h/week Materials Science II (E), 1 h/week lecture with demonstrations, exercises
Estimation of working load	42 h lecture (presence) 14 h exercises (presence) 50 h preparation and postprocessing lecture 28h solution of exercises, postprocessing 16 h exam preparation lecture total 150 h
Examinations	written examination of 120 min., Successful participation in the exercises is a prerequisite for the final examination.
Grade Composition	exam result
Usability	MSc course of studies Advanced Materials MSc course of studies Energy Science and Technology

Computational Methods in Materials Science

Module assigned to 2nd semester

Identification Code	2288870200
ECTS-Points	4
Credit Hours	3
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 60 students
Responsible Lecturer	Prof. Carl Emil Krill III, Ph.D.
Further Lecturer	Prof. PH. D. Carl Emil Krill, Prof. Dr,-Ing. Ulrich Herr, Dr. U. Simon
Study Programme	Master degree in Advanced Materials Master degree in Energy Science and Technology Advanced compulsory
Prerequisites	BSc degree
Study Objectives	Students should - learn the most important computational methods in Materials Science be familiar to these methods by practical training.
Module Contents	**Introduction** - What is a model? - Modeling in materials science - Simulation vs. modeling - Numerical solution of differential equations **Statistical mechanics** - Statistical mechanics in atomic-scale simulation - Ensembles and averages **Monte Carlo methods** - Introduction - Metropolis Monte Carlo algorithm - Ising model - Resident time algorithm, diffusion **Molecular dynamics** - Introduction - Interatomic potentials - Equations of motion, integration - Correlation functions - Examples **Phase-field models** - Introduction - Allen-Cahn model - Energy functional - Numerical solution methods - Examples **Finite element (FE) method** - Introduction and fundamentals - Linear variational functions - Applications in one dimension - General finite-element approach - Examples

Literature	- M. M. Wolfson, G. J. Pert: *An Introduction to Computer Simulation* (Oxford, 1999) - D. Raabe: *Computational Materials Science* (Wiley-VCH, 1998) S. E. Koonin, D. C. Meredith: *Computational Physics* (Addison- Wesley, 1990)
Teaching Methods	Computational Methods in Materials Science (L), 2 h/week Practical exercises (P) 1 h/week
Estimation of working load	28 h lecture (presence) 14 h exercises (presence) 34 h preparation and postprocessing lecture 28h solution of exercises, postprocessing 16 h exam preparation lecture total 120 h
Examinations	written examination of 120 min., precondition: successful participation in exercises
Grade Composition	exam result
Usability	MSc course of studies Advanced Materials MSc course of studies Energy Science and Technology

Lab Materials Science I

Module assigned to 2nd semester

Identification Code	2288870220
ECTS-Points	5
Credit Hours	4
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof. Dr. Hans-Jörg Fecht
Further Lecturer	Prof. Dr. Hans-Jörg Fecht, Prof. Dr.-Ing. Ulrich Herr, lecturers of the Faculty of Engineering and Computer Science
Study Programme	Master degree in Advanced Materials compulsory
Prerequisites	BSc degree
Study Objectives	Students should - learn to applicate their fundamental knowledge of Materials Science - be able to present and report own experimental work/results
Module Contents	Laboratory experiments: - Dynamic-mechanical analysis - Nanoindentation - X-ray diffraction - Phase transformations - Atomic force microscopy - Microstructure (2 sessions) Each experiment requires approximately 4 hours (1 session). In addition to carrying out the experiments listed above, students are required to attend three 2-hourseminars, during which members of the class give oral presentations of their experimental work to the remainder of the group
Literature	handouts
Teaching Methods	Lab Materials Science I (P), 4 h/week
Estimation of working load	25 h laboratory (presence), 25 h preparation, 100 h home writing report and revision Total: 150 h
Examinations	Seminar, report, certificate
Grade Composition	Passed or failed
Usability	MSc course of studies Advanced Materials

Lab Materials Science II

Module assigned to 3rd semester

Identification Code	2288870306
ECTS-Points	5
Credit Hours	4
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	Prof. Dr.-Ing. Ulrich Herr
Further Lecturer	Prof. Dr.-Ing. Ulrich Herr, lecturers of the Faculty of Engineering and Computer Science
Study Programme	Master degree in Advanced Materials compulsory
Prerequisites	BSc degree
Study Objectives	Students should - learn to applicate their fundamental knowledge of Materials Science - be able to present and report own experimental work/results
Module Contents	Laboratory experiments: - Lambda probe - Optical properties of ceramics - Vibrational sample magnetometry & Kerr microscopy - Thin film preparation - Magnetoresistance & Kerr magnetometry - Amorphous metals Each experiment requires approximately 4 hours (1 session). In addition to carrying out the experiments listed above, students are required to attend three 2-hourseminars, during which members of the class give oral presentations of their experimental work to the remainder of the group
Literature	handouts
Teaching Methods	Lab Materials Science I (P), 4 h/week
Estimation of working load	25 h laboratory (presence), 25 h preparation, 100 h home writing report and revision Total: 150 h
Examinations	Seminar, report, certificate
Grade Composition	Passed or failed
Usability	MSc course of studies Advanced Materials

CHEMISTRY

General Chemistry

Module assigned to 1st semester

Identification Code	2288870040
ECTS-Points	2
Credit Hours	2
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 60 students
Responsible Lecturer	Prof. Dr. Gerhard Taubmann
Further Lecturer	Prof. Dr. Gerhard Taubmann
Study Programme	Master degree in Advanced Materials Master degree in Energy Science and Technology compulsory
Prerequisites	BSc degree
Study Objectives	The students should - learn and understand the fundamentals of general chemistry and chemical synthesis with respect to the preparation of organic polymeric and inorganic materials
Module Contents	**Atoms:** - properties of the atoms, - hydrogen, many electron atoms, - periodic table **Hydrogen:** - isotopes, chemical kinetics - gas laws, ideals gas, van der Waals - synthesis and properties of hydrogen - metal hydrides - acids and bases **Halogens:** - synthesis and properties - oxidation and reduction, oxidation numbers - balancing redox reactions - hydrogen halides, hydrogen bond, azeotropes, - mass action law, principle of least restraint - dissociation of water, pH **Chalcogens:** - synthesis and properties of oxygen - liquefaction of gases, fractionation by destillation - diamagnetismn and paramegnetismn - ozone, mesomerism - water, phase diagram, phase law - colligative properties - hydrogen sulphide - oxides and oxo acids of sulfur - shape of molecules: VSEPR (valence shell electron pair repulsion - weak acids and bases, pKa, pKb - indicators, buffers, Henderson-Hasselbalch-equation

	- acidity of oxo-acids: Bell-Pauling rules - electromotive series, Nernst's equation - coordination chemistry
Literature	Handouts Charles E. Mortimer: *Chemistry: A Conceptual Approach* Brooks Cole; 6th ed. (Dez. 1986)
Teaching Methods	General Chemistry (L), 2 h/week
Estimation of working load	20 h lecture (presence) 24 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	written examination
Grade Composition	Passed or failed
Usability	MSc course of studies Advanced Materials

Synthesis of Inorganic and Organic Materials

Module assigned to 1st semester

Identification Code	2288870120
ECTS-Points	4
Credit Hours	2
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 60 students
Responsible Lecturer	Dr. Ulrich Ziener
Further Lecturer	Dr. Björn Bredenkötter, Prof. Dr. Dirk Volkmer, Dr. Ulrich Ziener
Study Programme	Master degree in Advanced Materials Master degree in Energy Science and Technology compulsory
Prerequisites	BSc degree
Study Objectives	The students should - understand the fundamentals of general chemistry and chemical synthesis with respect to the preparation of organic polymeric and inorganic materials
Module Contents	**First part:** Topics of the course are the basics in Organic Chemistry (nomenclature, functional groups, reactivity) as well as some fundamental applications of standard analytical methods (e.g. UV-, IR- and NMR-spectroscopy, HPLC and mass spectrometry). **Second part:** fundamental terms of polymer chemistry, chemical structure of polymers, molar mass and its distribution, configuration and stereoisomers, step- and chain-growth polymerisation, anionic polymerisation, insertion polymerisation, metathesis polymerisation, free radical polymerisation, polymerisation techniques (solution, suspension, emulsion), copolymerisations, polyaddition, polycondensation, networks, technical polymers.
Literature	Handouts - J. R. Dean, A. M. Jones, D. Holmes, R. Reed, J. Weyers, A. Jones: *Practical Skills in Chemistry* PEARSON - and basic textbooks of Organic Chemistry. - -H.-G. Elias: *An Introduction to Polymer Science* VCH Weinheim 1997, chapters 1-4. - John R. Dean: *Practical Skills in Chemistry* Prentice Hall 2002.
Teaching Methods	Synthesis of Organic and Inorganic Materials (L), 3 h/week

Estimation of working load	40 h lecture (presence) 64 h preparation and postprocessing lecture 16 h exam preparation Total: 120 h
Examinations	written examination
Grade Composition	exam result
Usability	MSc course of studies Advanced Materials

Physical Chemistry
Module assigned to 1st semester

Identification Code	2288870110
ECTS-Points	4
Credit Hours	2
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 60 students
Responsible Lecturer	NN
Further Lecturer	NN
Study Programme	Master degree in Advanced Materials Master degree in Energy Science and Technology compulsory
Prerequisites	BSc degree
Study Objectives	The students should
Module Contents	**A) Quantum Chemistry** 1. Problems with Newton's Classical World 2. The properties of waves and the wave-nature of matter 3. Quantum mechanical description of a simple system -The particle in a box 4. Extension of the model to examples closer to reality - a. The harmonic oscillator (basic model for a vibrating molecule) - b. The hydrogen atom, hydrogen-like ions and atomic orbitals 5. Molecular orbitals **B) Practical Aspects of the Laws of Thermodynamics** 1. The first law: Enthalpy 2. The second law: Entropy, Free-energy and Chemical equilibrium - The third law **C) Reaction Kinetics** 1. The order of a reaction 2. Temperature, the rate of reaction and the position of equilibrium 3. Catalyzed reactions, enzyme reactions
Literature	Handouts
Teaching Methods	Physical Chemistry (L), 2 h/week
Estimation of working load	28 h lecture (presence) 76 h preparation and postprocessing lecture 16 h exam preparation Total: 120 h
Examinations	written examination
Grade Composition	exam result
Usability	MSc course of studies Advanced Materials

PHYSICS

Introductory Solid State Physics

Module assigned to 1st semester

Identification Code	2288870080
ECTS-Points	5
Credit Hours	4
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	Prof. Dr. Paul Ziemann
Further Lecturer	Prof. Dr. Paul Ziemann
Study Programme	Master degree in Advanced Materials compulsory
Prerequisites	BSc degree
Study Objectives	This introductory course aims at providing the basic knowledge as well as some fundamental practical tools of Solid State Physics necessary to understand all the forthcoming more advanced Materials Science courses
Module Contents	a) Basic Classification of Solids by Bonds & Structure b) Lattice Vibrations & Phonons c) Electronic properties of Solids
Literature	- Handouts
Teaching Methods	Introductory Solid State Physics (L), 2 h/week Introductory Solid State Physics (E), 1 h/week
Estimation of working load	42 h lecture (presence) 14 h exercises (presence) 50 h preparation and postprocessing lecture 28 h solution of exercises, postprocessing 16 h exam preparation Total: 150 h
Examinations	written examination
Grade Composition	exam result
Usability	MSc course of studies Advanced Materials

