Modulhandbuch

Master of Science Nanoscience (2017)

Fachbereich Mathematik und Naturwissenschaften - Universität Kassel

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General goals of the curriculum

- Students have knowledge that is founded upon and extends that of the Bachelor's level and provides a basis for originality in developing and applying ideas within a interdisciplinary research context in nanoscience.
- Students become acquainted with advanced scientific methods, theories and current research in nanoscience.
- They learned how to work in scientific projects independently and are able to manage an own project.
- They have competencies which fit them for employment in chemical, physical, biological, nanotechnological and related industries or in public service.
- They are able to fulfill leading positions, develop ideas and solve complex problems with an interdisciplinary team.
- They can act in agreement with ethical guidelines and good scientific practice.
- They attained a standard of knowledge and competence which will give them access to third cycle course units or degree programmes (Dr. rer. nat. / PhD degree).

Outcomes / Competencies

- Students have the ability to apply their knowledge and understanding, and problem solving abilities, in new or unfamilar environments within broader or multidisciplinary context related to chemistry, physics and/or biology with special emphasis on the nanoscale.
- They obtained a deeper knowledge in scientific analysis methods and in at least two of the following subjects:
  nanochemistry (macromolecular, supramolecular and colloid chemistry)
  nanophysics (nanoelectronics, nanophotonics and nanotechnology)
  nanobiology (advanced molecular and cell biology).
- They have developed a personal portfolio by an appropriate combination of elective subjects.
- They have developed advanced practical skills in laboratory research projects and collaboration within a scientific workgroup.
- They have proven their ability to work in a special topic, conduct appropriate research of current literature, analyse unsolved problems and develop strategies for their solution.
- They have the ability to communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambigously.
- They have the ability to integrate knowledge and handle complexity, and formulate judgments with incomplete or limited information.
- They have developed those learning skills that will allow them to continue to study in a manner that may be largely self-directed or autonomous, and to take responsibility for their own professional development.

List of Modules

Required Modules		**Coordinator**	**Key**
P01 Methods of Nanostructure Analysis	5 c	Bruhn	
P02 Preparatory Project	13 c	Exam. commitee	(3)
P03 Masterabschlussmodul (Master's Degree Module)	30 c	Exam. commitee	(5)
sum	**48 c**		

Required Elective Modules Focus modules:

S01 Nanochemistry	12 c	Fuhrmann-Lieker	(1)
S02 Nanophysics	12 c	Reithmaier	(1)
S03 Nanobiology	12 c	Maniak	(1)
S04 Chemical and biological aspects of nanosciences	12 c	Backes	(1)
S05 Biological and physical aspects of nanosciences	12 c	Maniak	(1)
S06 Physical and chemical aspects of nanosciences	12 c	Reithmaier	(1)
sum (two focus modules to be selected)	**24 c**		

Other modules:

KEY Additive Key Competencies	max. 6 c	Exam. commitee	(6)
INT International Elective Modules	max. 30 c	Exam. commitee	(4)
BPM Professional Practical Training	8 c	Popov	(4)
APC Applied Physical Chemistry	6 c	N.N.	
ARO Aromatic Building Blocks for Organic Nanostructures*	3 c	Faust	
CHM Chemistry of Materials	3 c	Pietschnig	
ASP Applied Semiconductor Physics	6 c	Reithmaier	(1)
SCL Semiconductor Laser	6 c	Reithmaier	(1)
TFP Thin Film Physics	3 c	Ehresmann	
PSR Physics with Synchrotron Radiation	3 c	Ehresmann	
ULP Ultrashort Laserpulses and their Applications*	8 c	Baumert	
AEP Lab Course Advanced Experimental Physics	9 c	Baumert	(2)
EPS Experimental Physics Seminar	5 c	Baumert	(2)
SUR Surface Science	4 c	Matzdorf	
NQO Nanoscale Quantum Optics	6 c	Singer	(1)
NQ2 Advanced nanoscale Quantum Optics	6 c	Singer	(1)
TSP Thermodynamics and Statistical Physics*	8 c	Pastor	
COP Computational Physics	5 c	Pastor	
LA1 Laboratory Astrophysics I	6 c	Giesen	
LA2 Laboratory Astrophysics II	6 c	Giesen	
MMB Molecular Mechanisms of Biochemical Processes	4 c	Herberg	
BCT Biocatalysis	4 c	Pavlidis	
SEP Sensory Physiology*	5 c	Stengl	
GCO Seminar Basics of Chronobiology and Olfaction*	3 c	Stengl	
SCO Advanced Seminar Chronobiology and Olfaction*	3 c	Stengl	
SNE Seminar Basics of Neuroethology*	3 c	Stengl	
MMM Molecular Methods - Microbiology*	4 c	Schaffrath	
NTN Nanosystem technology and nanophotonic device fabrication*	6 c	Hillmer	
SEN Nanosensorics	5 c	Kusserow	

NPH Nanophotonics	4 c	Kusserow	
SDT Semiconductor Devices: Theory and Modelling	6 c	Witzigmann	
CE1 Computational Electromagnetics I	6 c	Witzigmann	
CE2 Computational Electromagnetics II	6 c	Witzigmann	
STN Special Topics in Nanoscience*	2 c	Fuhrmann-Lieker	
NUM Mathematics IV Numerical Analysis*	6 c	Meister	
ABT Applied Biotechnology	3 c	Bertinetti	
MMC Machine Learning for Materials and Chemistry	5 c	von Rudorff	
IOM Research Internship Organometallic Chemistry	6 c	Siemeling	(2)
IHM Research Internship Hybrid Materials	6 c	Pietschnig	(2)
IPC Research Internship Physical Chemistry	6 c	N.N.	(2)
IOC Research Internship Organic Chemistry	6 c	Faust	(2)
INM Research Internship Physics of Nanostructured Materials and Devices ITS	6 c	Reithmaier	(2)
Research Internship Thin Films and Synchrotron Radiation	6 c	Ehresmann	(2)
IUP Research Internship Ultrashort Laser Pulses	6 c	Baumert	(2)
IQO Research Internship Nanoscale Quantum Optics	6 c	Singer	(2)
IBC Research Internship Biochemistry	6 resp. 12 c	Herberg	(2)
IBP Research Internship Biophysics	6 resp. 12 c	Kleinschmidt	(2)
INE Research Internship Neuroscience	6 resp. 12 c	Stengl	(2)
IMI Research Internship Microbiology	6 resp. 12 c	Schaffrath	(2)
ICB Research Internship Cell Biology	6 resp. 12 c	Maniak	(2)
IDG Research Internship Developmental Genetics	6 resp. 12 c	Müller	(2)
INP Research Internship Nanophotonics	6 c	Kusserow	(2)
ICA Research Internship Biocatalysis	6 c	Pavlidis	(2)
ICC Research Internship Construction Chemistry	6 c	Wetzel	(2)
INA Research Internship Nanoprocessing and -analysis	6 c	Hillmer	(2)
ISS Research Internship Surface Science	6 c	Matzdorf	(2)
LAP Research Internship Laboratory Astrophysics	6 c	Giesen	(2)
sum	**48 c**		

Remarks:

* These modules may already be taken in the Bachelor programme. The same module cannot be credited twice.

Key: Credits for key competencies

Teaching methods according to KapVO und recommendation by HRK 14.06.2005

Lecture with (integrated) examination	VL+P	Seminar	S	Course	K
Lecture without (integrated) examination	VL	Project Seminar	PS	Laboratory/Practicum Internal/external	P / i/e
Blended Learning	BL	Seminar instruction	SU	Schulpraktische Studien	SPS
Exercise	Ü	Tutorium scientific/teaching	T sci./paed.		
Conversational exercises	KÜ				
E-Learning	EL	Colloquium	KO	Excursion	EX

n/a not applicable

(implied) course projects that are implicitly contained within module examination, are not registered separately

Module title	**MScNano P01 Methods of Nanostructure Analysis**
Module type	Required module
Educational outcomes, competencies, qualification objectives	Students … have acquired a thorough knowledge about modern spectroscopic and analytical methods … know the physical and device-related background of the analytical techniques … know the appropriate instrumental applications for investigations on inorganic and organic materials as well as nano scale structured surfaces … advantages and disadvantages of each methods will be discussed … are able to conduct fundamental analytical characterization methods for their own chemical research work
Types of courses, contact hours	VL+P 4 SWS
Contents	**Crystal structure analysis:** Basics on diffraction experiments, X-ray diffraction of powder samples and single crystals, data processing, visualisation of crystal structures, validation of experimental data **Mass spectrometry:** Instrumental basics, ion sources (esp. modern ionisation methods), mass analysers detectors and applications in nanostructural compounds and surfaces. **NMR spectroscopy:** Instrumental basics, a selection of 1D and 2D pulse sequences and their application in structure determination. Multinuclear nmr spectroscopy. MRI. **ESR-, circular dichroism, and fluorescence spectroscopy** of biomolecules, technical principles and instrumentation, methods and applications in investigations of biomolecular structure and function **IR-spectroscopy** **Microscopy:** Preparation of biological samples for light- and electron microscopes. Setup and function of the confocal laser scanning microscope, superresolution light microscope, as well as scanning and transmission electron microscope. **Scanning atomic force microscopy** **Scanning tunneling microscopy:** experimental setup, potential and limitations, interpretation of the resulting (STM) pictures. Scanning tunneling spectroscopy
Course titles	Methods of Nanostructure Analysis
Teaching methods	Lecture
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually in winter semester
Language	English, for a transitional period lecture notes and exam questions will also be available in German
Recommended Skills	Fundamental knowledge in chemistry, physics and biology on Bachelor level with respect to the interdisciplinary scientific paradigm of nanoscience
Prerequisites for participation	none
Students workload	Contact time: 60 h, Independent studies: 90 h, Summe = 150 h
Course projects / nongraded learning assignments (Studienleistungen)	none
Prerequisites for admission to examination	none
Examination	Written test (1-2 h) or oral examination (30 min) in case of very few participants - will be announced within the first week of the lecture
Number of credits	5 C
Responsible coordinator	Bruhn
Lecturer(s)	Bruhn, Ehresmann, Fürmeier, Kleinschmidt, Maniak, Matzdorf, Maurer
Media	Blackboard, projector
Literature	**Crystal structure analysis:** Massa, W., Crystal Structure Determination, 2nd ed., Springer, 2010 Clegg, W., X-Ray Crystallography (Oxford Chemistry Primers), Oxford, USA 2015 **Mass spectrometry:** Gross, J. W., Mass Spectrometry a textbook, 2nd ed., Springer, 2011 **NMR spectroscopy:** Andrew E. Derome, Modern NMR Techniques for Chemistry Research, Pergamon Press

	ESR-, circular dichroism and fluorescence spectroscopy: Cantor & Schimmel, Biophysical Chemistry Part II: Techniques for the study of biological structure and function, W.H. Freeman and Co, New York, 1980 Hammes, G.G. and Hammes-Schiffer, Physical Chemistry for the biological sciences, 2nd Ed., John Wiley & Sons, New Jersey, 2015