Advanced Physics of Materials

Module assigned to 2nd semester

Identification Code	2288870140
ECTS-Points	4
Credit Hours	3
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof. Dr. Klaus Thonke
Further Lecturer	Prof. Dr. Klaus Thonke
Study Programme	Master degree in Advanced Materials Compulsory for students with major Nanomaterials Elective for students with major Biomaterials
Prerequisites	BSc degree
Study Objectives	
Module Contents	This course is a continuation of the "Intermediate Physics". Thus, a successful attendance of this latter course is necessary. This course aims at providing the basic knowledge to understand physical properties of Solids, which are used to give various materials their function. Emphasis is put on optical, magnetic as well as superconducting properties. Contents: a) Optical properties of Solids b) Magnetic phenomena in Solids c) Superconducting properties of Solids
Literature	- Handouts
Teaching Methods	Introductory Solid State Physics (L), 2 h/week Introductory Solid State Physics (E), 1 h/week
Estimation of working load	28 h lecture (presence) 14 h exercises (presence) 34 h preparation and postprocessing lecture 28 h solution of exercises, postprocessing 16 h exam preparation Total: 120 h
Examinations	written examination
Grade Composition	exam result
Usability	MSc course of studies Advanced Materials

Lab Intermediate Physics

Module assigned to 1st semester

Identification Code	2288870140
ECTS-Points	4
Credit Hours	2
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	Prof. Dr. Paul Ziemann
Further Lecturer	Dr. Ulf Wiewald
Study Programme	Master degree in Advanced Materials Compulsory
Prerequisites	BSc degree
Study Objectives	The students will learn the principles of scientific working, scientific work and management, basic terms, methods and tools
Module Contents	I) X-ray diffraction: Evaporation of Au film at room temperature, short introduction into the problems of Vacuum physics and evaporation techniques, θ- 2θ-measurements on those films, identification of various reflexes, selection rules for fcc, determination of lattice parameters, second measurement on a pre-prepared epitaxially grown Au film, measurement of a low resolution pole figure. II) Thermal conductivity: Temperature dependence (4.2 - 15K, 15K - 77K) of the thermal conductivity of sapphire, quartz, Pb, Cu; this includes the handling of liquid Helium & Nitrogen. III) Electrical conductivity: Temperature dependence (4.2 - 77K) of metals (Cu, Au), a doped Semiconductor (p-Si), Constantan and Superconductors (Pb, YBaCuO), this includes the handling of liquid Helium & Nitrogene. IV) XPS/UPS: XPS/UPS spectra of different metals (Al, Au, $AuAl_2$) as well as non-metals (Si, BN, WO_3) are presented. After a short introduction into the applied methods the following properties should be discussed: Fermi energy, various involved electronic transitions, chemical shifts, line shapes, estimate of near surface stoichiometries.
Literature	- Handouts
Teaching Methods	Laboratory, seminar and report
Estimation of working load	18 h laboratory (presence), 22 h preparation, 80 h home writing report and revision Total: 120 h
Examinations	Seminar, report, certificate
Grade Composition	Passed or failed
Usability	MSc course of studies Advanced Materials

ENGINEERING
Introductory Engineering
Module assigned to 1st semester

Identification Code	2288870070
ECTS-Points	5
Credit Hours	4
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 60 students
Responsible Lecturer	Prof. Dr. Ferdinand Scholz
Further Lecturer	Prof. Dr. Ferdinand Scholz
Study Programme	Master degree in Advanced Materials Compulsory for students with major Nanomaterials Elective for students with major Biomaterials
Prerequisites	BSc degree
Study Objectives	Electrical Engineering: Students should be able to - perform circuit analysis of linear DC and AC (RLC) circuits - analyze transient problems of RLC circuits - understand the basics of crystal and semiconductor physics - understand how basic semiconductor devices work - understand basic treatment/evaluation of measured data - understand conversion of analogue data into digital data, basic treatment of digital data, advantages and problems of digital data processing
Module Contents	- Measurement units, SI units - Basic Electrical Engineering: Charge, voltage, current, power, energy, Kirchhoff's laws, Circuit analysis: Resistive circuits, resistances in series and parallel; network analysis by using series and parallel equivalents, voltage and current dividers, duality, node-voltage analysis, mesh current analysis, Thevenin and Norton equivalent circuits, superposition principle, linearity, Wheatstone bridge; Capacitor, inductor: capacitance, modelling of real elements, inductance, magnetic fields, magnetic circuits, magnetic materials, ideal and real transformers, Maxwell's equations - Analysis of transients: First and second order transient circuits, steady-state sinusoidal analysis: phasors, complex numbers, complex impedances, power in AC circuits, average power etc., Thevenin and Norton equivalent, maximum power transfer, Frequency analysis, filters etc.: Frequency response, logarithmic scale, Bode diagram, low pass, high pass, 2nd order low pass etc. - Fourier and Laplace transformation: Transfer function, step, pulse response, convolution - Semiconductors: Basics of crystallography: Miller's indices, reziprocal lattice, Brillouin zone, Basics of band structure: Naïve band diagram, dis-persion relation, Schrödinger equation, effective mass, concept of hole, direct/indirect band structure, interaction with light, carrier statistics, density of states, Fermi statistics, impurity conduction, mobility, diffusion, Hall effect

	- Diodes: p-n-junction, ideality factor, load line analysis, fabrication, special diodes, pn as capacitance, hetero junction, Schottky diode, compound semiconductors - Transistors: Bipolar transistor, band structure, common base, common emitter, amplification, Field Effect Transistor: Structure, operation, enhancement and depletion; load line analysis - Devices for measurement: Operational amplifier: Basics, adder, subtractor, integrator, differentiator, logarithmiser, instrumentation amplifier - Basics of measurement, errors, statistics: Random and systematic errors, mean value, standard deviation, probability distributions: Binomial, Poisson, Gauss, error propagation, regression - Signal filtering, Noise : Thermal, shot, 1/f, distribution, generation-recombination, noise figure of 4-port, Signal filtering: passive, active, Lock-In, Boxcar, signal transmission - Digital Signal Processing: Binary signals, Binary numbers, Gray code, basic logic operations, adders, flip-flop, Digitization: Basics, sampling theorem, DA and AD converters, Digital filters, z-transformation, Microcomputers, microcontrollers: Building blocks, data storage, data transmission
Literature	Electrical Engineering: - Allan R. Hambley: Electrical Engineering, Prentice Hall, Upper Saddle River, 2002 - Ch. Kittel, Introduction to Solid State Physics, Wiley, New York, 1996 - H.P. Hsu. Schaum's Outlines: Signals and Systems. McGraw-Hill, New York, 1995. - S.M. Sze. Physics of Semiconductor Devices. John Wiley & sons, New York, 1981. - P. Profos and T. Pfeifer. Handbuch der industriellen Messtechnik. R. Oldenbourg, München, 1994.
Teaching Methods	Introductory Engineering (L), 3 h/week Introductory Engineering (E), 1 h/week
Estimation of working load	42 h lecture (presence) 14 h exercises, practical training (presence) 50 h preparation and postprocessing lecture 28 h solution of exercises, postprocessing 16 h exam preparation Total: 150 h
Examinations	Written exam
Grade Composition	Exam result
Usability	MSc course of studies Advanced Materials

Micro- and Nanotechnology

Module assigned to 3rd semester

Identification Code	2288870390
ECTS-Points	4
Credit Hours	3
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	Prof. Dr. Peter Unger
Further Lecturer	Prof. Dr. Peter Unger
Study Programme	Master degree in Advanced Materials Compulsory for students with major Nanomaterials Elective for students with major Biomaterials
Prerequisites	BSc degree
Study Objectives	This course on the Micro- and Nanotechnology provides an advanced understanding of the technology for fabricating structures with micron- and nanometer-scale dimensions.
Module Contents	At the beginning of the course, the basic technological processes for lithography and pattern transfertechniques are discussed. As applications of these technologies, fabrication processes are presented like CMOS and III-V technology, micromechanics, magneticthin-film heads, flat-panel displays, micro optics, x-ray optics and quantum-effect electronic devices. The lectures are accompanied by exercises, where important original publications will be discussed and hands-on experiments in the clean room will be performed.
Literature	- Marc J. Madou: *Fundamentals of Microfabrication, 2nd edition* CRC Press, Bota Raton, 2002. - Henry I. Smith: *Submicron- and nanometer-structures technology, 2nd edition,* NanoStructures Press, 437 Peakham Road, Sudbury, MA 01776, USA, 1994. - L.F. Thompson, C.G. Willson, and M.J. Bowden: *Introduction to Microlithography, 2nd edition* ACS Professional Reference Book, American Chemical Society, 1994. - D.V. Morgan and K. Board: *An introduction to semiconductor microtechnology, 2nd edition* John Wiley & Sons, Chichester 1994. - S.M. Sze: *Semiconductor devices - Physics and technology* John Wiley & Sons, New York 1985.
Teaching Methods	Micro- and Nanotechnology (L), 2 h/week Micro- and Nanotechnology (E), 1 h/week
Estimation of working load	28 h lecture (presence) 14 h exercises, practical training (presence) 34 h preparation and postprocessing lecture 28 h solution of exercises, postprocessing 16 h exam preparation

	Total: 120 h
Examinations	examination of 120 min., precondition: successful participation in exercises
Grade Composition	Exam result
Usability	MSc course of studies Advanced Materials

BIOLOGY - BIOMATERIALS

Introductory Biology and Cell Biology

Module assigned to 1st semester

Identification Code	2288870
ECTS-Points	5
Credit Hours	4
Language	English
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	Prof. Dr. Bernhard Koch
Further Lecturer	Prof. Dr. Bernhard Koch, Prof. Dr. Paul Walther, PD Dr. Andreas Ziegler
Study Programme	Master degree in Advanced Materials Compulsory for students with major Biomaterials Elective for students with major Nanomaterials
Prerequisites	BSc degree
Study Objectives	The students should - be able to understand central problems of Biology and Cell Biology. - be well prepared to for lectures in Biomaterials in 2nd and 3rd semester
Module Contents	BASICS AND ECOSYSTEMS Secondary production in ecosystems The cycling of chemical elements in ecosystems BIOMOLECULES Water and the fitness of the environment Carbon and the molecular diversity of life Structure and function of macromolecules Introduction to metabolism, Enzymes CELLULAR RESPIRATION Harvesting chemical energy CELL MORPHOLOGY AND GENEXPRESSION A tour of the cell Membrane structure and function The cell cycle The molecular basis of inheritance From gene to protein ORGANISMIC AND ANIMAL DIVERSITY The major lineages of life Prokaryotes and the origins of metabolic diversity The origin and early diversification of eukaryote details from animal evolution and groups of invertebrates DEVELOPMENT Animal development FUNCTIONAL ANATOMY An introduction to animal structure and function muscle function Nervous system ENDOCRINOLOGY Chemical signals in animals Blood glucose and adrenal gland CIRCULATION AND GAS EXCHANGE Circulation and gas exchange Gas exchange in animals Intracellular Compartments and Protein Sorting Vesicular Transport Cytoskeleton and Mitosis Structure and function of cellular membranes Cell-cell contacts and cell adhesion