Module title	MScNano P02 Preparatory Project
Module type	Required module
Educational outcomes, competencies, qualification objectives	Students ... have acquired an advanced ability to plan a project and conduct appropriate literature research ... are trained in special methods and learn to modify them for needs in novel research ... have learned to organize and adapt equipment and materials needed in a project **Integrated key competencies:** <u>Communication competency:</u> Teamwork and advanced competency in scientific discussion <u>Organisational competency:</u> Advanced project planning and self-assessment <u>Methodic competency:</u> Advanced literature research in a special field
Types of courses, contact hours	S 1 SWS
Contents	Advanced theoretical and methodical competencies for conducting own research work
Course titles	Instruction to scientific work Research seminar
Teaching methods	Individual instruction
Applicability	M.Sc. Nanoscience
Duration	approx. 8 weeks
Frequency	every semester
Language	English
Recommended Skills	Nanochemistry or Nanophysics or Nanobiology Methods of Nanostructure Analysis
Prerequisites for participation	none
Students workload	Contact time and independent studies 390 h
Course projects / nongraded learning assignments (Studienleistungen)	none
Prerequisites for admission to examination	none
Examination	Seminar lecture incl. discussion (30-60 min)
Number of credits	13 C (including 3 C for integrated key competencies)
Responsible coordinator	Head of examination commitee
Lecturer(s)	Staff of the Department of Mathematics and Science
Media	Laboratory work, (electronic) library
Literature	Scientific literature

Module title	**MScNano P03 Masterabschlussmodul (Master's Degree Module)**
Module type	Required module
Educational outcomes, competencies, qualification objectives	Students have acquired the ability ... to develop experimental or theoretical methods in a field of nanoscience ... to apply them for solving scientific problems ... to interpret results with rational conclusions ... to deal with failures, unexpected problems and delays by applying modified strategies ... to understand and discuss complex topics with an interdisciplinary point of view ... to communicate their research in written and oral form **Integrated key competencies:** Communication competency: Teamwork and advanced competency in scientific discussion Organisational competency: Advanced project management Methodic competency: Writing a advanced scientific thesis including appropriate citation and using advanced methods of graphical presentations and text editing
Types of courses, contact hours	S 1 SWS
Contents	Advanced research work in a special field of nanoscience reaching the level of international state-of -the-art
Course titles	Instruction to scientific work Research seminar
Teaching methods	Individual instruction
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	every semester
Language	English
Recommended Skills	
Prerequisites for participation	Two modules from Nanochemistry, Nanophysics or Nanobiology Methods of Nanostructure Analysis Preparatory Project
Students workload	Contact time and independent studies 900 h
Course projects / nongraded learning assignments (Studienleistungen)	none
Prerequisites for admission to examination	n/a
Examination	Written Master thesis and Master colloquium, weighted 4:1
Number of credits	30 C (including 5 C for integrated key competencies)
Responsible coordinator	Head of examination commitee
Lecturer(s)	*Lecturers of the University of Kassel*
Media	Laboratory work, computer
Literature	Scientific literature

Module title	**MScNano S01 Nanochemistry**
Module type	Required elective module (focus chemistry)
Educational outcomes, competencies, qualification objectives	Students … have acquired a thorough knowledge about the chemistry of nanosystems … know the principles of colloid, polymer and supramolecular chemistry … know bottom-up strategies for the preparation of chemical nanostructures … gained experience in physicochemical experiments on nanosystems … are able to conduct multistep chemical syntheses … are able to present and discuss own chemical research work **Integrated key competencies:** <u>Methodic competency:</u> Students have the ability to apply their knowledge and understanding, and problem solving abilities to actual research work
Types of courses, contact hours	VL 6 SWS P i 1+6.5 SWS S 0.5 SWS
Contents	**Nanochemistry I (Colloid and polymer chemistry)** Intermolecular forces and colloid forces, hydrophobic effect, DLVO theory, association colloids, micelles, liquid crystals, micro- and macroemulsions, polymer structure and nomenclature, radical and ionic polymerizations, living polymerizations, catalyzed polymerizations, polycondensation and polyaddition, radius of gyration, scaling laws, polymer solutions and blends, Flory-Huggings model, demixing mechanisms, block copolymers, physicochemical properties of macromolecules **Nanochemistry II (Supramolecular chemistry, special topics)** a) Non-covalent interactions (bond interactions, H-bridges), molecular recognition, artificial enzymes, nanocarriers, molecular wires b) Sol-gel process, oxide-based gels, aerogels and xerogels, porous materials, metal-organic-frameworks (MOFs), oxide-based nanoparticles, core-shell-hybrids, solid materials by gas phase reactions (CVS, CVD) c) Host-guest chemistry, selfassembly and -organization, rotaxanes and catenanes, molecular knots, container molecules, coordination polymers, self-assembling monolayers (SAM), nanopatterning (microcontact printing, dip-pen nanolithography) **Lab Course Nanochemistry** Experimental methods in nanochemistry (e.g. polymer characterization, light scattering, rheology, Langmuir-Blodgett technique) **Advanced Synthetic Chemistry:** Participation in a nanochemical research project in one of the groups of the institute of chemistry
Course titles	(a) Nanochemistry I (b) Nanochemistry II (c) Lab course Nanochemistry (d) Advanced Synthetic Chemistry (e) Seminar Advanced Synthetic Chemistry
Teaching methods	Lecture, laboratory work
Applicability	M.Sc. Nanoscience
Duration	two semesters
Frequency	annually, start in winter or summer semester possible
Language	English, for a transitional period lecture notes and exam questions will also be available in German
Recommended Skills	Fundamental knowledge in chemistry on Bachelor level with respect to the interdisciplinary scientific paradigm of nanoscience
Prerequisites for participation	For "Advanced Synthetic Chemistry": Laboratory skills in chemical synthesis on intermediate level, obtained with Bachelor degree or subject to admission obligations to the master programme
Students workload	Contact time: 210 h, Independent studies: 150 h, Summe = 360 h
Course projects / nongraded learning assignments (Studienleistungen)	Report on experiments in the Lab Course Nanochemistry with oral tests on comprehension
Prerequisites for admission to examination	none
Examination	Three examination parts: - Written test about lecture contents of Nanochemistry I (2 h) - Laboratory report „Advanced Synthetic Chemistry“ according to criteria of scientific documentation - 15 min presentation For the final grade, the parts are weighted 2:2:1
Number of credits	12 C (including 1 C for integrated key competencies)
Responsible coordinator	Fuhrmann-Lieker

Lecturer(s)	Fuhrmann-Lieker, Siemeling, Faust, Pietschnig
Media	Blackboard, projector, laboratory equipment
Literature	**Nanochemistry I:** Israelachvili, Intermolecular and Surface Forces, 3rd Ed., Academic Press, Amsterdam 2011 Dörfler, Grenzflächen und kolloid-disperse Systeme, Springer, Berlin 2002 Hiemenz, Rajagopalan, Principles of Colloid and Surface Chemistry, 3rd Ed., M. Dekker 1997 Butt, Graf, Kappl, Physics and Chemistry of Interfaces, Wiley-VCH, Weinheim 2006 Tieke, Makromolekulare Chemie, Wiley-VCH, Weinheim, 2005 Gnanou, Fontanille, Organic and Physical Chemistry of Polymers, Wiley, Hoboken 2008 Ravve, Principles of Polymer Chemistry, 3rd Ed., Springer 2012 Young, Lovell, Introduction to Polymers, 3rd Ed., CRC Press, Boca Raton 2011 Cowie, Arrighi, Polymers: Chemistry and Physics of Modern Materials, 3rd Ed. , CRC press, Boca Raton, 2007 **Nanochemistry IIa:** Steed, Atwood, Supramolecular Chemistry, 2nd Ed., Wiley-VCH, Chichester 2009 Beer, Gale, Smith, Supramolecular Chemistry, Oxford University Press, Oxford 1999 Lehn, Supramolecular Chemistry, VCH, Weinheim 1995 **Nanochemistry IIb:** Schubert, Hüsing, Synthesis of Inorganic Materials, Wiley-VCH, Weinheim 2000 Brinker, Scherer, Sol-Gel-Science - The Physics and Chemistry of Sol-Gel Processing, Academic Press, San Diego 1989 **Nanochemistry IIc:** Beer, Gale, Smith, Supramolecular Chemistry, Oxford University Press, Oxford 1999 Lehn, Supramolecular Chemistry, VCH, Weinheim 1995 Ozin, Arsenault, Nanochemistry, RSC, Cambridge 2005 Steed, Atwood, Supramolecular Chemistry, 2nd Ed., Wiley-VCH, Chichester 2009 Steed, Turner, Wallace: Core Concepts in Supramolecular and Nanochemistry, Wiley-VCH, Weinheim 2007 Vögtle, Supramolekulare Chemie, Teubner, Stuttgart 1989 Special literature

Module title	**MScNano S02 Nanophysics**
Module type	Required elective module (focus physics)
Educational outcomes, competencies, qualification objectives	Students ... have acquired a thorough knowledge about the fundamental physics of low-dimensional systems and nanomaterials ... understand the principles of propagation of electrons and light in nanostructured materials ... know about quantum mechanical principles and limits of various physical nanosystems ... know about fabrication and characterization techniques of nanosystems ... get an overview about actual and potential applications of nanostructured materials ... are able to characterize different physical properties of nanosystems by state-of-the-art characterization tools ... are able to evaluate, document and report experimental results **Integrated key competencies:** Methodic competency: Students have the ability to apply their knowledge and understanding, and problem solving abilities to actual research work
Types of courses, contact hours	VL 6 SWS P i 4 SWS
Contents	**Nanophysics I (Basics)** - Introduction to the physics of nanostructured systems - Fundamental electronic, optical, thermal and mechanical properties of nano structures - Quantum mechanical considerations of nanostructured systems - Overview about physical fabrication techniques - Overview of characterization techniques for nanostructure technologies -Further keywords: density of states, electronic and photonic band structures, low-dimensional systems, light-matter interaction, quantum well, wire, dot, giant magnetic resistance, tunnel magnetic resistance, single electron transport, single photon emission, nanocavities, photonic crystals **Nanophysics II (Applications)** - Overview about properties and fabrication of nanostructured electronic devices - Introduction to quantum effect devices - Introduction to quantum information technologies and different physical realizations - Introduction of nanostructured optoelectronic devices - Fundamental properties of carbon nanotubes and their potential applications - Overview about nanostructured memory devices based on various physical techniques including electronic, optical, magnetic, mechanical and crystallographic **Lab course Nanophysics:** Participation in experimental studies of physical properties of nanostructured materials using research type characterization tools, like low-temperature photoluminescence and excitation spectroscopy, x-ray diffraction, and atomic force microscopy and nanolithography tool. Four experiments have to be successfully performed. Each of them needs about 1 week preparation, 1-2 days for experiments and about 1 week for data evaluation and report writing. The course will be offered preferably as a 2-month block after the winter semester.
Course titles	(a) Nanophysics I (b) Lab course Nanophysics (c) Nanophysics II
Teaching methods	Lecture, laboratory work
Applicability	M.Sc. Nanoscience
Duration	Two semesters
Frequency	Annually, start in winter or summer semester possible, start in winter semester is preferable
Language	English, lecture notes are also available in German
Recommended Skills	Fundamental knowledge in physics on Bachelor level with respect to the interdisciplinary scientific paradigm of nanoscience
Prerequisites for participation	Good knowledge of fundamentals in experimental physics (mechanics, electromagnetism, atomic and molecular physics, optics), course in theoretical physics (quantum mechanics) and in solid-state physics.
Students workload	Contact time: 150 h, Independent studies: 210 h, sum = 360 h
Course projects / nongraded learning assignments (Studienleistungen)	none
Prerequisites for admission to examination	none
Examination	Two examination parts: - written (2 h) or oral examination (45-60 min) about content of both lectures & lab work - laboratory work report including oral pre-test The parts are weighted as 2:1
Number of credits	12 C (including 1 C for integrated key competencies)
Responsible coordinator	Reithmaier