	Structure and function of the extracellular matrix CELLULAR CIRCULATION AND GAS EXCHANGE Circulation and gas exchange Gas exchange in animals Intracellular Compartments and Protein Sorting Vesicular Transport Cytoskeleton and Mitosis Structure and function of cellular membranes Cell-cell contacts and cell adhesion Structure and function of the extracellular matrix CELLULAR RESPIRATION Harvesting chemical energy CELL MORPHOLOGY AND GENEXPRESSION A tour of the cell Membrane structure and function The cell cycle The molecular basis of inheritance From gene to protein ORGANISMIC AND ANIMAL DIVERSITY The major lineages of life Prokaryotes and the origins of metabolic diversity The origin and early diversification of eukaryote details from animal evolution and groups of invertebrates DEVELOPMENT Animal development FUNCTIONAL ANATOMY An introduction to animal structure and function muscle function Nervous system ENDOCRINOLOGY Chemical signals in animals Blood glucose and adrenal gland CIRCULATION AND GAS EXCHANGE Circulation and gas exchange Gas exchange in animals Intracellular Compartments and Protein Sorting Vesicular Transport Cytoskeleton and Mitosis Structure and function of cellular membranes Cell-cell contacts and cell adhesion Structure and function of the extracellular matrix
Literature	Handouts N. A. Campbell, J. B. Reece: BIOLOGY, Benjamin Cummings Publisher, 6th edition (2002)
Teaching Methods	Introductory Biology and Cell Biology (L), 4 h/week
Estimation of working load	55 h lecture (presence) 79 h preparation and postprocessing lecture 16 h exam preparation Total: 150 h
Examinations	examination of 120 min
Grade Composition	Exam result
Usability	MSc course of studies Advanced Materials Biomaterials

Biological Tissues

Module assigned to 2nd semester

Identification Code	2288870160
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof. Dr. biol. hum. Lutz Claes
Further Lecturer	Brenner, Walcher, Kupferschmid, Willie, Haller, Schrezenmaier, Keller, Klass, Scharfetter-Kochanek
Study Programme	Master degree in Advanced Materials Compulsory for students with major Biomaterials Elective for students with major Nanomaterials
Prerequisites	BSc degree Biology, Cell Biology
Study Objectives	The students should - which biological tissues can be (partly) substituted or supported by Biomaterials
Module Contents	1) Cartilage 2) Tendon, ligament 3) Blood vessels, heart 4) Eyes 5) Bone 6) Teeth 7) Blood 8) Kidney 9) Liver/ pancreas 10) Skin
Literature	Handouts
Teaching Methods	Biological Tissues (L), 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	examination of 120 min (together with Applications of Biomaterials and Classes of Biomaterials)
Grade Composition	Exam result
Usability	MSc course of studies Advanced Materials Biomaterials

Classes of Biomaterials

Module assigned to 2nd semester

Identification Code	2288870180
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof. Dr. biol. hum. Lutz Claes
Further Lecturer	Seliger, Doser, Fink, Brenner, Claes, Wenz
Study Programme	Master degree in Advanced Materials Compulsory for students with major Biomaterials Elective for students with major Nanomaterials
Prerequisites	BSc degree Biology, Cell Biology
Study Objectives	The students should - learn about properties, processing and usage of biocompatible materials
Module Contents	1) Polymers 2) Hydrogels 3) Metals 4) Natural Materials 5) Composites 6) Ceramics (Bone Sustitute)
Literature	Handouts
Teaching Methods	Biological Tissues (L), 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	examination of 120 min (together with Biological Tissues and Applications of Biomaterials)
Grade Composition	Exam result
Usability	MSc course of studies Advanced Materials Biomaterials

Applications of Biomaterials

Module assigned to 2nd semester

Identification Code	2288870170
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof. Dr. biol. hum. Lutz Claes
Further Lecturer	Lecturers of the Institute of Orthopaedic Research and Biomechanics
Study Programme	Master degree in Advanced Materials Compulsory for students with major Biomaterials Elective for students with major Nanomaterials
Prerequisites	BSc degree Biology, Cell Biology
Study Objectives	The students should -
Module Contents	
Literature	Handouts
Teaching Methods	Biological Tissues (L), 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	examination of 120 min (together with Biological Tissues and Classes of Biomaterials)
Grade Composition	Exam result
Usability	MSc course of studies Advanced Materials Biomaterials

Degradation of Biomaterials

Module assigned to 3rd semester

Identification Code	2288870300
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof. Dr. biol. hum. Lutz Claes
Further Lecturer	
Study Programme	Master degree in Advanced Materials Compulsory for students with major Biomaterials Elective for students with major Nanomaterials
Prerequisites	BSc degree Biology, Cell Biology
Study Objectives	Degradation of Biomaterials
Module Contents	
Literature	Handouts
Teaching Methods	Host reactions to Biomaterials (L), 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	examination of 120 min (together with Host Reactions to Biomaterials and Testing of Biomaterials)
Grade Composition	Exam result
Usability	MSc course of studies Advanced Materials

Host Reactions to Biomaterials

Module assigned to 3rd semester

Identification Code	2288870350
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof. Dr. biol. hum. Lutz Claes
Further Lecturer	Wendel, Ignatius, Neidlinger-Wilke, Brenner
Study Programme	Master degree in Advanced Materials Compulsory for students with major Biomaterials Elective for students with major Nanomaterials
Prerequisites	BSc degree Biology, Cell Biology
Study Objectives	Host reactions to Biomaterials
Module Contents	1) Blood reactions to biomaterials (Wendel) 2) In vitro cell-biomaterials reactions (Ignatius) 3) In vivo tissue reactions to biomaterials (Neidlinger-Wilke) 4) Systematic effects of biomaterials (Brenner)
Literature	Handouts
Teaching Methods	Host reactions to Biomaterials (L), 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	examination of 120 min (together with Degradation of Biomaterials and testing of Biomaterials)
Grade Composition	Exam result
Usability	MSc course of studies Advanced Materials

Testing of Biomaterials

Module assigned to 3rd semester

Identification Code	2288870300
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof. Dr. biol. hum. Lutz Claes
Further Lecturer	
Study Programme	Master degree in Advanced Materials Compulsory for students with major Biomaterials Elective for students with major Nanomaterials
Prerequisites	BSc degree Biology, Cell Biology
Study Objectives	Testing of Biomaterials
Module Contents	
Literature	Handouts
Teaching Methods	Host reactions to Biomaterials (L), 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	examination of 120 min (together with Host Reactions to Biomaterials and Degradation of Biomaterials)
Grade Composition	Exam result
Usability	MSc course of studies Advanced Materials

Production of Biomaterials

Module assigned to 3rd semester

Identification Code	
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	Winter term, 20 students
Responsible Lecturer	Prof. Dr. biol. hum. Lutz Claes
Further Lecturer	Lecturers of the Faculties of Medicine and Natural Science
Study Programme	Master degree in Advanced Materials Compulsory for students with major Biomaterials Elective for students with major Nanomaterials
Prerequisites	BSc degree
Study Objectives	The students should gain a knowledge of properties, processing and usage of biocompatible materials
Module Contents	Commercial production of Biomaterials -Excursions to different companies Whole day excursions to different companies, where different labs, processing halls and plants are visited. Often combination with an additional lecture.
Literature	Handouts
Teaching Methods	Seminars
Estimation of working load	Excursions 30 hs presence and 30 hs home
Examinations	Attendance of all excursions
Grade Composition	Certificate
Usability	MSc course of studies Advanced Materials

NANOMATERIALS

Functional Properties of Nanomaterials

Module assigned to 3rd semester

Identification Code	2288870330
ECTS-Points	34
Credit Hours	2
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	PD Dr. Joachim Bansmann,
Further Lecturer	PD Dr. Joachim Bansmann,
Study Programme	Master degree in Advanced Materials Compulsory for students with major Nanomaterials Elective for students with major Biomaterials
Prerequisites	BSc degree
Study Objectives	In the first part, the course aims at introducing state of the art approaches of how to prepare and characterize various nanostructures. The second part focuses on physical properties like electronic, optic and magnetic properties of nanostructures which are due to their dimensional constraints
Module Contents	I.. Introduction Nanoscience: What is it all about? Examples, Approaches, Perspectives II.. Analytical Tools in Nanoscience a) STM/STS b) AFM c) SEM d) TEM III. Preparations & Properties of Nanostructures A. Top-down Approaches & New Materials 1. Optical Lithography 2. Lithographic Etching - Wet etching - Dry etching 3. Electron Beam Lithography 4. Clusters 5. Fullerenes & Nanotubes B. Bottom-up Approaches 1. STM/AFM-manipulations 2. Self-assembled monolayers 3. Colloidal approach 4. Micellar approach C. Electronic & Optical Properties 1. Level spacing 2. Coulomb-blockade & single electron effects 3. Semiconducting quantum dots D. Magnetic Properties

	1. Magnetic Anisotropy 2. Stoner-Wohlfahrth Model, Superparamagnetism 3. Magnetoresistance Overview: AMR, GMR, TMR, CHR
Literature	- Handouts
Teaching Methods	- Functional Properties of Nanomaterials (L), 3 h/week
Estimation of working load	28 h lecture (presence) 46 h preparation and postprocessing lecture 16 h exam preparation Total: 90 h
Examinations	written examination
Grade Composition	exam result
Usability	MSc course of studies Advanced Materials

Principles of structure formation in nanomaterials

Module assigned to 3rd semester

Identification Code	2288870410
ECTS-Points	5
Credit Hours	4
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	Prof.Dr. Katharina Landfester
Further Lecturer	Prof. Dr. Katharina Landfester, PD. Dr. Elena Mena-Osteritz, Prof. Dr. T. Bernhardt, Prof. Dr. J. Behm
Study Programme	Master degree in Advanced Materials Compulsory for students with major Nanomaterials Elective for students with major Biomaterials
Prerequisites	BSc degree
Study Objectives	
Module Contents	Polymeric Materials: 1. Block copolymers 2. Liquid-crystalline polymers 3. Semiconducting and conducting polymers 4. Nanolithography with Polymers 5. Molecular Imprinting Surface Structuring and Nanoparticles 1. classes of chemical reactions/processes 2. growth modes in growth processes 3. elementary surface processes during film growth 4. applications of nanoparticles is their use in Heterogeneous Catalysis, as part of supported catalysts 5. basic types of bimolecular catalytic reactions 1 .Van der Waals interaction 2. Interaction forces 3. Electrostatic interaction between systems Cluster Based Materials 1. Chemisorption (dissociative or molecular) and molecular physisorption. 2. Clusterstructure calculations based on the Lennard-Jones (LJ) interaction potential 3. cluster mass spectra 4. Carbon cluster structures 5. One-dimensional metal structures
Literature	- Handouts