Lecturer(s)	Reithmaier, Popov
Media	Blackboard, projector, laboratory equipment
Literature	**Nanophysics I:** - J.D. Jackson, "Klassische Elektrodynamik", Walter de Gryter, 1981. - Stephan Gasiorowicz, "Quantenphysik", Oldenburg-Verlag, 2. Aufl., 1981. - Charles Kittel, "Einführung in die Festkörperphysik", Olderburg-Verlag, 6. Aufl., 1983. - N. W. Ashcroft, N. D. Mermin, "Solid State Physics", Saunders College Publishing, 1976. - Stratis Karamanolis, "Faszination Nanotechnologie", Elektra-Verlag, 2005. - Horst-Günter Rubahn, "Nanophysik und Nanotechnologie", Teubner-Verlag, 2002. - Michael Köhler, "Nanotechnologie", Wiley-VCH Verlag, 2001. - Gregory Timp, "Nanotechnology", Springer-Verlag, 1999. - Siegmar Roth, "One-Dimensional Metals", VCH-Verlag, 1995. - Dieter Bimberg, Marius Grundmann, Nikolai N. Ledentsov, "Quantum Dot Heterostructures", John Wiley & Sons, 1999. - Thomas Heinzel, "Mesoscopic Electronics in Solid State Nanostructures", Wiley-VCH Verlag, 2003. - Paul Harrison, "Quantum Wells, Wires and Dots", John-Wiley & Sons, 2000. - J.D. Joannopoulos, R.D. Meade, J.N. Winn, "Photonic Crystals: Molding the flow of light", Princeton University Press, 1995. - G. Ali Mansoori, "Principles of Nanotechnology", World Scientific Publishing, 2005. - K. Busch, S. Lölkes, R.B. Wehrspohn, H. Föll, "Photonic Crystals", Wiley-VCH Verlag, 2004. - K. Inoue, K. Ohtaka, "Photonic crystals: physics, fabrication and applications", Springer Verlag, 2004. - K. Sakoda, "Optical Properties of Photonic Crystals", Springer Verlag, 2004. - D. A. Bonnell, „Scanning Tunneling Microscopy and Spectroscopy“, VCH, 1993. - F. Henneberger, O. Benson, „Semiconductor Quantum Bits“, Pan Standford Publishing, 2007. **Nanophysics II:** - Rainer Waser, "Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices", Wiley-VCH, 2003. - J.P. Reithmaier P. Petkov, W. Kulisch, C. Popov, "Nanostructured Materials for Advanced Technological Applications“, Springer, Nato ASI Series B, Physics and Biophysics, 2009. - J.P. Reithmaier P. Paunovic, W. Kulisch, C. Popov, P. Petkov, "Nanotechnological Basis for Advanced Sensors", Springer, Nato ASI Series B, Physics and Biophysics, 2011. **Lab course Nanophysics:** Special literature, instructions and documents (supplied prior to lab course)

Module title	**MScNano S03 Nanobiology**
Module type	Required elective module (focus biology)
Educational outcomes, competencies, qualification objectives	Students … have acquired knowledge far beyond the contents of textbooks … know advantages and limitations of molecular and physiological methods … have reached profound insight into structure function relationships … gained practical experience in projects at the forefront of research **Integrated key competencies:** <u>Methodic competency:</u> exercises in the disciplines of critical thinking and problem analysis
Types of courses, contact hours	VL 2+2 SWS P i 6 SWS
Contents	**Nanobiology I** Assembly of bacterial flagella and pili structures Polymerising proteins of the prokaryotic and eukaryotic cytoskeleton Engineering of turning and stepping motors Force production on a nano scale by cytoskeletal motor proteins Protein Machines and the rise of Synthetic Biology Visualisation and measurement of nano scale forces in biological materials Protein folding into membranes – α-helical vs. β-barrel membrane proteins Transmembrane transport – Structure-function relationships of outer membrane proteins Transmembrane signal transduction in phototaxis **Nanobiology II** Mass spectrometry Labelling methods Data analysis Applying mass spectrometry to biomedical sciences Protein kinases and epithelial cell polarity Structure and function of nerve-cells and ion channels Signal transduction cascades on excitable membranes Synaptic transmission and information processing in the brain **Research Internship:** Participation in one research project. Choice is possible among Research Internships in Bio-chemistry, Biophysics, Molecular or Organismic Neuroscience, Microbiology and Cell Biology. Upon agreement with the module coodinator, other internships may be chosen as well.
Course titles	Nanobiology I Nanobiology II Research Internship
Teaching methods	Lectures, laboratory work
Applicability	M.Sc. Nanoscience
Duration	two semesters
Frequency	annually, start in winter or summer semester possible
Language	English, for a transitional period lecture notes and exam questions will also be available in German
Recommended Skills	Fundamental knowledge in biology on Bachelor level with respect to the interdisciplinary scientific paradigm of nanoscience
Prerequisites for participation	none
Students workload	Contact time: 150 h, Independent studies: 210 h, Sum = 360 h
Course projects / nongraded learning assignments (Studienleistungen)	Report on experiments with oral tests on comprehension
Prerequisites for admission to examination	none
Examination	Three examination parts: - written test about lecture contents of Nanobiology I (90 min) - written test about lecture contents of Nanobiology II (90 min) - 30 min presentation (weighted 1:1:1)
Number of credits	12 C (including 1 C for integrated key competencies)
Responsible coordinator	Maniak
Lecturer(s)	Beati, Kleinschmidt, Maniak, Müller, Wei
Media	Blackboard, beamer, laboratory equipment
Literature	Special literature, to be announced by the lecturers

Module title	**MScNano S04 Chemical and biological aspects of nanosciences**
Module type	Required elective module (focus chemistry and biology)
Educational outcomes, competencies, qualification objectives	Students … have acquired a thorough knowledge about the chemistry of nanosystems … know the principles of colloid, polymer and supramolecular chemistry … know bottom-up strategies for the preparation of chemical nanostructures … have acquired knowledge far beyond the contents of textbooks … know advantages and limitations of molecular and physiological methods … have reached profound insight into structure function relationships **Integrated key competences:** … Students are able to draw cross-links between different disciplines in the context of nanosciences
Types of courses, contact hours	VL 3+3+2+2 SWS
Contents	**Nanochemistry I (Colloid and polymer chemistry)** Intermolecular forces and colloid forces, hydrophobic effect, DLVO theory, association colloids, micelles, liquid crystals, micro- and macroemulsions, polymer structure and nomenclature, radical and ionic polymerizations, living polymerizations, catalyzed polymerizations, polycondensation and polyaddition, radius of gyration, scaling laws, polymer solutions and blends, Flory-Huggings model, demixing mechanisms, block copolymers, physicochemical properties of macromolecules **Nanochemistry II (Supramolecular chemistry, special topics)** a) Non-covalent interactions (bond interactions, H-bridges), molecular recognition, artificial enzymes, nanocarriers, molecular wires Contents b) Sol-gel process, oxide-based gels, aerogels and xerogels, porous materials, metal-organic-frameworks (MOFs), oxide-based nanoparticles, core-shell-hybrids, solid materials by gas phase reactions (CVS, CVD) c) Host-guest chemistry, self-assembly and -organization, rotaxanes and catenanes, molecular knots, container molecules, coordination polymers, self-assembling monolayers (SAM), nanopatterning (microcontact printing, dip-pen nanolithography) **Nanobiology I** Assembly of bacterial flagella and pili structures Polymerising proteins of the prokaryotic and eukaryotic cytoskeleton Engineering of turning and stepping motors Force production on a nano scale by cytoskeletal motor proteins Protein Machines and the rise of Synthetic Biology Visualisation and measurement of nano scale forces in biological materials Protein folding into membranes – α-helical vs. β-barrel membrane proteins Transmembrane transport – Structure-function relationships of outer membrane proteins Transmembrane signal transduction in phototaxis **Nanobiology II** Mass spectrometry Labelling methods Data analysis Applying mass spectrometry to biomedical sciences Protein kinases and epithelial cell polarity Structure and function of nerve-cells and ion channels Signal transduction cascades on excitable membranes Synaptic transmission and information processing in the brain
Course titles	(a) Nanochemistry I (b) Nanochemistry II (c) Nanobiology I (d) Nanobiology II
Teaching methods	Lectures
Applicability	M. Sc. Nanoscience
Duration	two semesters
Frequency	annually, start in winter or summer semester possible
Language	English
Recommended Skills	Fundamental knowledge in chemistry and biology on Bachelor level with respect to the interdisciplinary scientific paradigm of nanoscience
Prerequisites for participation	Admission to M.Sc. program Nanoscience
Students workload	Contact time: 150 h, Independent studies: 210 h, Sum = 360 h
Course projects / nongraded learning assignments	none
Prerequisites for admission to examination	none
Examination	Written or oral exams (to be announced) for courses (a), (b), (c) and (d)
Credits	12 C (including 1 C for integrated key competences)

Responsible coordinator	Backes
Lecturer(s)	Fuhrmann-Lieker, Siemeling, Faust, Pietschnig, Kapp, Kleinschmidt, Maniak, Müller, Neupert
Media	Blackboard, projector, digital platforms
Literature	**Nanochemistry I:** Israelachvili, Intermolecular and Surface Forces, 3rd Ed., Academic Press, Amsterdam 2011 Dörfler, Grenzflächen und kolloid-disperse Systeme, Springer, Berlin 2002 Hiemenz, Rajagopalan, Principles of Colloid and Surface Chemistry, 3rd Ed., M. Dekker 1997 Butt, Graf, Kappl, Physics and Chemistry of Interfaces, Wiley-VCH, Weinheim 2006 Tieke, Makromolekulare Chemie, Wiley-VCH, Weinheim, 2005 Gnanou, Fontanille, Organic and Physical Chemistry of Polymers, Wiley, Hoboken 2008 Ravve, Principles of Polymer Chemistry, 3rd Ed., Springer 2012 Young, Lovell, Introduction to Polymers, 3rd Ed., CRC Press, Boca Raton 2011 Cowie, Arrighi, Polymers: Chemistry and Physics of Modern Materials, 3rd Ed. , CRC press, Boca Raton, 2007 **Nanochemistry IIa:** Steed, Atwood, Supramolecular Chemistry, 2nd Ed., Wiley-VCH, Chichester 2009 Beer, Gale, Smith, Supramolecular Chemistry, Oxford University Press, Oxford 1999 Lehn, Supramolecular Chemistry, VCH, Weinheim 1995 **Nanochemistry IIb:** Schubert, Hüsing, Synthesis of Inorganic Materials, Wiley-VCH, Weinheim 2000 Brinker, Scherer, Sol-Gel-Science - The Physics and Chemistry of Sol-Gel Processing, Academic Press, San Diego 1989 **Nanochemistry IIc:** Beer, Gale, Smith, Supramolecular Chemistry, Oxford University Press, Oxford 1999 Lehn, Supramolecular Chemistry, VCH, Weinheim 1995 Ozin, Arsenault, Nanochemistry, RSC, Cambridge 2005 Steed, Atwood, Supramolecular Chemistry, 2nd Ed., Wiley-VCH, Chichester 2009 Steed, Turner, Wallace: Core Concepts in Supramolecular and Nanochemistry, Wiley-VCH, Weinheim 2007 Vögtle, Supramolekulare Chemie, Teubner, Stuttgart 1989 Special literature, to be announced by the lecturers
Additional remarks	Lectures of the module which are part of other modules as well may only be credited once

Module title	**MScNano S05 Biological and physical aspects of nanosciences**
Module type	Required elective module (focus biology and physics)
Educational outcomes, competencies, qualification objectives	Students … have acquired knowledge far beyond the contents of textbooks … know advantages and limitations of molecular and physiological methods … have reached profound insight into structure function relationships … have acquired a thorough knowledge about the fundamental physics of low-dimensional systems and nanomaterials … understand the principles of propagation of electrons and light in nanostructured materials … know about quantum mechanical principles and limits of various physical nanosystems ... know about fabrication and characterization techniques of nanosystems … get an overview about actual and potential applications of nanostructured materials **Integrated key competences:** … Students are able to draw cross-links between different disciplines in the context of nanosciences
Types of courses, contact hours	VL 2+2+3+3 SWS
Contents	**Nanobiology I** Assembly of bacterial flagella and pili structures Polymerising proteins of the prokaryotic and eukaryotic cytoskeleton Engineering of turning and stepping motors Force production on a nano scale by cytoskeletal motor proteins Protein Machines and the rise of Synthetic Biology Visualisation and measurement of nano scale forces in biological materials Protein folding into membranes – α-helical vs. β-barrel membrane proteins Transmembrane transport – Structure-function relationships of outer membrane proteins Transmembrane signal transduction in phototaxis **Nanobiology II** Mass spectrometry Labelling methods Data analysis Applying mass spectrometry to biomedical sciences Protein kinases and epithelial cell polarity Structure and function of nerve-cells and ion channels Signal transduction cascades on excitable membranes Synaptic transmission and information processing in the brain **Nanophysics I (Basics)** - Introduction to the physics of nanostructured systems - Fundamental electronic, optical, thermal and mechanical properties of nano structures - Quantum mechanical considerations of nanostructured systems - Overview about physical fabrication techniques - Overview of characterization techniques for nanostructure technologies -Further keywords: density of states, electronic and photonic band structures, low-dimensional systems, light-matter interaction, quantum well, wire, dot, giant magnetic resistance, tunnel magnetic resistance, single electron transport, single photon emission, nanocavities, photonic crystals **Nanophysics II (Applications)** - Overview about properties and fabrication of nanostructured electronic devices - Introduction to quantum effect devices - Introduction to quantum information technologies and different physical realizations - Introduction of nanostructured optoelectronic devices - Fundamental properties of carbon nanotubes and their potential applications - Overview about nanostructured memory devices based on various physical techniques including electronic, optical, magnetic, mechanical and crystallographic
Course titles	(a) Nanobiology I (b) Nanobiology II (c) Nanophysics I (d) Nanophysics II
Teaching methods	Lectures
Applicability	M. Sc. Nanoscience
Duration	two semesters
Frequency	annually, start in winter or summer semester possible
Language	English
Recommended Skills	Fundamental knowledge in biology and physics on Bachelor level with respect to the interdisciplinary scientific paradigm of nanoscience
Prerequisites for participation	Admission to M.Sc. program Nanoscience
Students workload	Contact time: 150 h, Independent studies: 210 h, Sum = 360 h
Course projects / nongraded learning assignments	none
Prerequisites for admission to examination	none
Examination	Written or oral exams (to be announced) for courses (a), (b), (c) and (d)

Credits	12 C (including 1 C for integrated key competences)
Responsible coordinator	Maniak
Lecturer(s)	Kapp, Kleinschmidt, Maniak, Müller, Neupert, Reithmaier, Popov
Media	Blackboard, projector, digital platforms
Literature	Special literature, to be announced by the lecturers **Nanophysics I:** - J.D. Jackson, "Klassische Elektrodynamik", Walter de Gryter, 1981. - Stephan Gasiorowicz, "Quantenphysik", Oldenburg-Verlag, 2. Aufl., 1981. - Charles Kittel, "Einführung in die Festkörperphysik", Olderburg-Verlag, 6. Aufl., 1983. - N. W. Ashcroft, N. D. Mermin, "Solid State Physics", Saunders College Publishing, 1976. - Stratis Karamanolis, "Faszination Nanotechnologie", Elektra-Verlag, 2005. - Horst-Günter Rubahn, "Nanophysik und Nanotechnologie", Teubner-Verlag, 2002. - Michael Köhler, "Nanotechnologie", Wiley-VCH Verlag, 2001. - Gregory Timp, "Nanotechnology", Springer-Verlag, 1999. - Siegmar Roth, "One-Dimensional Metals", VCH-Verlag, 1995. - Dieter Bimberg, Marius Grundmann, Nikolai N. Ledentsov, "Quantum Dot Heterostructures", John Wiley & Sons, 1999. - Thomas Heinzel, "Mesoscopic Electronics in Solid State Nanostructures", Wiley-VCH Verlag, 2003. - Paul Harrison, "Quantum Wells, Wires and Dots", John-Wiley & Sons, 2000. - J.D. Joannopoulos, R.D. Meade, J.N. Winn, "Photonic Crystals: Molding the flow of light", Princeton University Press, 1995. - G. Ali Mansoori, "Principles of Nanotechnology", World Scientific Publishing, 2005. - K. Busch, S. Lölkes, R.B. Wehrspohn, H. Föll, "Photonic Crystals", Wiley-VCH Verlag, 2004. - K. Inoue, K. Ohtaka, "Photonic crystals: physics, fabrication and applications", Springer Verlag, 2004. - K. Sakoda, "Optical Properties of Photonic Crystals", Springer Verlag, 2004. - D. A. Bonnell, „Scanning Tunneling Microscopy and Spectroscopy“, VCH, 1993. - F. Henneberger, O. Benson, „Semiconductor Quantum Bits“, Pan Standford Publishing, 2007. **Nanophysics II:** - Rainer Waser, "Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices", Wiley-VCH, 2003. - J.P. Reithmaier P. Petkov, W. Kulisch, C. Popov, "Nanostructured Materials for Advanced Technological Applications“, Springer, Nato ASI Series B, Physics and Biophysics, 2009. - J.P. Reithmaier P. Paunovic, W. Kulisch, C. Popov, P. Petkov, "Nanotechnological Basis for Advanced Sensors", Springer, Nato ASI Series B, Physics and Biophysics, 2011.
Additional remarks	Lectures of the module which are part of other modules as well may only be credited once

Module title	**MScNano S06 Physical and chemical aspects of nanosciences**
Module type	Required elective module (focus physics and chemistry)
Educational outcomes, competencies, qualification objectives	Students … have acquired a thorough knowledge about the fundamental physics of low-dimensional systems and nanomaterials … understand the principles of propagation of electrons and light in nanostructured materials … know about quantum mechanical principles and limits of various physical nanosystems ... know about fabrication and characterization techniques of nanosystems … get an overview about actual and potential applications of nanostructured materials … have acquired a thorough knowledge about the chemistry of nanosystems … know the principles of colloid, polymer and supramolecular chemistry … know bottom-up strategies for the preparation of chemical nanostructures **Integrated key competences:** … Students are able to draw cross-links between different disciplines in the context of nanosciences
Types of courses, contact hours	VL 3+3+3+3 SWS
Contents	**Nanophysics I (Basics)** - Introduction to the physics of nanostructured systems - Fundamental electronic, optical, thermal and mechanical properties of nano structures - Quantum mechanical considerations of nanostructured systems - Overview about physical fabrication techniques - Overview of characterization techniques for nanostructure technologies -Further keywords: density of states, electronic and photonic band structures, low-dimensional systems, light-matter interaction, quantum well, wire, dot, giant magnetic resistance, tunnel magnetic resistance, single electron transport, single photon emission, nanocavities, photonic crystals **Nanophysics II (Applications)** - Overview about properties and fabrication of nanostructured electronic devices - Introduction to quantum effect devices - Introduction to quantum information technologies and different physical realizations - Introduction of nanostructured optoelectronic devices - Fundamental properties of carbon nanotubes and their potential applications - Overview about nanostructured memory devices based on various physical techniques including electronic, optical, magnetic, mechanical and crystallographic **Nanochemistry I (Colloid and polymer chemistry)** Intermolecular forces and colloid forces, hydrophobic effect, DLVO theory, association colloids, micelles, liquid crystals, micro- and macroemulsions, polymer structure and nomenclature, radical and ionic polymerizations, living polymerizations, catalyzed polymerizations, polycondensation and polyaddition, radius of gyration, scaling laws, polymer solutions and blends, Flory-Huggings model, demixing mechanisms, block copolymers, physicochemical properties of macromolecules **Nanochemistry II (Supramolecular chemistry, special topics)** a) Non-covalent interactions (bond interactions, H-bridges), molecular recognition, artificial enzymes, nanocarriers, molecular wires Contents b) Sol-gel process, oxide-based gels, aerogels and xerogels, porous materials, metal-organic-frameworks (MOFs), oxide-based nanoparticles, core-shell-hybrids, solid materials by gas phase reactions (CVS, CVD) c) Host-guest chemistry, self-assembly and -organization, rotaxanes and catenanes, molecular knots, container molecules, coordination polymers, self-assembling monolayers (SAM), nanopatterning (microcontact printing, dip-pen nanolithography)
Course titles	(a) Nanophysics I (b) Nanophysics II (c) Nanochemistry I (d) Nanochemistry II
Teaching methods	Lectures
Applicability	M. Sc. Nanoscience
Duration	two semesters
Frequency	annually, start in winter or summer semester possible
Language	English
Recommended Skills	Fundamental knowledge in physics and chemistry on Bachelor level with respect to the interdisciplinary scientific paradigm of nanoscience
Prerequisites for participation	Admission to M.Sc. program Nanoscience
Students workload	Contact time: 180 h, Independent studies: 180 h, Sum = 360 h
Course projects / nongraded learning assignments	none
Prerequisites for admission to examination	none