Teaching Methods	- Principles of structure formation in nanomaterials (L), 4 h/week
Estimation of working load	42 h lecture (presence) 92 h preparation and postprocessing lecture 16 h exam preparation Total: 150 h
Examinations	written examination
Grade Composition	exam result
Usability	MSc course of studies Advanced Materials

GERMAN LANGUAGE

German Language

Module assigned to 1st, 2nd and 3rd semester

Identification Code	
ECTS-Points	8
Credit Hours	10
Language	english
Length of the Module	3 semester
Date and Capacity	winter and summer term 30 students
Responsible Lecturer	Dr. Timm, Ms Husemann
Further Lecturer	Ms Kathrin Husemann, Ms Sabine Hagen, Ms Frauke Nowak-Arendt Lecturers of the Center of Languages
Study Programme	Master degree in Advanced Materials compulsory
Prerequisites	BSc degree
Study Objectives	The students should be able to talk and understand German
Module Contents	German language I - Words and phrases - People, travelling - Supermarket - Rent a room, buying furnitures - Talks, discussion - Grammar German language II - Grammar - Talks, discussion, - Writing German language III - Grammar - Talks, discussion - Writing
Literature	- Handouts - H. Aufderstraße, J. Müller, T. Starz, Delfin: *Lehrbuch und Arbeitsbuch* Max Hueber Verlag
Teaching Methods	Seminars, 4 h/week (1st and 2nd semester), 2h/week (3rd semester)
Estimation of working load	140 h seminars (presence) 76 h preparation and postprocessing seminars 24 h exam preparation Total: 240 h
Examinations	written examination
Grade Composition	Passed or failed
Usability	MSc course of studies Advanced Materials

ELECTIVE COURSES
Advanced Engineering

Compound semiconductors: Physics, technology and device concepts
Module assigned to 2nd semester

Identification Code	
ECTS-Points	4
Credit Hours	3
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof. Dr. Ferdinand Scholz
Further Lecturer	Prof. Dr. Ferdinand Scholz
Study Programme	Master degree Electrical Engineering Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	The lecture covers physics and technology of modern compound semiconductors with major focus on III-V compounds like GaAs and related materials. These semiconductors are indispensable for modern optoelectronic devices like LEDs (all color visible, infrared, ultraviolet), laser diodes, photodetectors etc. where silicon is useless due to its indirect band structure. Moreover, they find applications as high frequency electronic devices in modern communication systems like mobile phones etc. In the lecture, we will discuss the physics which enables these applications, the preparation of the materials, epitaxial structures and devices and some particular characterisation methods.
Module Contents	Semiconductors, Compound Semiconductors Bulk crystal growth, liquid phase epitaxy, vapor phase epitaxy, molecular beam epitaxy Optical processes, spectroscopic methods, x-ray diffraction Electrical characterization methods Strain in semiconductor structures Low-dimensional structures: quantum wells, wires, dots Short Wavelength materials: Group III nitrides Semiconductor LEDs and Laser diodes Electronic devices: HEMTs, HBTs Solar Cells
Literature	Handouts
Teaching Methods	Advanced Engineering(L), 2 h/week, (E) 1h/week

Estimation of working load	28 h lecture (presence) 14 h exercises (presence) 34 h preparation and postprocessing lecture 28 h solution of exercises, postprocessing 16 h exam preparation Total: 120 h
Examinations	written examination
Grade Composition	exam result
Usability	MSc course of studies Advanced Materials

Basics of TEM

Module assigned to 2nd semester

Identification Code	
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof. Dr. Ute Kaiser
Further Lecturer	Prof. Dr. Ute Kaiser
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	Students should learn - theory and basics of Transmission Electron Microscopy
Module Contents	Transmission Electron Microscopy is a basic characterisation method in advanced materials science. In this course we will give you an introduction into the basic components of a transmission electron microscope, into its electron optics and to kinematical and dynamical theory of electron scattering.
Literature	
Teaching Methods	Basics of TEM (L) 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	written examination
Grade Composition	result of exam
Usability	MSc course of studies Advanced Materials

Cell Interaction with Biomaterials and Imaging Techniques

Module assigned to 2nd semester

Identification Code	
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Dr. Ralf Kemkemer
Further Lecturer	Dr. Ralf Kemkemer
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	This lecture introduces some basic features and physical models of cell adhesion and interaction with physically and chemically micro- and nano-structured materials
Module Contents	Special emphasis is on recent developments in that rapidly growing field: I. Introduction to the cell and cytoskeleton and adhesion elements II. Interaction of cells with topographical features of surfaces and response to physical and chemical structures of materials III. Design and application of nanostructured materials for cellular biotechnology IV. Imaging techniques for cell studies (fusion proteins, FRET)
Literature	handouts
Teaching Methods	Cell Interaction with Biomaterials and Imaging Techniques (L) 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	written examination
Grade Composition	result of exam
Usability	MSc course of studies Advanced Materials

Colloids

Module assigned to 2nd semester

Identification Code	
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof. Dr. Katharina Landfester
Further Lecturer	Prof. Dr. Katharina Landfester
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	The course covers the most fundamental principles of colloid chemistry
Module Contents	Historical background Definition of colloidal systems Electrostatic stabilization (DLVO theory) Steric stabilization Thermodynamics of interfaces Surfactants Macro-, Mini-, Microemulsions Preparation of Nanoparticles
Literature	Handouts
Teaching Methods	Colloids(L), 1 h/week
Estimation of working load	28 h lecture (presence) 764 h preparation and postprocessing lecture 16 h exam preparation Total: 120 h
Examinations	written examination
Grade Composition	exam result
Usability	MSc course of studies Advanced Materials

Mechanics of Materials

Module assigned to 2nd semester

Identification Code	
ECTS-Points	3
Credit Hours	2
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof. Dr. Carl Krill
Further Lecturer	Dr. J.-H. You
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	Introduction into all relevant methods describing mechanical behavior and mechanical properties of materials
Module Contents	**Topics** 1. Introduction i. Equilibrium conditions, internal forces ii. Stress iii. Strain iv. Generalized Hooke's law 2. Axial loading i. Deformations ii. Thin-walled pressure vessels 3. Flexural loading i. Stresses a. introduction b. elastic flexure formula c. shear forces and bending moments d. shear stress ii. Deflections a. introduction b. deflections by integration c. singularity functions d. deflections by superposition e. deflections due to shearing stress iii. Statically indeterminate systems 4. Torsional loading i. Stress ii. Displacements iii. Thin-walled tubes—shear flow

	5. Stress and strain transformation i. Stress transformation equations for plane stress ii. Principle stresses iii. Mohr's circle for plane stress iv. General stress state 6. Combined loading i. Special cases ii. Theories of failure
Literature	W. F. Riley, L. D. Sturges and D. H. Morris, *Mechanics of Materials,* 5th ed. (Wiley, New York, 1999). Note: several copies are available in the university library's "Lehrbuchsammlung." R. C. Hibbeler, *Mechanics of Materials,* 6th ed. (Pearson Prentice Hall, Upper Saddle River, NJ, 2005).
Teaching Methods	Mechanics of Materials (L) 2 h/week
Estimation of working load	28 h lecture (presence) 46 h preparation and postprocessing lecture 16 h exam preparation Total: 90 h
Examinations	written examination
Grade Composition	result of exam
Usability	MSc course of studies Advanced Materials

Polymers in Medicine

Module assigned to 2nd semester

Identification Code	
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Dr. Andreas Boger
Further Lecturer	Dr. Andreas Boger
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	Polymers are widely used in medical applications – from the simple drug delivery syringe to Biomaterials which are implanted into the body for a long term. Purpose of the lecture is to give an idea about daily work in industrial R&D on Biomaterials and special aspects of the development of improved osteosyntheses implants.
Module Contents	1. Introduction 2. What can be done with polymeric Biomaterials 3. Biomaterials Definition History Overview 4. Examples of the use of metallic, ceramic, plastic Biomaterials 5. Polymers used in Medicine 6. Historical development of Plastics in Medical Engineering 7. Election criteria for Biomaterials 8. Material properties & functionality / performance 9. Categories of Medical products 10. Regulation of Medical Devices 11. Validation Definition Content, steps 12. Sterilization methods Radiation (γ -, e-beam) sterilization Gas (Ethylenoxid) sterilization 13. Define Functional design requirements for injectable implant material Video of vertebroplasty Surgery 14. Injectable implant material (VP-implant material) a) Injection Biomechanics Factors defining the injctabiltiy (viscosity, pressure,..) Adaptation of the rheolgical properties implant material to the application b) X-ray density Basics on x-ray attenuation Testing of radiopacity (X-ray density)

	c) Mechanical adaptation of current implant material (PMMA) Porous PMMA as compliant material for cancellous bone Biomechanical testing of polymeric material 15. Resorbable polymers Resorbable material – applications, properties, manufacturing – reinforced resorbable material Tuning of implant surface / Functionalization of osteosynthese implants Polymers to improve implants Coated intramedular nails – drug delivery devices as combination device (background, clinical problem, principles, properties, process technology,) Drawback when titanium is replaced with polymer? Plasma spraying on polymers to improve osteointegration - Ti coated Carbon Fiber, reinforced PEEK
Literature	Handouts
Teaching Methods	Polymers in Medicine (L), 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	examination of 120 min
Grade Composition	Exam result
Usability	MSc course of studies Advanced Materials

Sensors and Actuators
Module assigned to 2nd semester

Identification Code	2288870250
ECTS-Points	5
Credit Hours	4
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof.Dr.-Ing. Erhard Kohn
Further Lecturer	Prof.Dr.-Ing. Erhard Kohn
Study Programme	Master degree in Advanced Materials Elective
Prerequisites	BSc degree
Study Objectives	Introduction in Si-based Semiconductor sensors
Module Contents	Aquisition of radiation, magnetic fields, mechanical forces, temperature, MSTbasics
Literature	- Sze, S.M.: *Physics of Semiconductor Devices* John Wiley &Sons Inc., 1981
Teaching Methods	Sensors and Actuators (L), 3 h/week Sensors and Actuators (L), 1 h/week
Estimation of working load	42 h lecture (presence) 14 h exercises, practical training (presence) 50 h preparation and postprocessing lecture 28 h solution of exercises, postprocessing 16 h exam preparation Total: 150 h
Examinations	examination of 120 min., precondition: successful participation in exercises
Grade Composition	Exam result
Usability	MSc course of studies Advanced Materials