Examination	Written or oral exams (to be announced) for courses (a), (b), (c) and (d)
Credits	12 C (including 1 C for integrated key competences)
Responsible coordinator	Reithmaier
Lecturer(s)	Reithmaier, Popov, Fuhrmann-Lieker, Siemeling, Faust, Pietschnig
Media	Blackboard, projector, digital platforms
Literature	**Nanophysics I:** - J.D. Jackson, "Klassische Elektrodynamik", Walter de Gryter, 1981. - Stephan Gasiorowicz, "Quantenphysik", Oldenburg-Verlag, 2. Aufl., 1981. - Charles Kittel, "Einführung in die Festkörperphysik", Olderburg-Verlag, 6. Aufl., 1983. - N. W. Ashcroft, N. D. Mermin, "Solid State Physics", Saunders College Publishing, 1976. - Stratis Karamanolis, "Faszination Nanotechnologie", Elektra-Verlag, 2005. - Horst-Günter Rubahn, "Nanophysik und Nanotechnologie", Teubner-Verlag, 2002. - Michael Köhler, "Nanotechnologie", Wiley-VCH Verlag, 2001. - Gregory Timp, "Nanotechnology", Springer-Verlag, 1999. - Siegmar Roth, "One-Dimensional Metals", VCH-Verlag, 1995. - Dieter Bimberg, Marius Grundmann, Nikolai N. Ledentsov, "Quantum Dot Heterostructures", John Wiley & Sons, 1999. - Thomas Heinzel, "Mesoscopic Electronics in Solid State Nanostructures", Wiley-VCH Verlag, 2003. - Paul Harrison, "Quantum Wells, Wires and Dots", John-Wiley & Sons, 2000. - J.D. Joannopoulos, R.D. Meade, J.N. Winn, "Photonic Crystals: Molding the flow of light", Princeton University Press, 1995. - G. Ali Mansoori, "Principles of Nanotechnology", World Scientific Publishing, 2005. - K. Busch, S. Lölkes, R.B. Wehrspohn, H. Föll, "Photonic Crystals", Wiley-VCH Verlag, 2004. - K. Inoue, K. Ohtaka, "Photonic crystals: physics, fabrication and applications", Springer Verlag, 2004. - K. Sakoda, "Optical Properties of Photonic Crystals", Springer Verlag, 2004. - D. A. Bonnell, „Scanning Tunneling Microscopy and Spectroscopy“, VCH, 1993. - F. Henneberger, O. Benson, „Semiconductor Quantum Bits“, Pan Standford Publishing, 2007. **Nanophysics II:** - Rainer Waser, "Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices", Wiley-VCH, 2003. - J.P. Reithmaier P. Petkov, W. Kulisch, C. Popov, "Nanostructured Materials for Advanced Technological Applications“, Springer, Nato ASI Series B, Physics and Biophysics, 2009. - J.P. Reithmaier P. Paunovic, W. Kulisch, C. Popov, P. Petkov, "Nanotechnological Basis for Advanced Sensors", Springer, Nato ASI Series B, Physics and Biophysics, 2011. **Nanochemistry I:** Israelachvili, Intermolecular and Surface Forces, 3rd Ed., Academic Press, Amsterdam 2011 Dörfler, Grenzflächen und kolloid-disperse Systeme, Springer, Berlin 2002 Hiemenz, Rajagopalan, Principles of Colloid and Surface Chemistry, 3rd Ed., M. Dekker 1997 Butt, Graf, Kappl, Physics and Chemistry of Interfaces, Wiley-VCH, Weinheim 2006 Tieke, Makromolekulare Chemie, Wiley-VCH, Weinheim, 2005 Gnanou, Fontanille, Organic and Physical Chemistry of Polymers, Wiley, Hoboken 2008 Ravve, Principles of Polymer Chemistry, 3rd Ed., Springer 2012 Young, Lovell, Introduction to Polymers, 3rd Ed., CRC Press, Boca Raton 2011 Cowie, Arrighi, Polymers: Chemistry and Physics of Modern Materials, 3rd Ed. , CRC press, Boca Raton, 2007 **Nanochemistry IIa:** Steed, Atwood, Supramolecular Chemistry, 2nd Ed., Wiley-VCH, Chichester 2009 Beer, Gale, Smith, Supramolecular Chemistry, Oxford University Press, Oxford 1999 Lehn, Supramolecular Chemistry, VCH, Weinheim 1995 **Nanochemistry IIb:** Schubert, Hüsing, Synthesis of Inorganic Materials, Wiley-VCH, Weinheim 2000 Brinker, Scherer, Sol-Gel-Science - The Physics and Chemistry of Sol-Gel Processing, Academic Press, San Diego 1989 **Nanochemistry IIc:** Beer, Gale, Smith, Supramolecular Chemistry, Oxford University Press, Oxford 1999 Lehn, Supramolecular Chemistry, VCH, Weinheim 1995 Ozin, Arsenault, Nanochemistry, RSC, Cambridge 2005 Steed, Atwood, Supramolecular Chemistry, 2nd Ed., Wiley-VCH, Chichester 2009 Steed, Turner, Wallace: Core Concepts in Supramolecular and Nanochemistry, Wiley-VCH, Weinheim 2007 Vögtle, Supramolekulare Chemie, Teubner, Stuttgart 1989 Special literature, to be announced by the lecturers
Additional remarks	Lectures of the module which are part of other modules as well may only be credited once

Module title	**MScNano KEY Additive Key Competencies**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students acquire additional non study-specific competencies that are relevant for their professional life
Types of courses, contact hours	One or more courses listed in the course catalogue of the university of Kassel under "Schlüsselkompetenzen fachübergreifend" which will be actualized every semester. For single courses 1 to 6 Credits may be given upon decision of the lecturer. Participation in academic commitees (faculty council, student representation etc.) and voluntary support in academic administration, teaching or student counseling may also be acknowledged up to a limit of 3 credits.
Contents	Contents depend on the courses selected. For example the following courses may be taken: - a foreign language - project management - intellectual property management - stress management - conflict management - advanced software usage This module comprises also the courses within the "International Track" of the Faculty of Mathematics and Natural Sciences, namely English for Scientists and Intercultural Communication as preparation for a mobility.
Course titles	See "Schlüsselkompetenzen fachübergreifend" in the course catalogue of the University of Kassel
Teaching methods	Depending on the selected course
Applicability	M.Sc. Nanoscience
Duration	Courses for additive key competencies are given in every semester
Frequency	Depending on the selected course
Language	Depending on the selected course
Recommended Skills	none
Prerequisites for participation	none
Students workload	Depending on the selected course
Course projects / nongraded learning assignments (Studienleistungen)	Records of all course projects according to the respective lecturers. Engagement in academic self-administration has to be confirmed by the electoral office of the university of Kassel, the AStA, the head of the respective committee or the dean of studies. In this case a portfolio of 5±1 pages has to be added which shall contain a self-reflection about the key competencies acquired.
Prerequisites for admission to examination	n/a
Examination	none
Number of credits	varying, max. 6 C
Responsible coordinator	Head of examination committee
Lecturer(s)	Instructors of all departments and central institutions of the University of Kassel
Media	Depending on the selected course
Literature	Depending on the selected course

Module title	**MScNano INT International Elective Modules**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... are able to apply their basic studies to successfully participate in nanoscience modules given by another university or research institution ... have been working successfully in lectures, seminars, laboratory courses and/or research projects equivalent to elective modules offered in Kassel **Integrated key competencies:** Students <u>Communication competency:</u> ... gained intercultural experience ... are able to work in an international team ... are able to communicate in English on a higher level (min. C1) or in another language <u>Organisational competency:</u> ... have been able to organize a stay abroad ... have experience in continuing their studies in a different environment
Types of courses, contact hours	according to Learning Agreement
Contents	The contents will be defined by a Learning agreement prior to departure that is signed by the student, the receiving institution, the head of the examination committee, and, if applicable, by the programme coordinator. The module comprises the upper two levels of the "International Track" of the Faculty of Mathematics and Natural Sciences, i.e. seminars during and after the mobility.
Course titles	(a) According to Learning Agreement (b) International day
Teaching methods	Lectures, exercises, seminars, laboratory work, and others
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	every semester
Language	English or the main language of the receiving institution
Recommended Skills	Fundamental knowledge in nanoscience on Bachelor level
Prerequisites for participation	none
Students workload	varying, for one semester max. 900 h
Course projects / nongraded learning assignments (Studienleistungen)	Report on the experiences abroad, given as talk (20-30 min) e.g. at the International Day or in written form
Prerequisites for admission to examination	none
Examination	According to the Transcript of Records (Recognition outcomes). After acceptance by the head of the examination commitee, an overall grade will be calculated as mean of the modules graded abroad, weighted by the number of credits.
Number of credits	varying, max. 30 C (including 4 C for integrated key competencies)
Responsible coordinator	Head of examination committee
Lecturer(s)	
Media	
Literature	

Module title	**MScNano BPM Professional Practical Training**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Insight into the professional world for the graduates of M.Sc. Nanoscience **Integrated key competencies:** Interdisciplinary studies: depending on location Communication competency: Ability for integration and teamwork Organisational competency: Keeping deadlines Methodic competency: depending on location
Types of courses, contact hours	P e 6 weeks Practical training in a company, seminar
Contents	Six weeks practical training in a company or institution (outside the university) in which work physicists, chemists, biologists or graduates of nanoscience and nanotechnology. During this time a small project should be prepared, which gives an insight in the job activities of graduates of nanoscience and nanotechnology. Every student will be supervised by a lecturer from the university, who will be a contact person and will evaluate the final report or the seminar talk. Once per year an introductory seminar is organized where students who have made their practical training share their experience with the other students.
Course titles	Seminar to Professional Practical Training for Students of Physics and Nanoscience
Teaching methods	Professional practical training
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	every semester
Language	German or English
Recommended Skills	none
Prerequisites for participation	none
Students workload	Contact hours 40 h x 6 = 240 h
Course projects / nongraded learning assignments	none
Prerequisites for admission to examination	none
Examination	Seminar talk ca. 15 min or written report ca. 10 pages
Credits	8 C (including 4 C for integrated key competencies)
Responsible coordinator	Popov
Lecturer(s)	Lecturers of nanoscience, including partners from industry
Media	
Literature	

Module title	MScNano APC Applied Physical Chemistry
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... have insight into modern research areas of physical chemistry ... have experience with measurement equipment of physical chemistry ... experience the connection of physical chemistry with fields such as materials science and other disciplines ... are able to read special research literature in applied physical chemistry and present it to an advanced audience
Types of courses, contact hours	S 2 SWS P i 2 SWS
Contents	Seminar-type lecture on a modern research field connected with the research in the physical chemistry group (subject to change according to the actual head). In the second half of the semester, the lecture is supplemented by talks given by the participants. Laboratory course with experiments on applied physical chemistry e.g. laser spectroscopy and voltammetry on soft matter and functional materials, conductive polymers, dye-sensitized solar cells, organic display materials, etc.
Course titles	(a) Applied Physical Chemistry (b) Lab course Applied Physical Chemistry
Teaching methods	Lecture, seminar talks, laboratory work
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually in summer semester
Language	English
Recommended Skills	Basic Physical Chemistry
Prerequisites for participation	none
Students workload	Contact time: 4 h x 15 = 60 h, Independent studies: 120 h, Summe = 180 h
Course projects / nongraded learning assignments (Studienleistungen)	- Four successfully completed experiments, including report and final discussion - (implied) Regular and active participation in the seminar
Prerequisites for admission to examination	none
Examination	Seminar talk with discussion (30 min)
Number of credits	6 C
Responsible coordinator	Head of physical chemistry group
Lecturer(s)	N.N.
Media	Projector, laboratory equipment, online learning platform
Literature	Special literature