Solid State Chemistry
Module assigned to 2nd semester

Identification Code	
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Prof. Dr. Nicola Hüsing
Further Lecturer	Prof. Dr. Nicola Hüsing
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	The lecture covers the most fundamental principles of modern solid state chemistry, i. e. structures, properties, syntheses and applications of solid materials. Besides minerals and bulk materials, today's advanced materials serve to illustrate these basics.
Module Contents	1. Structure of solids: Close packing, basic structure types, complex structures, structure of nanomaterials 2. Basic crystallography: unit cells, symmetry elements, spacegroups, "International Tables for Crystallography" 3. Characterization of solids I: diffraction techniques 4. Characterization of solids II: electron microscopy, spectroscopy, thermal analysis 5. Bonding in solids: Ionic bonding, metallic bonding, band structure, concepts to predict structures 6. Real structure of crystals: defects, solid solutions, extended defects and nanostructures 7. Electrical, magnetic and optical properties: semiconductivity, superconductivity, ionic conductivity, ferromagnetism, luminescence 8. Synthesis of solids: solid state reaction, sol-gel method, hydrothermal synthesis, vapor phase transport, methods for crystal growth 9. Structure-property relations I: zeolites 10. Structure-property relations II: nanomaterials
Literature	Handouts
Teaching Methods	Solid State Chemistry(L), 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	written examination
Grade Composition	exam result
Usability	MSc course of studies Advanced Materials

Applications of Transmission Electron Microscopy

Module assigned to 3rd semester

Identification Code	
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	Prof. Dr. Ute Kaiser
Further Lecturer	Prof. Dr. Ute Kaiser
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	Introduction into newest development of TEM
Module Contents	New generation electron microscopes equipped with a corrector for the spherical aberration of lenses have great potential in NanoScience for solving questions on the functionality of nanostructures. In this course we will give you an introduction into new imaging, diffraction and spectroscopic possibilities of transmission electron microscopy.
Literature	Handouts
Teaching Methods	Applications of Electronmicroscopy, (L) 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	Written exam
Grade Composition	result of exam
Usability	MSc course of studies Advanced Materials

Biosensors

Module assigned to 3rd semester

Identification Code	
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	summer term 30 students
Responsible Lecturer	Dr. Alberto Pasquarelli, Prof. Dr. Hermann Schumacher
Further Lecturer	Dr. Alberto Pasquarelli
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree. Basic knowledge of chemistry and biochemistry help understanding the biological part of biosensors.
Study Objectives	▪ Basic principles and techniques used in biosensors ▪ Informations on fabrication technologies ▪ Description of research, clinical and industrial applications
Module Contents	▪ Introduction to biosensors ▪ Applications overview ▪ Detection methods: physical, interfacial, biological ▪ Biochip technologies: DNA and protein chips, Ion-channel devices, MEA and MTA, Inplants ▪ Introduction to microfabrication - Extras: invited talk(s), experimental exercise, excursion
Literature	
Teaching Methods	Biosensors (L) 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	written examination
Grade Composition	result of exam
Usability	MSc course of studies Advanced Materials

Cell Mechanics and Interactions with Biomaterials

Module assigned to 3rd semester

Identification Code	
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	Dr. Ralf Kemkemer
Further Lecturer	Dr. Ralf Kemkemer
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	Cells are very adaptive Systems and respond to various external Signals. Besides chemical Stimuli, cells react to mechanical manipulations as wells as to physical properties of the materials they interact with. Studies of the mechanics of Single cells, subcellular components and biological molecules have rapidly evolved during the past decade with significant implications for biotechnology, tissue engineering, and human health. This lecture introduces some basic features of the deformation of Single cells and the interaction of cells with physically and chemically micro- and nano-structured materials. Special emphasis is on recent developments in that rapidly growing field.
Module Contents	1. Introduction to the cell and cytoskeleton elements 2. Basics mechanical properties of filaments and networks 3. Experiments for mechanical probing and manipulation of single cells, - measuring the elastic properties of cells - mechanical manipulation of cells - how does it sense mechanical forces - what force can a cell apply during cell movement 4. Interaction of cells with topographical features of surfaces sensing and response to physical and chemical structures of materials 5. Design and application of nanostructured materials for cellular biotechnology
Literature	handouts
Teaching Methods	Cell Interaction with Biomaterials and Imaging Techniques (L) 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	written examination
Grade Composition	result of exam
Usability	MSc course of studies Advanced Materials

Exploring the Nanoworld with X-Rays and High-Energy Electrons

Module assigned to 3rd semester

Identification Code	
ECTS-Points	3
Credit Hours	2
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	Prof. Dr. Ute Kaiser
Further Lecturer	Prof. Dr. Ute Kaiser, Prof. Ph. D. Carl Emil Krill, Prof. Dr.-Ing. Ulrich Herr
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	Selected topics of research and methods in Nanophysics and Nanoengineering
Module Contents	Scattering of x-rays and electrons - elastic scattering - background info: biographies of Röntgen, Bragg/Bragg, Ruska - application: Ewald sphere—x-ray diffraction vs. TEM Inelastic scattering of x-rays and electrons - theory of absorption - applications: EBSD Diffraction from crystals—Bragg peak intensities - structure factor - intensity analysis (Rietveld) - indexing complex powder diffraction patterns - application: macromolecular crystallography Diffraction from crystals—Bragg peak shapes - peak shape analysis (Fourier methods) - size/strain separation (Warren-Averbach) - application: characterization of nanocrystalline materials X-ray reflectometry - Fresnel equation - effect of interface roughness - methods for simulation - application: analysis of thin-film thickness, multilayers Magnetic lenses and lens aberrations - magnetic focusing of electrons - sources of lens aberrations - application: CS-corrector High-resolution TEM

	- phase and amplitude contrast - contrast transfer function - application: multislice simulation, Atomic-resolution Z-contrast - Z-contrast , STEM, TEM - application: atomic-resolution imaging, EELS, energy-filtered TEM Holography - amplitude vs. phase information - light holography - electron holography - application: magnetic microstructure of bacteria Lorentz microscopy - magnetic contrast - imaging conditions - application: magnetic "ripple" in thin films, Abrikosov lattice Electron tomography (Bright-field, Z-contrast) - imaging (Z-contrast, Amplitude Contrast) - principles of image reconstruction, visualization - application: materials science - application life science X-ray tomography - sources of contrast (absorption, phase, diffraction, fluorescence) - reconstruction artefacts - applications: CT of human bone under mechanical loading, metallic foams X-ray microscopy - x-ray lenses (Fresnel, refraction) - concepts for 3-D resolution - application: growth of individual grains during recrystallization Focused ion beam - ion irradiation - imaging with ion beam - single vs. dual-beam units - application: sample preparation, lithography, electron tomography Small-angle x-ray scattering (SAXS) - theory - measurement apparatus - application: nanoparticle growth, ferrofluid characterization
Literature	handouts
Teaching Methods	Exploring the Nanoworld (L) 1 h/week
Estimation of working load	28 h lecture (presence) 52 h preparation of presentation and postprocessing seminar 10 h seminar (presence) an presentation Total: 90 h
Examinations	Presentation, report
Grade Composition	result of presentation and report
Usability	MSc course of studies Advanced Materials

Laser, Laser-Matter Interactions

Module assigned to 3rd semester

Identification Code	2288870370
ECTS-Points	3
Credit Hours	2
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	PD Dr. Alwin Kienle
Further Lecturer	PD Dr. Alwin Kienle
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	- to understand the physics and techniques of lasers - to gain a broad overlook concerning the variety of lasers and possible applications - to understand the various interaction mechanisms of laser radiation with materials - to be prepared to use lasers in practice - to be able to select appropriate lasers and laser parameters for a given task - to train presentation skills: lecture, presentation (powerpoint) material, script
Module Contents	The course consists of: - lectures (16 h) - short seminar presentations (textbook level) (4h) - extended presentations (scientific level) (8 h) - exercises (class discussions of homework) (2h) - demonstrations (2h) Syllabus: - physical background of generation of laser radiation - setup of lasers - characterization of laser radiation - transport and focussing of laser radiation - physical and technical properties of laser types - theoretical description of light, - optical properties of dielectrics, semi-conductors, metals - modelling of reflection, absorption, scattering, and light distribution Fresnel, Lorentz, Rayleigh, Mie, Boltzman transport Monte Carlo - time scales of excitation and relaxation - photochemical effects - heating and heat transport, heat confinement - melting, surface vaporisation - special laser induced phase changes: confined boiling, phase explosions - plasma formation - mechanical side effects, pressure confinement, shock waves, spallation

	- modelling of laser ablation - dependence of effects on laser parameters - laser applications in material processing - laser applications in material production - laser applications physics, biology, and medicine
Literature	Handouts: Reference texts: a) General - J. F. Ready, D.F. Farson: *LIA Handbook of Laser Materials Processing,* Laser Institute of America, 2001 - M. von Allmen: *Laser-Beam Interactions with Materials* Springer, 1987 - D. B. Suerle: *Laser Processing and Chemistry* Springer, 2000 - W.M. Steen: *Laser Material Processing* Springer, 2003 b) Laser physics - W. Koechner: *Solid-State Laser Engineering* Springer, 1996 - F.K. Kneubühl, M.W. Sigrist: *Laser* Teubner, 1999 - *dtv-Atlas zur Atomphysik* dtv, 1980 c) Optical properties of matter and light propagation - Bergmann, Schaefer: *Lehrbuch der Experimentalphysik,* Band 3, Optik, de Gruyter, 1993 - Bergmann, Schaefer: *Lehrbuch der Experimentalphysik* Band 6, Festkörper, de Gruyter, 1992 - C.F. Bohren, D.R. Huffmann: *Absorption and Scattering of Light by Small Particles* Wiley, 1983 - *Handbook of Chemistry and Physics* CRC, 1986 d) Laser material interactions - R. Hibst: *Technik, Wirkungsweise und medizinische Anwendung von Holmium-und Erbium-Lasern* ecomed, 1997 - A.L. McKenzie: *Physics of thermal laser-tissue interaction* Phys. Med. Biol. 1990, Vol. 35, No. 9, pp. 1175-1209 - A.L. Lehninger: *Prinzipien der Biochemie* de Gruyter, 1987
Teaching Methods	Laser, Laser/Material-Interaction, and Applications (L), 1 h/week Laser, Laser/Material-Interaction, and Applications (L), 1 h/week
Estimation of working load	14 h lecture (presence) 14 h exercises, practical training (presence) 18 h preparation and postprocessing lecture 28 h solution of exercises, postprocessing 16 h exam preparation Total: 90 h
Examinations	examination of 120 min., precondition: successful participation in exercises
Grade Composition	Exam result
Usability	MSc course of studies Advanced Materials

Thin Films

Module assigned to 3rd semester

Identification Code	
ECTS-Points	3
Credit Hours	3
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	Prof. Dr. Ulrich Herr
Further Lecturer	Prof. Dr. Ulrich Herr
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	Understanding of thin film technology and processing techniques. Critical assessment of property changes in thin films with respect to bulk materials. Understand microstructure/property relationshipsin thin films.
Module Contents	1. Vacuum science and technology - Kinetic gas theory, application - Vacuum pumps and measurement 2. Thin film growth techniques - Evaporation - Sputtering 3. Substrate surface and nucleation - Thermodynamics and kinetics of nucleation and growth 4. Epitaxy - Lattice misfit and defects - Mechanisms and characterization 5. Film structure - Structural morphology - Grain growth, texture, microstructure control - Amorphous thin films 6. Mechanical properties of thin films - Internal stresses : origin and analysis - Mechanical relaxation effects 7. Magnetic properties of thin films - Micromagnetism - Magnetic structures in thin films 8. Applications - Magnetic recording media - Magnetoelectronics
Literature	- M. Ohring, Materials Science of Thin Films, Academic Press, 2002 - R. Waser (ed.), Nanoelectronics and Information Technology, Wiley VCH, 2003
Teaching Methods	Thin Films (L) 2 h/week, (E) 1 h/week
Estimation of working load	28 h lecture (presence) 32 h preparation and postprocessing lecture 14 h exercises (presence)

	16 h exam preparation Total: 90 h
Examinations	written examination
Grade Composition	result of exam
Usability	MSc course of studies Advanced Materials

Micro- and Nanostructured Optics

Module assigned to 3rd semester

Identification Code	
ECTS-Points	1
Credit Hours	2
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	Dr. Robert Brunner
Further Lecturer	Dr. Robert Brunner
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	The shrinking of optical dimensions down to the micro- and nanometer scale is opening new approaches to design and to realize optical devices and systems with divers and fascinating opportunities. The application spectrum ranges from consumer optics, e.g. micro-mirror devices for projection displays, up to sophisticated, high performance systems in deep-UV lithography or in space science. Learned lessons from nature and also the introduction of new bottom-up structuring techniques is meanwhile shifting optical features sizes down to the nanometer range The goal of the course is to present a selection of topics of micro- and nanooptics and to develop and to expand an intuitive understanding of the application potentials in this field and the technological challenges.
Module Contents	• refractive and diffractive microoptics • fabrication techniques: e.g. e-beam-, laser- ,interference lithography • replication processes • microoptical mechanical systems (MOEMS) • hybrid optics • nanostructured optics • moth-eye effect • near field optics
Literature	Handouts
Teaching Methods	Micro- and nanostructured Optics(L), 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	written examination
Grade Composition	exam result
Usability	MSc course of studies Advanced Materials

Innovation Management for Nanotechnology From Science to Technology to Markets

Module assigned to 3rd semester

Identification Code	
ECTS-Points	3
Credit Hours	3
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	Dr. Stefan Altmann
Further Lecturer	Dr. Stefan Altmann
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	Students will learn a broad overview of what is progressing in the field of nanoscale systems today
Module Contents	Nanotechnology is expected by many to become one of the key technological developments in the 21st century. Nanotechnology is so promising because it is not simply scaled down microtechnology. Consequently, it is – and probably will be so for some time to come - strongly linked to Nanoscience, a young and strongly interdisciplinary field of research. Between the Nanosciences and Nanotechnology is where experts in the Natural Sciences, Engineering, Medicine and other fields join forces to jointly drive novel developments and create new solutions. With increasing speed, the Material and Life Sciences are picking up on these novel developments and transferring them to daily applications, thus opening new markets with potentials, sometimes exaggerated but often simply too promising to pass by. The idea behind this lecture is to give you a broad overview of what is progressing in the field of nanoscale systems today. I would like to analyze and discuss the scientific, technological and market potentials - and risks - of Nanotechnology. **Content of course:** · Introduction Definition and Relevancy Class Work: Nanoscience—fundamental new laws · Tools of Nanotechnology Chromatographies & Spectroscopies Microscopies & Nanomanipulation Case: From Tools to Technology · Nanoscience Nanochemistry & Nanophysics Nanobiology & Nanomedicine Case: from Nanoscience to Nanotechnology

	· Nanoprojects Translating Science into Technology Project Management for Nanotechnology Class-Work: Bringing Your Work to Market · Nanotechnology as Enabler for Industries Transportation & Construction Optics & Electronics Pharma & Medicine Case: from Nanotechnology to Nanomarkets · Nanomarkets Technology Push from Nanotech - solutions needed Market Pull for Nanotech - where it comes from Future Opportunities Created by Nanoscience Existing and Growing Markets Class Work: Markets and Society · Nanofinance Financing Nanotechnology Portfolio Management for Nanotechnology · Nanocare Societal Concerns Real and Apparent Dangers Ensuring Sustainable Business Success · Nanovision Needs Drive Innovation Coming Technologies Markets of Tomorrow
Literature	Meeting the Challenge of Sustainable Mobility, by Harry Geerlings Springer, Berlin (1999) The Company of the Future by Hans G. Danielmeyer, Yasutsugu Takeda Springer, Berlin (1999) Nano-Stocks. Profitieren Sie von der nächsten industriellen Revolution by Marco Beckmann, Philip Lenz Börsenmedien (2004) Nanotechnology. Assessment and Perspectives by Harald Brune, u. a. Springer, Berlin (2006) What is what in Nanoworld. A Handbook on Nanoscience and Nanotechnology by Victor E. Borisenko, Stefano Ossinici Wiley-VCH (2004) Nanotechnologie - Aufbruch ins Reich der Zwerge by Klaus Jopp Gabler (2006) Springer Handbook of Nanotechnology by Bharat Bhushan, a.o. Springer, Berlin (2006)
Teaching Methods	Nanotechnology (L) 2 h/week
Estimation of working load	28 h lecture (presence) 16 h preparation and postprocessing lecture 8 h seminar (presence) 30 h seminar, presentation, report 8 h excursion (BASF) Total: 90 h
Examinations	Presentation, report
Grade Composition	result of exam
Usability	MSc course of studies Advanced Materials

Theory in Materials Science

Module assigned to 3rd semester

Identification Code	
ECTS-Points	2
Credit Hours	1
Language	english
Length of the Module	1 semester
Date and Capacity	winter term 30 students
Responsible Lecturer	Dr. Igor Potemkin, Prof. Dr. Alexei Khokhlov
Further Lecturer	Dr. Igor Potemkin, Prof. Dr. Alexei Khokhlov
Study Programme	Master degree in Advanced Materials elective
Prerequisites	BSc degree
Study Objectives	The course is called to show the basic physical properties of various polymeric systems
Module Contents	**1 Introduction to Polymer Physics** **2 Flexibility of a polymer chain. Flexibility mechanisms** 2.1 Flexibility mechanisms 2.2 Portrait of a polymer coil 2.3 Ideal Polymer Chain 2.4 Kuhn segment length of a polymer chain 2.5 Persistent length of a polymer chain 2.6 Stiff and flexible chains 2.7 Polymer volume fraction inside ideal coil 2.8 Radius of gyration of ideal chain 2.9 Gaussian distribution for the end-to-end vector for ideal chain **3 High Elasticity of Polymer Networks** 3.1 The property of high elastisity 3.2 Elasticity of a Single Ideal Chains 3.3 Elasticity of a polymer network (rubber) **4 Viscoelasticity of Entangled Polymer Fluids** 4.1 Main properties of entangled polymer fluids 4.2 Viscosity of fluids 4.3 The property of viscoelasticity 4.4 Theory of reptations 4.5 The method of gel-electrophoresis in application to DNA molecules 4.6 Gel permeation chromatography **5 Swelling and Collapse of Single Polymer Molecules and Gels** 5.1 Basic physical effects 5.2 Simplified polymer chain models for the consideration of polymer chains with interacting monomer units 5.2.1 Model of beads on a Gaussian filament 5.2.2 Lattice model 5.3 Concept of θ -temperature 5.4 The excluded volume problem 5.5 Swelling of polymer gels 5.6 Superabsorbing properties of polyelectrolyte gels

	5.7 Coil-Globule Transition. 5.8 Collapse of polyelectrolyte gels **6 Concentrated polymer solutions** 6.1 Possible concentration regimes of polymer solution 6.2 Screening of excluded volume in semidilute and concentrated polymer solutions 6.3 Polymer coil dimensions in semidilute solutions: example of scaling arguments 6.4 Behavior of polymer solutions in poor solvent 6.4.1 Free energy of polymer solution in the Flory-Huggins theory 6.4.2 Conditions for macroscopic phase separation 6.4.3 Phase diagram for polymer solutions **7 Other polymer systems** 7.1 Polymer mixtures 7.2 Microphase separation in block-copolymers 7.3 Liquid-crystalline ordering in polymer solutions 7.4 Basic properties of polyelectrolytes
Literature	A.Yu. Grosberg, A.R. Khokhlov, Statistical Physics of Macromolecules, AIP Press, New York, 1994
Teaching Methods	Theory in Materials Science, (L) 1 h/week
Estimation of working load	14 h lecture (presence) 30 h preparation and postprocessing lecture 16 h exam preparation Total: 60 h
Examinations	Written exam
Grade Composition	result of exam
Usability	MSc course of studies Advanced Materials

Preparatory course Mathematical Methods in Physics

Precourse

Identification Code	
ECTS-Points	0
Credit Hours	0
Language	english
Length of the Module	14 days
Date and Capacity	winter term 60 students
Responsible Lecturer	Dr. Peter Eckle
Further Lecturer	Dr. Peter Eckle
Study Programme	Master degree in Advanced Materials Master degree in Energy Science and Technology elective
Prerequisites	BSc degree
Study Objectives	The course aims to introduce students to the mathematical techniques which they require to study a wide range of topics in the Advanced Materials Science course programme. The course objectives, building on the assumed prerequisites as outlined above, are twofold: • a thorough foundation covering the most common and basic tools of advanced mathematical methods, and • a review of further mathematical methods. The methods will be developed and applied to solve selected problems arising in a physical sciences context.
Module Contents	A repertory of mathematical methods ranging from the indispensable basic mathematical tools for any physical science to a number of more advanced and specialized methods will be presented The topics selected according to student's needs include: • Review and some advanced tricks of the trade of the elementary methods from arithmetic, algebra and elementary calculus with an emphasis on self-study materials to test and refresh these elementary methods. • Complex numbers, complex arithmetic and elementary complex functions. • Scalars, vectors (especially vector algebra) and introduction to tensors. • Calculus (differentiation and integration) of functions of many variables. • Vector analysis in two and three spatial dimensions. o Vector operations gradient, divergence and curl. o Integral theorems of Gauss, Stokes and Green. • Matrices, determinants, linear equations, especially eigenvalue equations. • Elementary methods of solution for ordinary and partial differential equations. • Fourier methods – Fourier series and Fourier integrals. • Linear vector spaces as the unifying theme of much of the above, and, especially, as the foundation of Quantum Mechanics.

	• Selected applications, emphasising the mathematical aspects, from, e.g.:
	  o Optics, Quantum Mechanics, Statistical Mechanics, Condensed Matter
	Further topics may include, if time permits:
	• Complex analysis
	  o Contour integration and the residue theorem, Laurent series
	• Calculus of variations
	• Integral equations
	• Probability and elementary statistical methods
	• Group and group representation theory
	
	Education Aims:
	The course aims to introduce students to the mathematical techniques which they require to study a wide range of topics in the Advanced Materials Science course programme. The course objectives, building on the assumed prerequisites as outlined above, are twofold:
	• a thorough foundation covering the most common and basic tools of advanced mathematical methods, and
	• a review of further mathematical methods.
	