Module title	**MScNano ARO Aromatic building blocks for organic nanostructures**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... know important applications of two- and three-dimensional aromatic systems in the nanosciences and in nanotechnology ... can judge the electronic nature of aromatic and heteroaromatic compounds ... have an impression of various structural motives based on aromatic building blocks ... know fundamental and exemplary procedures for the preparation of aromatic and heteroaromatic organic nanostructures
Types of courses, contact hours	VL 2 SWS
Contents	- Graded reactivity for the construction of aromatic and heteroaromatic nanostructures. - Exemplary Syntheses of heteroaromatic compounds with variable numbers of heteroatoms (N, O, S). - Application of aromatic heterocycles as molecular switches, for molecular transport, and as molecular logical gates. - Planar linear and angular benzene nanostructures, preparation and properties. - Three-dimensional aromatic nanostructures, preparation and properties. - Fullerene model compounds and their preparations. - Fullerenes, their chemistry and some applications.
Course titles	Aromatic building blocks for organic nanostructures
Teaching methods	Lecture series
Applicability	M.Sc. Nanoscience B.Sc. Nanostrukturwissenschaften
Duration	one semester
Frequency	annually, in summer semester
Language	English or German
Recommended Skills	Fundamentals in Organic Chemistry Molecular Synthetic Chemistry
Prerequisites for participation	none
Students workload	Contact hours 2 h x 15 = 30 h, independent studies, 60 h, sum = 90 h
Course projects / nongraded learning assignments	none
Prerequisites for admission to examination	none
Examination	Written (2 h) or oral (30 min.) examination. The type and the date of the examination will be communicated by the lecturer at the beginning of the course.
Credits	3 C
Responsible coordinator	Faust
Lecturer(s)	Faust, Flock, Fürmeier
Media	Projector, black board, powerpoint
Literature	- Eicher/Hauptmann: The Chemistry of Heterocycles, Wiley-VCH, Weinheim.* - Hopf: Classics in Hydrocarbon Chemistry, Wily-VCH, Weinheim.* - Hirsch/Brettreich: Fullerenes, Wiley-VCH, Weinheim.* * als e-Book über UB Kassel zugänglich / as e-book available

Module title	**MScNano CHM Chemistry of Materials**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … gain fundamental knowledge in preparation, properties, application and usage of hybrid materials and polymers on an advanced level … are able to establish structure property relationships in the context of materials chemistry … can judge how structure information can be derived from the combination of various analytical techniques
Types of courses, contact hours	VL 2 SWS
Contents	Building principles and aspects of structure, properties and applications of important inorganic materials and polymers with crosslinks to organic, hybrid and responsive materials. Synthetic aspects in the chemistry of materials with respect to their preparation and post-synthetic modification on an advanced level.
Course titles	Chemistry of Materials
Teaching methods	Lecture series
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually in summer semester
Language	English or German
Recommended Skills	General Chemistry Basic Inorganic Chemistry Molecular Inorganic Chemistry Fundamentals of Organic Chemistry Physical Chemistry
Prerequisites for participation	none
Students workload	Contact hours 2 h x 15 = 30 h, independent studies, 60 h, sum = 90 h
Course projects / nongraded learning assignments	none
Prerequisites for admission to examination	none
Examination	Written or oral exam (to be announced)
Credits	3 C
Responsible coordinator	Pietschnig
Lecturer(s)	Pietschnig, Maurer
Media	Blackboard, projector
Literature	- Schubert/Hüsing: Synthesis of Inorganic Materials. Wiley-VCH: Weinheim. - Allcock: Introduction to Materials Chemistry. Wiley-VCH: Weinheim. - specialized literature

Module title	**MScNano ASP Applied Semiconductor Physics**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … have acquired a thorough knowledge about fundamental semiconductor physics … understand the principles of electron transport in semiconductors … know about basic building blocks for electronic and optoelectronic devices … know about fabrication and functioning of major electronic and optoelectronic devices including quantum effect devices and integrated circuits … to be trained to solve practical problems quantitatively **Integrated key competencies:** Methodic competency: Training to communicate solutions to the audience using a blackboard
Types of courses, contact hours	VL 3 SWS Ü 1 SWS
Contents	**Lectures** - Repetition of basics in solid state physics from the point of view of semiconductors - Introduction in the fundamentals of semiconductors - Electronic and optical properties of semiconductors - Fabrication and properties of electronic and optoelectronic devices - Integration technologies for memories and processors - Static and dynamic behavior of devices - High power, microwave and high frequency applications - Quantum effect and nanostructured devices Further keywords: reciprocal space, electronic bandstructure, carrier transport and scattering phenomena, light-matter interaction, doping, pn-junction, field-effect, Bipolar and MOS transistor, resonant tunneling diodes, thyristor, LED and laser, memory chip, integrated circuit **Excercises** - Repetition of deepening of lecture contents - Calculations of device characteristics, e.g., field distribution of pn-junction or I-V-curves for bipolar or field-effect devices
Course titles	Applied Semiconductor Physics Exercises to Applied Semiconductor Physics
Teaching methods	Lecture, exercise
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually, in winter semester
Language	English, lecture notes are also available in German
Recommended Skills	Fundamental knowledge in physics on Bachelor level (in particular in electromagnetism, optics and solid-state physics) with respect to the interdisciplinary scientific paradigm of nanoscience
Prerequisites for participation	none
Students workload	Contact time: 60 h, Independent studies: 120 h, sum = 180 h
Course projects / nongraded learning assignments (Studienleistungen)	Participation in exercises
Prerequisites for admission to examination	At least 60% of all exercises solved
Examination	Examination either written (2 h) or oral (30 min)
Number of credits	6 C (including 1 C for integrated key competencies)
Responsible coordinator	Reithmaier
Lecturer(s)	Reithmaier
Media	Blackboard, projector
Literature	- J.D. Jackson, "Klassische Elektrodynamik", Walter de Gryter, 1981. - Stephan Gasiorowicz, "Quantenphysik", Oldenburg-Verlag, 2. Aufl., 1981. - Charles Kittel, "Einführung in die Festkörperphysik", Olderburg-Verlag, 6. Aufl., 1983. - N. W. Ashcroft, N. D. Mermin, "Solid State Physics", Saunders College Publishing, 1976. - Rudolf Müller, "Halbleiter-Elektronik, Bd. 1 (Grundlagen der Halbleiterelektronik)", Springer-Verlag, 7. Aufl., 1995. - Rudolf Müller, "Halbleiter-Elektronik, Bd. 2 (Bauelemente der Halbleiterelektronik)", Springer-Verlag, 4. Aufl., 1991. - Walter Heywang, Hans W. Pötzl, "Halbleiter-Elektronik, Bd. 3 (Bänderstruktur und Stromtransport)", Springer-Verlag, 1976. - Günter Winstel, Claus Weyrich, "Halbleiter-Elektronik, Bd. 10 (Optoelektronik I: Lumineszenz- und Laserdioden)", Springer-Verlag, 1980. - S.M. Sze, "Semiconductor Devices: Physics and Technology", John Wiley & Sons, 1985. - S.M. Sze, "Physics of Semiconductor Devices", John Wiley & Sons, 2nd Edition, 1981. - S.M. Sze, "Modern Semiconductor Device Physics", John Wiley & Sons, 1997 - K.J. Ebeling, "Integrierte Optoelektronik", Springer Verlag, 2. Aufl., 1992.

	- H. Ghafouri-Shiraz, B.S.K. Lo, "Distributed Feedback Laser Diodes: Principles and Physical Modelling", Wiley & Sons, 1996. - G. Bastard, "Wave mechancis applied to semiconductor heterostructures", monographies de physique, les éditions de physique, Les Ulis, ca. 1980 (kein Erscheinungsjahr). - L.A. Coldren, S.W. Corzine, "Diode Lasers and Photonic Integrated Circuits", Wiley & Sons, 1995. - Amnon Yariv, "Optical Electronics in Modern Communications", 5th Edition, Wiley & Sons, 1997

Module title	MScNano SCL Semiconductor Laser
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … have acquired a thorough knowledge about fundamentals of laser physics … understand the principles of semiconductor lasers including static and dynamic properties … know about quantum mechanical origin of major laser properties … get a quantitative understanding of device properties and specifications … get an overview about device fabrication and application driven designs … get an overview about most important types of semiconductor lasers and their applications … get involved on actual research and development of semiconductor lasers **Integrated key competencies:** Methodic competency: - Training for the preparation of a scientific talk - Learn how to find actual literature and to extract information for the talk preparation - Training to speak in front of an audience and to defend a scientific content
Types of courses, contact hours	VL 3 SWS S 1 SWS
Contents	**Lectures** - Repetition of basics in semiconductor physics - Introduction in the fundamental laser and semiconductor laser physics - Phenomenological and quantum mechanical description - Static and dynamic behavior of lasers - Laser materials and device designs - Fabrication techniques and properties of specialized lasers - Applications of lasers (high-power, communication, integration) Further keywords: threshold condition, fluid model, gain functions, quantum mechanics, light propagation, waveguides, carrier dynamics, feedback gratings, transfer matrix theory, VCSEL, DFB and DBR lasers, quantum cascade laser, high-power laser, high-speed communication laser, quantum dot laser, nanolaser **Seminar** - Topics will be chosen based on actual research and development
Course titles	Semiconductor Laser Seminar to Semiconductor Laser
Teaching methods	Lecture, seminar
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually, in summer semester
Language	English, lecture notes are also available in German
Recommended Skills	Good knowledge of fundamentals in experimental physics (in particular in electromagnetism and optics) and in solid-state physics. Knowledge in semiconductor physics is helpful.
Prerequisites for participation	none
Students workload	Contact time: 60 h, Independent studies: 120 h, sum = 180 h
Course projects / nongraded learning assignments (Studienleistungen)	One talk presented at seminar with active participation in discussions
Prerequisites for admission to examination	Course projects
Examination	Examination either written (2 h) or oral (30 min)
Number of credits	6 C (including 1 C for integrated key competencies)
Responsible coordinator	Reithmaier
Lecturer(s)	Reithmaier
Media	Blackboard, projector
Literature	- L.A. Coldren, S.W. Corzine, "Diode Lasers and Photonic Integrated Circuits", Wiley & Sons, 1995. - H. Ghafouri-Shiraz, B.S.K. Lo, "Distributed Feedback Laser Diodes: Principles and Physical Modelling", Wiley & Sons, 1996. - A. Yariv, "Optical Electronics in Modern Communications", Oxford Univ. Press, 5. Aufl., 1997. - K.J. Ebeling, "Integrierte Optoelektronik", Springer Verlag, 2. Aufl., 1992. - R.G. Hunsperger, "Integrated Optics", Springer Verlag, 4. Aufl., 1995. W.W. Chow, St.W. Koch, Murray Sargant III, "Semiconductor -Laser Physics", Springer Verlag, 1994. - S.M. Sze, "Semiconductor Devices: Physics and Technology", John Wiley & Sons, 1985. - J.D. Jackson, "Klassische Elektrodynamik", Walter de Gryter, 1981. - Stephan Gasiorowicz, "Quantenphysik", Oldenburg-Verlag, 2. Aufl., 1981. - G. Bastard, "Wave mechancis applied to semiconductor heterostructures", monographies de physique, les éditions de physique, Les Ulis, ca. 1980 (kein Erscheinungsjahr).

	- Charles Kittel, "Einführung in die Festkörperphysik", Oldenburg-Verlag, 6. Aufl., 1983. - Neil W. Ashcroft, N. David Mermin, "Solid State Physics", Saunders College Publishing, 1976. - Rudolf Müller, "Halbleiter-Elektronik, Bd. 1 (Grundlagen der Halbleiterelektronik)", Springer-Verlag, 7. Aufl., 1995. - Rudolf Müller, "Halbleiter-Elektronik, Bd. 2 (Bauelemente der Halbleiterelektronik)", Springer-Verlag, 4. Aufl., 1991. - Walter Heywang, Hans W. Pötzl, "Halbleiter-Elektronik, Bd. 3 (Bänderstruktur und Stromtransport)", Springer-Verlag, 1976. - Günter Winstel, Claus Weyrich, "Halbleiter-Elektronik, Bd. 10 (Optoelektronik I: Lumineszenz- und Laserdioden)", Springer-Verlag, 1980. - S.M. Sze, "Physics of Semiconductor Devices", John Wiley & Sons, 2nd Edition, 1981.