	Learning Outcomes:
	On completion of the course, students should:
	• have acquired a set of basic mathematical tools from (vector) analysis, differential equations and linear algebra to enable them to solve the applied problems encountered in subsequent courses of the Advanced Materials Science programme.
	• Having gained confidence with the basic methods, they should then also be able to acquire independently more details of further methods as required to solve more involved applied problems.
	-

Literature	In preparation for this course to test and refresh knowledge of the topics mentioned in the prerequisites above, the following book (or similar) may be consulted: • Jenny Olive: Maths – A student's survival guide: A self-help workbook for science and engineering students, Cambridge University Press, Cambridge, 2nd edition 2003. Much helpful material to test and refresh your mathematical skills is available on the World Wide Web, e. g.: • Thomas B Ward's lecture notes on elementary mathematical methods at http://www.mth.uea.ac.uk/~h720/lecturenotes/OB81lectures.pdf. • W Chen's and XT Duong's lecture notes on 'Elementary Mathematics' at (containing also several other interesting sets of lecture notes): http://www.maths.mq.edu.au/~wchen/ln.html. • 'The algebra refresher' and 'The calculus refresher', available, e. g., at the London School of Economics mathematics department's web site: http://www.maths.lse.ac.uk/Refreshers/. • Try their 'Background You Should Know and Exercises' set first: http://www.maths.lse.ac.uk/Courses/MA100/mmbackex.pdf. There's no end of course web sites providing lots of lecture notes, problem sets and sometimes even solutions.

	The material of this course is covered in lots of other books. Texts, which are useful along our purposes, usually contain combinations of subsets of the following words in their titles: mathematical methods, tools, techniques for physics, physicists, science, scientists, engineering, and engineers or similar. Almost anything with a title like 'Advanced Calculus', 'Vector Calculus' and 'Mathematical Methods' will also overlap with this course. If browsing, try to avoid books that are too sophisticated, mathematically. This is not meant to be a rigorous analysis course. It isn't meant to be a computing course either, so avoid differential equations books that are clearly directed towards numerical solutions. A reference which you may find useful is: • Ramamurti Shankar: Basic Training in Mathematics: A fitness program for science students, Plenum Press, New York and London, 1995 Much useful material for this course is available on the World Wide Web for free (try a search engine using search words gleaned from, e. g., this module description). Very useful for the purposes of this course is, for instance: • James Nearing: 'Mathematical tools for physics', available at http://www.physics.miami.edu/~nearing/mathmethods/. Very useful for parts of the course is the course material of • MX3526 Mathematical Methods by JR Pulham at the University of Aberdeen, available at http://www.maths.abdn.ac.uk/courses/mx3526/main.html.
Teaching Methods	Seminar, lecture 40h
Estimation of working load	40 h seminar and lecture (presence) 20 h preparation and postprocessing lecture Total: 60 h
Examinations	none
Grade Composition	none
Usability	MSc course of studies Advanced Materials

Scientific Communication Skills –
The Craft of Scientific Writing
Precourse

Identification Code	
ECTS-Points	0
Credit Hours	0
Language	english
Length of the Module	10 h
Date and Capacity	winter term 60 students
Responsible Lecturer	Dr. Peter Eckle
Further Lecturer	Dr. Peter Eckle
Study Programme	Master degree in Advanced Materials Master degree in Energy Science and Technology elective
Prerequisites	BSc degree
Study Objectives	Communication is an important part in the study and practice of science. This course is an introduction to a major scientific communication skill: the craft of scientific writing with a special focus on the writing of a Master thesis in a scientific discipline. Other communication skills include the preparation and presentation of scientific results in various settings, and will be more briefly addressed. The students will be alerted to the ● necessity and unavoidability of scientific communication and writing and provided with the ● requisite tools to analyse (“reading”) and compose (“writing”) scientific texts On completion of the course, students will: ● be able to understand and correctly compose the structural parts of a scientific text ● be aware and able to avoid common errors in the preparation of scientific texts, ranging from grammar errors to logical inconsistencies

Module Contents	After a general introduction to various aspects of scientific communication, the core of the course offers practical advice and interactive training on the questions of
	● constraints
	    o e.g. audience and format of a scientific document or presentation
	● style
	    o structure
	● the function of the various parts in a scientific document or presentation
	    o language
	        ● e.g. precision and clarity
	    o illustration
	        ● e.g. tables and figures

Literature	Michael Alley: *The Craft of Scientific Writing*, 3rd edition (Springer, 1996) Michael Alley: *The Craft of Scientific Presentations*, (Springer, 2003)
Teaching	Workshop 10h

Methods	**Workshop (10h)** Discussion of case studies Interactive exercises
Estimation of working load	10 h presence 10 h preparation and postprocessing Total: 20 h
Examinations	none
Grade Composition	none
Usability	MSc course of studies Advanced Materials

German Intensive Course

Precourse

Identification Code	
ECTS-Points	0
Credit Hours	0
Language	english
Length of the Module	14 days
Date and Capacity	winter term 60 students
Responsible Lecturer	Dr. Kathrin Husemann
Further Lecturer	Dr. Kathrin Husemann (responsible), Sabine Hagen / Annemarie Firme, Frauke Nowak-Arendt
Study Programme	Master degree in Advanced Materials Master degree in Energy Science and Technology elective
Prerequisites	BSc degree
Study Objectives	First introduction into German language, to understand people in daily life
Module Contents	Words, numbers, phrases
Literature	
Teaching Methods	Workshop 10h
Estimation of working load	30 h presence 15 h preparation and postprocessing Total: 45 h
Examinations	none
Grade Composition	none
Usability	MSc course of studies Advanced Materials

Fachspezifische Studien- und Prüfungsordnung für den englischsprachigen Masterstudiengang „Advanced Materials“ der Fakultäten für Naturwissenschaften, Ingenieurwissenschaften und Informatik sowie Medizin der Universität Ulm vom …………..

Aufgrund von §§ 19 Abs. 1 Satz 2 Nr. 9 i. V. m. 34 Landeshochschulgesetz (LHG) hat der Senat der Universität Ulm auf Vorschlag der Fakultäten für Naturwissenschaften, Ingenieurwissenschaften und Informatik sowie Medizin in seiner Sitzung am ……………. die nachstehende Studien- und Prüfungs-ordnung beschlossen. Der Präsident der Universität Ulm hat am ……………. gemäß § 34 Abs. 1 Satz 3 LHG seine Zustimmung erteilt.

Inhaltsübersicht

Vorbemerkung zum Sprachgebrauch

Nach Artikel 3 Abs. 2 des Grundgesetzes sind Frauen und Männer gleichberechtigt; alle maskulinen Personen- und Funktionsbezeichnungen in dieser Ordnung gelten für Frauen und Männer in gleicher Weise.

I. Allgemeine Bestimmungen

§ 1 Geltungsbereich

(1) Die vorliegende Fachspezifische Studien- und Prüfungsordnung enthält spezifische Regelungen für den Masterstudiengang „Advanced Materials“.

(2) Die Fachspezifische Studien- und Prüfungsordnung ergänzt die Allgemeinen Bestimmungen zu Studien- und Prüfungsordnungen für das Bachelor- und Masterstudium an der Universität Ulm (Rahmenordnung). Im Zweifel hat diese Rahmenordnung Vorrang.

§ 2 Ziele des Studiums, akademische Grade (§ 2 Rahmenordnung)

(1) Der Masterstudiengang „Advanced Materials“ ist ein forschungsorientierter Studiengang. Er soll Studienabsolventen dazu befähigen, naturwissenschaftliche und materialwissenschaftliche Fragestellungen selbstständig mit den Methoden der Naturwissenschaften und der Ingenieurwissenschaften zu lösen. Im Bereich der Biomaterialien kommen interdisziplinäre Ansätze aus Medizin und Biologie hinzu. Ausbildungsziel ist der Erwerb von Wissen und Fähigkeiten, die den Studienabsolventen für Tätigkeiten im Bereich von Forschung, Entwicklung und Anwendung auf dem Gebiet der Naturwissenschaften, der Ingenieurwissenschaften und der Biomaterialien insbesondere an Universitäten, Forschungsinstituten und der forschenden bzw. entwickelnden Industrie qualifiziert. Das Masterstudium sieht die beiden Fachrichtungen Nanomaterials und Biomaterials vor. Bei der Anmeldung zur ersten Prüfung im Masterstudiengang legt der Studierende seine Entscheidung für eine bestimmte Fachrichtung fest.

(2) An der Universität Ulm wird der nichtkonsekutive Masterstudiengang „Advanced Materials“ mit dem Abschluss „Master of Science“ (abgekürzt „M.Sc.“) angeboten.

§ 3 Studienbeginn (§ 3 Rahmenordnung)

Das Studium im Masterstudiengang „Advanced Materials“ beginnt im Wintersemester.

§ 4 Regelstudienzeit (§ 5 Rahmenordnung)

Die Regelstudienzeit des Masterstudiums beträgt vier Semester.

§ 5 Zusatzmodule (§ 5 Abs. 8 Rahmenordnung)

Aus dem Angebot der Masterstudiengänge der Universität Ulm können Module von Studierenden auch als Zusatzmodule gewählt werden. Ein Modul wird als Zusatzmodul gewertet, wenn der Studierende dies bei der Anmeldung zur Modulprüfung ausdrücklich und unwiderruflich erklärt. Auf Antrag des Studierenden werden höchstens zwei Zusatzmodule in das Zeugnis aufgenommen.

§ 6 Fristen (§ 6 Abs. 9 Rahmenordnung)

Bis zum Ende des Prüfungszeitraums des vierten Fachsemesters im Masterstudiengang „Advanced Materials“ soll der Studierende Modul(teil-)prüfungen gemäß § 14 zu Pflicht- und Wahlpflichtmodulen im Umfang von mindestens 90 LP erbracht haben. Bis zum Ende des Prüfungszeitraums des sechsten Fachsemesters muss der Studierende Modul(teil-)prüfungen gemäß § 14 zu Pflicht - und Wahlpflichtmodulen im Umfang von mindestens 120 LP erbracht haben. Der Prüfungsanspruch erlischt, wenn die nach Satz 2 vorgegebenen Leistungspunkte nicht in dem nach Satz 2 vorgegebenen Zeitraum erreicht worden sind, es sei denn, der Studierende hat die Nichterreichung der vorgegebenen Leistungspunkte in der vorgegebenen Zeit nicht zu vertreten.

§ 7 Lehrveranstaltungen, Prüfungsleistungen

Ziele und Inhalte des Studiums werden in folgenden Lehrveranstaltungen vermittelt:

- Vorlesungen
- Übungen
- Tutorien
- Praktika
- Projekte
- Seminare
- Exkursionen.

Prüfungsleistungen sind schriftliche und mündliche Prüfungen.

§ 8 Lehrveranstaltungen und Prüfungen in Englisch (§ 7 Rahmenordnung)

Die Lehr- und Prüfungssprache ist englisch.

§ 9 Fachprüfungsausschuss (§ 10 Rahmenordnung)

(1) Es wird ein Fachprüfungsausschuss für den Masterstudiengang „Advanced Materials" gebildet.