Module title	**MScNano TFP Thin Film Physics**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … have acquired a basic knowledge about the deposition and characterization of thin films … know the electric, mechanic and magnetic properties of thin films and techniques to manipulate them (focus on magnetic properties) … know magnetic coupling phenomena in thin films and their applications …. know about fundamental effects in magnetic nanostructures and its applications
Types of courses, contact hours	VL 2 SWS
Contents	**Thin film physics** Deposition techniques, layer growth, analysis of thin films, electrical and mechanical and magnetic properties of thin films, magnetic anisotropy, exchange bias, interlayer exchange coupling, magneto-resistance effects, magnetic pattering
Course titles	Functional thin films
Teaching methods	Lecture
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually, in winter semester
Language	English, for a transitional period lecture notes and exam questions might also be in German
Recommended Skills	Fundamental knowledge in physics on Bachelor level
Prerequisites for participation	none
Students workload	Contact time: 30 h, Independent studies: 60 h, Summe = 90 h
Course projects / nongraded learning assignments (Studienleistungen)	none
Prerequisites for admission to examination	none
Examination	Oral (30 min.) or written (1-2 h) exam. Type, date and duration of the exam will be announced at the start of the lecture.
Number of credits	3 C
Responsible coordinator	Ehresmann
Lecturer(s)	Ehresmann
Media	Blackboard, projector
Literature	References to original literature will be given in the lecture

Module title	**MScNano PSR Physics with Synchrotron Radiation**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... gained basic knowledge about the properties of synchrotron radiation and its applications ... know about material analysis methods using synchrotron radiation ... have acquired basic knowledge about synchrotron based lithography processes
Types of courses, contact hours	VL 2 SWS
Contents	**Physics with synchrotron radiation** Theory of synchrotron radiation, construction of synchrotron radiation facilities, Wiggler and Undulators, Free-Electron-Laser, x-ray fluorescence analysis, EXAFS, NEXAFS, XMCD, LIGA-procedure, x-ray lithography
Course titles	Physics with synchrotron radiation
Teaching methods	Lecture
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually, in summer semester
Language	English, for a transitional period lecture notes and exam questions might also be in German
Recommended Skills	Fundamental knowledge in physics on Bachelor level
Prerequisites for participation	none
Students workload	Contact time: 30 h, Independent studies: 60 h, Summe = 90 h
Course projects / nongraded learning assignments (Studienleistungen)	none
Prerequisites for admission to examination	none
Examination	Oral (30 min.) or written (1-2 h) exam. Type, date and duration of the exam will be announced at the start of the lecture.
Number of credits	3 C
Responsible coordinator	Ehresmann
Lecturer(s)	Ehresmann
Media	Blackboard, projector
Literature	K. Wille: Physik der Teilchenbeschleuniger und Synchrotronstrahlungsquellen, Teubner (in German) References to original literature will be given in the lecture

Module title	**MScNano ULP Ultrashort Laserpulses and their Application**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... have familiarized with an elected area of expertise in the experimental physics and are able to start a research work in an experimental working group in short pulse laser physics. ... have an overview of the established knowledge in that special research area. ... know the outstanding developments in short-term laser physics from recent years and decades and have an idea of current unresolved problems in that special area. ... know experimental techniques, which can be used in short pulse laser physics, and can evaluate which techniques can be used to measure certain physical values. ... know the advantages and disadvantages of each experimental technique and know, how the different methods can be complemented. .... know the relevant models and approaches for the description of physical phenomena in short pulse laser physics. ... are aware of the limits of the models used. ... know the basics of producing, dispersion, manipulation and characterization of ultrashort laser pulses in theory and the corresponding experimental setups. ... know current application areas with understanding of the underlying theory and of the corresponding experimental setups. Furthermore students have a detailed understanding of the advantages of short pulse laser pulses for the relevant areas.
Types of courses, contact hours	VL, 2 SWS VL, 1 SWS (block lecture) P i, 1 SWS
Contents	Basics of generation, dispersion, manipulation and characterization of ultrashort laser pulses Application examples from femtochemistry, reaction control, quantum optics, 3D-light microscopy, (nano-)materials processing, Generation of CE-Phase Stabilized Few Cycle Laser Pulses
Course titles	Ultrashort laserpulses and their application
Teaching methods	Lecture, laboratory work
Applicability	M.Sc. Nanoscience B.Sc. Nanostrukturwissenschaften
Duration	one semester
Frequency	annually
Language	German / English
Recommended Skills	none
Prerequisites for participation	none
Students workload	Contact time: 4 h x 15 = 60 h Independent studies: 180 h Sum = 240 h
Course projects / nongraded learning assignments (Studienleistungen)	none
Prerequisites for admission to examination	none
Examination	Written examination (1 – 2 hours) or oral examination (30 minutes). Type, date and duration of examination will be fixed by the tutor well in time
Number of credits	8 C
Responsible coordinator	Baumert
Lecturer(s)	Baumert, Assion
Media	Blackboard, projector, Power-Point presentation, laboratory equipment, software-based hands-on training
Literature	- Wollenhaupt M, Assion A, Baumert T. Femtosecond Laser Pulses: Linear Properties, Manipulation, Generation and Measurement. In: Springer Handbook of Lasers and Optics. Springer, 2007: in print (can be found on the homepage of the Experimental Physics III) - Brixner T, Pfeifer T, Gerber G, Wollenhaupt M, Baumert T. Optimal Control of Atomic, Molecular and Electron Dynamics With Tailored Femtosecond Laser Pulses. In: "Femtosecond Laser Spectroscopy". Springer Verlag, 2005: 225-266 (can be found on the homepage of the Experimental Physics III) - Rulliere C. Femtosecond Laser Pulses. Principles and Experiments. Berlin: Springer, 2004. - Diels JC, Rudolph W. Ultrashort Laser Pulse Phenomenon : Fundamentals, Techniques, and Applications on a Femtosecond Time Scale (Optics and Photonics Series). Academic Press, 2006. - Trebino R. Frequency-Resolved Optical Gating: The Measurement of Ultrashort Laser Pulses. Norwell, Massachusetts: Kluwer Academic Publishers, 2000. Further supporting literature will be available via moodle

Module title	**MScNano AEP Lab Course Advanced Experimental Physics**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... will conduct sophisticated scientific experiments on advanced subjects related to the research areas of the experimental physics groups. ... will analyse data, calculate physical values from the data and calculate the error for the data. ... will get the knowledge of systematic planning, conduction, logging and analysis of physical measurement. **Integrated key competencies:** <u>Methodic competency:</u> - Gaining additional competence in independent familiarization in complex natural sciences topics under the practical point of view of an experiment - Safe and competent working in a physical laboratory - Development of the ability to work in a team - Gaining insight in the professional world of an experimentally working physicist. - Gaining competence in the documentation of complex experiments and their results - Gaining competence in the presentation of own experimental results under scientific aspects in writing.
Types of courses, contact hours	P i 6 SWS
Contents	Students choose a total of six experiments out of those offered by the research groups in experimental physics and listed by the lab course coordinator. Possible experiments are: - Measurement of ultrashort laser pulses through autocorrelation technique - Dye laser - Magnetization of thin films - Tunneling microscopy and spectroscopy - Infrared spectroscopy of atmospheric gases - Electron collision induced fluorescence of atoms and molecules - Photon statistics - High temperature superconductivity - Diode laser spectroscopy - Myon physics Or others upon availability
Course titles	Lab course advanced experimental physics
Teaching methods	Lab course in groups of two
Applicability	M.Sc. Nanoscience
Duration	upon arrangement
Frequency	upon arrangement
Language	English / German
Recommended Skills	Basic training in experimental physics
Prerequisites for participation	none
Students workload	Contact time: 90 h Independent studies: 180 h Sum: 270 h
Nongraded learning assignments (Studienleistungen)	Report on six experiments including incorporation of the underlying physics, conduction of the experiments, logging and scientific analysis in an acceptable form
Prerequisites for admission to examination	none
Examination	Oral examination (around 15 - 45 minutes including discussion)
Number of credits	9 Credits (including 3 C for integrated key competencies)
Responsible coordinators	Baumert, Senftleben
Lecturer(s)	The professors of experimental physics
Media	Laboratory equipment
Literature	A manual and additional literature for each experiment is handed out to the students by the instructor. Please note that some material is available in German only.

Module title	**MScNano EPS Experimental Physics Seminar**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... are able to investigate independently literature for a given, up-to-date issue out of modern experimental physics, which can partly be a subject matter for research ... are able to prepare independently a current field of knowledge ... are able to structure and give a lecture about a complex issue out of modern experimental physics, so that a sophisticated audience can follow easily. Through the structure of their talk, students can produce interest in the audience for a complex special topic. **Integrated key competencies:** <u>Communication competency:</u> ... are able to create an attractive presentation. ... are able to lead a scientific discussion (about their own topic as well as about the topics of the remaining participants of the seminar). ... are able to orally cope with the scientific language in German and English
Types of courses, contact hours	S 2 SWS ("Hauptseminar")
Contents	Talks about changing complex issues of modern experimental physics
Course titles	Experimental Physics Seminar: Femtosecond Spectroscopy in Physics, Biology, Chemistry and Engineering
Teaching methods	Seminar talks with scientific discussion
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually in winter semester
Language	English / German
Recommended Skills	none
Prerequisites for participation	none
Students workload	Contact time: 2 h x 15 = 30 h Independent studies: 120 h Sum = 150 h
Course projects / nongraded learning assignments (Studienleistungen)	none
Prerequisites for admission to examination	none
Examination	Seminar talk with scientific discussion (in total 30 – 60 min)
Number of credits	5 C (including 2 C for integrated key competencies)
Responsible coordinator	Baumert
Lecturer(s)	Baumert
Media	Projector presentation
Literature	Recommendations for the access in literature investigations will be provided for each topic.