(2) Der Fachprüfungsausschuss besteht aus 7 Mitgliedern. Er setzt sich aus vier hauptberuflichen Hochschullehrern und hauptberuflich an der Universität Ulm beschäftigten habilitierten Mitgliedern, von denen je einer aus der Fakultät für Ingenieurwissenschaften und Informatik und der Fakultät für Medizin und zwei aus der Fakultät für Naturwissenschaften stammen, einem wissenschaftlichen Mitarbeiter aus einer der am Studiengang beteiligten Fakultäten sowie zwei Studierenden mit beratender Stimme zusammen. Die Studierenden sollen aus unterschiedlichen Semestern des Masterstudiengangs „Advanced Materials" kommen. Die Amtszeit beträgt für die Hochschullehrer, für die hauptberuflich an der Universität Ulm beschäftigten habilitierten Mitglieder und für den wissenschaftlichen Mitarbeiter drei Jahre, für studentische Mitglieder ein Jahr. Eine Wiederbestellung ist möglich.

§ 10 Organisation von Modulprüfungen (§ 13 Rahmenordnung)

Schriftliche Modulprüfungen finden abweichend von der Empfehlung in § 13 Abs. 1 Rahmenordnung im Masterstudium in jedem Semester in der Regel in den der Vorlesungszeit folgenden drei Wochen, die Wiederholungsprüfungen in den ersten zwei Wochen nach Vorlesungsbeginn des darauf folgenden Semesters statt.

§ 11 Verwandte Studiengänge (§ 14 Rahmenordnung)

Verwandte Fächer gemäß § 14 Rahmenordnung sind insbesondere die Studiengänge Physik und Chemie. Der Fachprüfungsausschuss entscheidet über nicht in Satz 1 aufgeführte Studiengänge.

§ 12 Regelungen zum Modul Masterarbeit (§ 16c Rahmenordnung)

(1) Die Masterarbeit hat ein Volumen von 30 LP. Die Bearbeitungszeit der Masterarbeit beträgt sechs Monate. Eine Verlängerung von maximal drei Monaten ist nach Genehmigung durch den Prüfungsausschuss möglich.

(2) Wenn eine Masterarbeit gemäß § 16c Abs. 5 Rahmenordnung extern durchgeführt wird, muss dies durch einen Betreuungsplan nachgewiesen werden. Der Kandidat kann für das Thema der Masterarbeit Vorschläge machen.

(3) Die Masterarbeit ist insgesamt dreifach in gebundener Form beim Studiensekretariat einzureichen.

§ 13 Bewertung von Modulprüfungen (§ 17 Rahmenordnung)

(1) Die endnotenrelevanten Module für die Gesamtnote der Masterprüfung sind die in § 14 genannten Modul(teil-)prüfungen und das Modul „Masterarbeit".

(2) Die Gesamtnote der Masterprüfung errechnet sich gemäß § 17 Abs. 3 Rahmenordnung. Dabei gehen die Noten der Modul(teil-)prüfungen des Moduls Materials Science und der Masterarbeit mit doppeltem Gewicht ein.

§ 14 Wiederholung von Modulprüfungen (§ 20 Rahmenordnung)

Höchstens 4 nicht bestandene Modul(teil-)prüfungen können jeweils zweimal nach erfolgloser Teilnahme und nur innerhalb des auf den erfolglosen Versuch folgenden Studienjahres wiederholt werden. Legt ein Studierender eine Modul(teil-)prüfung zum in Satz 1 festgesetzten Termin nicht ab, verliert er den Prüfungsanspruch, es sei denn, er hat die Fristüberschreitung nicht zu vertreten.

§ 15 Studieninhalte, Zulassung zu Modulprüfungen

(1) Jedes Modul wird mit einer oder mehreren Modul(teil-)prüfungen abgeschlossen.

(2) Folgende Module sind zu absolvieren:

a) Fachrichtung Nanomaterials

Nr.	Modul	ECTS	Art der LV*	Art der Prüfungsleistung*[1]	Semester	Endnotenrelevant
1	Materials Science I	5	V, S	sc oder m	1	ja
2	Materials Science II	5	V, S	sc oder m	2	ja
3	Computation in Materials Science	4	V, S	sc oder m	2	ja
4	Material Science Lab I	5	P	Protokoll	2	nein
5	Material Science Lab II	5	P	Protokoll	3	nein
6	Physical Chemistry	4	V, S	sc oder m	1	ja
7	Synthesis of Organic and Inorganic Materials	4	V, S	sc oder m	1	ja
8	General Chemistry	2	V, S	sc oder m	1	nein
9	Introductory Solid State Physics	5	V, S	sc oder m	1	ja
10	Advanced Physics of Materials	4	V, S	sc oder m	2	ja
11	Physics Lab	4	P	Protokoll	1	nein
12	Introductory Engineering	5	V, S	sc oder m	1	ja
13	Micro- and Nanotechnology	4	V, S	sc oder m	3	ja
14	Functional Properties of Nanomaterials	3	V, S	sc oder m	3	ja
15	Principles of Structure Formation in Nanomaterials	5	V, S	sc oder m	3	ja
16	Additive Schlüsselqualifikationen (ASQ)	8	P, S	sc	1-3	nein
17	Elective Courses	mindestens 18	V, S	sc oder m	1-3	Ja
18	Masterarbeit	30	Thesis	sc	3	ja

b) Fachrichtung Biomaterials

Nr.	Modul	ECTS	Art der LV*	Art der Prüfungsleistung*[1]	Semester	Endnotenrelevant
1	Materials Science I	5	V, S	sc oder m	1	ja
2	Materials Science II	5	V, S	sc oder m	2	ja
3	Computation in Materials Science	4	V, S	sc oder m	2	ja
4	Material Science Lab I	5	P	Protokoll	2	nein
5	Material Science Lab II	5	P	Protokoll	2	nein
6	Physical Chemistry	4	V, S	sc oder m	1	ja
7	Synthesis of Organic and Inorganic Materials	4	V, S	sc oder m	1	ja
8	General Chemistry	2	V, S	sc oder m	1	nein
9	Introductory Solid State Physics	5	V, S	sc oder m	1	ja
10	Physics Lab	4	P	Protokoll	1	nein
11	Introductory Biology and Cell Biology	5	V	sc oder m	1	ja
12	Biological Tissues	2	V, S	sc oder m	2	ja
13	Classes of Biomaterials	2	V, S	sc oder m	2	ja
14	Applications of Biomaterials	2	V, S	sc oder m	2	ja
15	Degradation of Biomaterials	2	V, S	sc oder m	3	ja
16	Testing of Biomaterials	2	V, S	sc oder m	3	ja
17	Host Reactions to Biomaterials	2	V, S	sc oder m	3	ja
18	Production of Biomaterials	2	Ex	Teilnahme	3	nein
19	Additive Schlüsselqualifikationen (ASQ)	8	P, S	sc	1-3	nein
20	Elective Courses	mindestens 20	V, S	sc oder m	1-3	Ja
21	Masterarbeit	30	Thesis	sc	3	ja

(3) Studierende, deren Muttersprache Deutsch ist sowie Bildungsinländer haben Prüfungsleistungen im Rahmen des Moduls „ASQ“ aus dem Angebot des Sprachenzentrums oder des Humboldt-Studienzentrums zu erbringen. Studierende, die nicht unter Satz 1 fallen, haben im Modul „ASQ“ die Prüfungsleistungen „German language I – III“ im Volumen von insgesamt 8 LP zu erbringen. In Ausnahmefällen entscheidet der Prüfungsausschuss über die zu erbringenden Leistungen.

§ 16 Fachliche Zulassungsvoraussetzungen zur Masterarbeit

Zur Masterarbeit kann nur zugelassen werden, wer mindestens 83 LP aus Modulen im Rahmen des Masterstudiums erworben hat

II. Schlussbestimmungen

§ 17 Inkrafttreten

Die Studien- und Prüfungsordnung tritt zum Wintersemester 2007/08 in Kraft. Sie wird in den Amtlichen Bekanntmachungen der Universität Ulm veröffentlicht. Die Studien- und Prüfungsordnung der Universität Ulm für den Master-Studiengang „Advanced Materials“ der Fakultäten Naturwissenschaften, Ingenieurwissenschaften und Medizin vom 15. November 2002, veröffentlicht in den Amtlichen Bekanntmachungen der Universität Ulm, Nr. 19 vom 04.12.2002 sowie die erste Satzung zur Änderung der Studien- und Prüfungsordnung der Universität Ulm für den Masterstudiengang „Advanced Materials“ der Fakultäten für Naturwissenschaften, Ingenieurwissenschaften und Medizin vom 17.08.2004, veröffentlicht in den Amtlichen Bekanntmachungen der Universität Ulm, Nr. 13 vom 25.08.2004 treten außer Kraft. Studierende, die sich im Wintersemester 2007/08 in einem höheren als dem ersten Fachsemester befanden, beenden ihr Studium nach der Prüfungsordnung aus dem Jahr 2002.

Ulm, den
Prof. Dr. K. -J. Ebeling

Präsident

ADVANCED MATERIALS Curriculum Nanomaterials

	1st semester		2nd semester		3rd semester		4th semester	
Materials Science	Materials Science I	5 CP	Materials Science II Computational Methods in Materials Science Lab Materials Science I	5 CP 4 CP 5 CP	Lab Materials Science II	5 CP		
Chemistry	Physical Chemistry General Chemistry Synthesis of Org. & Inorg. Materials	4 CP 2 CP 4 CP						
Physics	Introductory Solid State Physics Lab Intermediate Physics	5 CP 4 CP	Advanced Physics of Materials	4 CP				
Engineering	Introductory Engineering	5 CP			Micro- and Nanotechnolgy	4 CP		
Nanomaterials					Functional Properties of Nanomaterials Principles of structure formation in nanomaterials	3 CP 5 CP		
Elective Courses			Elective Courses in Nano- / Biomaterials	9 CP	Elective Courses in Nano- / Biomaterials	9 CP		
ASQ	German Language I	3 CP	German Language II	3 CP	German Language III	2 CP		
Master Thesis							Master Thesis	30 CP
		32 CP		30 CP		28 CP		30 CP

ADVANCED MATERIALS Curriculum Biomaterials

	1st semester		2nd semester		3rd semester		4th semester	
Materials Science	Materials Science I	5 CP	Materials Science II Computational Methods in Materials Science Lab Materials Science I	5 CP 4 CP 5 CP	Lab Materials Science II	5 CP		
Chemistry	Physical Chemistry General Chemistry Synthesis of Org. & Inorg. Materials	4 CP 2 CP 4 CP						
Physics	Introductory Solid State Physics Lab Intermediate Physics	5 CP 4 CP						
Biology	Introductory Biology and Cell Biology	5 CP						
Biomaterials			Biological Tissues Classes of Biomaterials Applications of Biomaterials	2 CP 2 CP 2 CP	Host Reactions of Biomaterials Degradation of Biomaterials Testing of Biomaterials Production of Biomaterials	2 CP 2 CP 2 CP 2 CP		
Elective Courses			Elective Courses in Bio- / Nanomaterials	7 CP	Elective Courses in Nano- / Biomaterials	13 CP		
ASQ	German Language I	3 CP	German Language II	3 CP	German Language III	2 CP		
Master Thesis							Master Thesis	30 CP
		32 CP		30 CP		28 CP		30 CP