Module title	**MScNano SUR Surface Science**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... have familiarized with an elected area of expertise in the experimental physics and are able to start a research work in an experimental working group in surface science. ... have an overview of the established knowledge in that special research area. ... know the common experimental techniques used in surface science. ... know the physical properties, that can be addressed by each of the experimental technique and know, how the different methods can be complemented. ... are aware of the limits of the experimental techniques. ... know current application examples of the common experimental techniques. ... can present the results from a recent international publication in the field.
Types of courses, contact hours	S 2 SWS
Contents	XPS/AES, LEED, ARPES, STM, STS, HREELS, surface states, adsorbate systems
Course titles	Surface Science
Teaching methods	Student seminar
Applicability	M.Sc. Nanoscience, M.Sc. Physics
Duration	one semester
Frequency	annually, in summer semester
Language	German / English (talks can be given in the preferred language)
Recommended Skills	none
Prerequisites for participation	none
Students workload	Contact time: 2 h x 15 = 30 h Independent studies: 90 h Sum = 120 h
Course projects / nongraded learning assignments (Studienleistungen)	none
Prerequisites for admission to examination	none
Examination	Seminar talk (30-45 minutes).
Number of credits	4 C
Responsible coordinator	Matzdorf
Lecturer(s)	Matzdorf
Media	Power-Point presentation
Literature	Literature is recommended for each seminar talk individually

Module title	**MScNano NQO Nanoscale Quantum Optics**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … will have acquired a thorough knowledge about quantum optics applicable to the nanoscale … will be able to describe experiments which are depicting key concepts of quantum optics ... will know different experimental platforms to perform quantum optics experiments with special focus on the nano scale ... are able to present and discuss research work … will be able to understand and apply experimental and theoretical concepts from quantum information processing **Integrated key competencies:** <u>Methodic competency:</u> Preparation of a seminar talk
Types of courses, contact hours	VL 3 SWS S 1 SWS
Contents	**Nanoscale Quantum Optics I – Basic principles** Quantization of the electro-magnetic field, quantum states of the light field, photon statistics, experimental realizations, two level systems, density matrix formalism, quantization of atom light interaction, Jaynes-Cummings-Model, dressed states, entanglement, experiments with entangled photons, measurement process, decoherence, nano scale experimental realizations of quantum optics experiments, quantum teleportation. **Nanoscale Quantum Optics II – Applications in Quantum Information Processing** Advanced nano scale experiments from quantum information processing, colour centres (also in nano diamonds), quantum information processing with single ions, quantum communication, quantum repeater, quantum computer and algorithms, ultra-precise nano sensors, quantum error correction and experimental implementation on the nano scale, quantum simulation, cavity quantum electrodynamics and Schrödinger-cat states.
Course titles	Nanoscale Quantum Optics I – Basic principles Nanoscale Quantum Optics II – Applications in Quantum Information Processing
Teaching methods	Lecture, Seminar
Applicability	M.Sc. Physics, M.Sc. Nanoscience
Duration	two semesters
Frequency	annually, start in winter or summer semester possible
Language	English, for a transitional period lecture notes and exam questions will also be available in German
Recommended Skills	Fundamental knowledge of Quantum mechanics on Bachelor level
Prerequisites for participation	none
Students workload	Contact time: 60 h, Independent studies: 120 h, Summe = 180 h
Course projects / nongraded learning assignments (Studienleistungen)	Active participation in seminar including exercises and seminar talk presentation
Prerequisites for admission to examination	none
Examination	Two examination parts: - written test about lecture contents (2 h) - 45 min presentation (weighted 2:1)
Number of credits	6 C (including 1 C for integrated key competencies)
Responsible coordinator	Singer
Lecturer(s)	Singer
Media	Blackboard, projector, online material
Literature	**Nanoscale Quantum Optics I** Gerry & Knight, Introductory quantum optics, Mark Fox, Quantum Optics: An Introduction, Oxford Master Series in Physics Haroche und Raimond, Exploring the quantum, Oxford graduate texts Also: Auletta, Fortuato und Parisi , Quantum Mechanics , Cambridge. Loudon, The Quantum theroy of light Scully & Zubairy, Quantum optics, Walls & Milburn, Quantum optics Cohen-Tannoudji, Dupont-Roc & Grynberg, Atom photon interactions, **Nanoscale Quantum Optics II** Gerry & Knight, Introductory quantum optics, Nielsen & Chuang, Quantum Computation and Quantum Information, Cambridge press. Haroche und Raimond, Exploring the quantum, Oxford graduate texts. Lo, Popescu & Spiller, Introduction to Quantum Computation and Quantum Information. Bouwmeester, Ekert & Zeilinger, The Physics of Quantum Information. John Preskill Lecture Notes for Physics 229, Quantum Information and Computation.

Module title	**MScNano NQ2 Advanced Nanoscale Quantum Optics**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … will have acquired an advanced knowledge about quantum information processing … will be able to describe sophisticated experiments which are depicting key concepts of quantum information processing … will know different experimental platforms to perform quantum optics experiments with special focus on quantum information processing … are able to simulate and verify research work … will be able to extend and develop advanced experimental and theoretical concepts from quantum information processing **Integrated key competencies:** Methodic competency: Students have the ability to apply their knowledge and understanding to develop new ideas in quantum information processing and quantum optics
Types of courses, contact hours	VL 3 SWS S 1 SWS
Contents	**Advanced Nano Scale Quantum Optics – Applications in Quantum Information Processing** Advanced nano scale experiments from quantum information processing, colour centres (also in nano diamonds), quantum information processing with single ions, quantum communication, quantum repeater, quantum computer and algorithms, ultra-precise nano sensors, quantum error correction and experimental implementation on the nano scale, quantum simulation, cavity quantum electrodynamics and Schrödinger-cat states.
Course titles	Advanced Nano Scale Quantum Optics – Applications in Quantum Information Processing
Teaching methods	Lecture, Seminar
Applicability	M.Sc. Physics, M.Sc. Nanoscience
Duration	one semester
Frequency	annually in summer semester
Language	English, for a transitional period lecture notes and exam questions will also be available in German
Recommended Skills	Fundamental knowledge of Quantum mechanics on Bachelor level Nano Scale Quantum Optics
Prerequisites for participation	none
Students workload	Contact time: 60 h, Independent studies: 120 h, Summe = 180 h
Course projects / nongraded learning assignments (Studienleistungen)	Active participation in seminar including exercises and seminar talk presentation
Prerequisites for admission to examination	none
Examination	Written test about lecture contents (ca. 1 h) or oral test (30 min), will be announced at the beginning of the course
Number of credits	6 C (including 1 C for integrated key competencies)
Responsible coordinator	Singer
Lecturer(s)	Dawkins
Media	Blackboard, beamer, online material
Literature	**Advanced Nano Scale Quantum Optics** Gerry & Knight, Introductory quantum optics, Nielsen & Chuang, Quantum Computation and Quantum Information, Cambridge press. Haroche und Raimond, Exploring the quantum, Oxford graduate texts. Lo, Popescu & Spiller, Introduction to Quantum Computation and Quantum Information. Bouwmeester, Ekert & Zeilinger, The Physics of Quantum Information. John Preskill Lecture Notes for Physics 229, Quantum Information and Computation.

Module title	**MScNano TSP Thermodynamics and Statistical Physics**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... ... understand the fundamental concepts and specific scopes of thermodynamics and statistical mechanics. ... have a solid knowledge of the formulation of thermodynamics and statistical mechanics, of the underlying assumptions and of the related mathematical methods. ... are able to mathematically formulate and solve explicit problems in thermodynamics and statistical mechanics by applying the appropriate calculation methods. This includes analytical techniques as well as the ability to introduce convenient physically sound approximations. ... are familiar with the basic temperature-dependent properties of fermionic and bosonic systems particularly concerning their quantum statistical origin. They are able to correlate the microscopic parameters with the thermodynamic observables and can solve related problems of moderate difficulty.
Types of courses, contact hours	VL 4 SWS Ü 2 SWS
Contents	Thermal equilibrium, Temperature, State functions and changes of state, Thermodynamic principles, Entropie, Reversible and irreversible transformations, cyclic process. Thermodynamic potentials, Legendre-Transformations, Maxwell-Relations, Stability criteria. Phase transitions and their classification. Clausius-Clapeyron equation, Principels of Statistical Mechanics. Classical statistics: Phase space, Liouville-Theorem. Microcanonical ensemble, entropy. canonical ensemble, partition function, grand canonical ensemble. Derivation of the principles of thermodynamic. Ensembles equivalence. Quantum statistics: Mixed states and density oprator. Equilibrium ensembles. Third principle of Thermodynamics. Ideal quantum gases. Principle of indistinguishability of identical particles, Fermi-Dirac, Bose-Einstein and Boltzmann distributions. Degenerate Fermi-Gase. Photon gas in thermal equilibrium. Planck's law. Bose-Einstein-Kondensation.
Course titles	Theoretische Thermodynamik und Statistische Physik / Thermodynamics and Statistical Physics Übungen zur Theoretischen Thermodynamik und Statistischen Physik / Exercises on Thermodynamics and Statistical physics
Teaching methods	Lecture, Exercises
Applicability	B.Sc. Nanostrukturwissenschaften, M.Sc. Nanostrukturwissenschaften, B.Sc. Physik
Duration	one semester
Frequency	annually, in summer semester
Language	Deutsch / German
Recommended Skills	Quantenmechanik in den Nanostrukturwissenschaften
Prerequisites for participation	none
Students workload	Contact hours 6 h x 15 =90 h, independent studies, 150 h, sum = 240 h
Course projects / nongraded learning assignments	Successful participation at the exercises
Prerequisites for admission to examination	Course project
Examination	Written (2-3h) or oral (30 min) exam. Type of exam, date and duration will be given by the lecturer at the beginning.
Credits	8 C
Responsible coordinator	Pastor
Lecturer(s)	Koch, Garcia, Pastor
Media	Tafel
Literature	R. Kubo, Thermodynamics (Elsevier) R. Kubo, Statistical Mechanics (North Holland) Callen, Thermodynamics F. Schwabl, Statistische Mechanik (Springer-Verlag) F. Reif, Theorie der Wärme (Mc Graw-Hill) K. Huang, Statistical Mechanics (John-Wiley) Landau-Lifshitz, Statistical Physics (Pergamon) Nolting, Statistische Mechanik Greiner, Thermodynamik

Module title	**MScNano COP Computational Physics**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	- Understand and apply the fundamental numerical implementation procedures in order to solve problems in theoretical physics by means of computers. Knowledge of the most important numerical methods for solving problems in classical, quantum and stastitical mechanics. - Acquire state of the art programming skills, good programming practices and an efficient use of high performance computer clusters, including experience with performance evaluation software.. - Understand the current computer architectures. - Ability to implement a mathematically formulated theoretical problem in the form of computer algorithm. - First practical experience with a small theoretical problem from the mathematical formulation, over the Computer-program conception, its implementation and run-time debugging up to the physical analysis of the numerical results.
Types of courses, contact hours	VL 3 SWS Ü 1 SWS
Contents	Introduction to the Fortran programming language. Use of Fortran compilers and the Unix operating system. Introduction to parallel programming: Computer architectures, parallelization strategies, performance evaluation, message passing interface, OpenMp, etc. A selection of the following subjects. The choice is made by the lecturer taking into account possible student interests so that a diverse and most instructive field is covered. 1) Numerical methods for solving optimisation problems (genetic algorithms, basin hopping, Metropolis Monte Carlo, parallel tempering Monte Carlo). 2) Numerical methods for quantum many-body lattice models (Lanczos- and Davidson-Methods). 3) Density functional theory with local basis sets. 4) Classical adiabatic and non-adiabatic molecular dynamics simulations. Langevin Dynamics. 5) Statistical Markov dynamics (Master equation, kinetic Monte Carlo). 6) Numerical methods for the description of non-adiabatic quantum dynamics. 7) Methods of numerical representation of dynamical quantum systems (discrete variable representation, Binary representation of spin systems). 8) Numerical solution of the time-dependent Schrödinger and Liouville von Neumann equations (orthogonal polynom propagator, Krylov-Space methods). Time-dependent density functional theory 9) Non-perturbative treatment of light-matter interactions . 10) Numerical Ansätze in optimal control theory (Gradient methods, Krotov-Method, etc.)
Course titles	Computational Physics Exercises on Computational Physics
Teaching methods	Lecture, Exercises, practical work at desktop computers
Applicability	M.Sc. Nanoscience, M.Sc. Physik
Duration	one Semester
Frequency	every second year in summer semester
Language	English
Recommended Skills	
Prerequisites for participation	none
Students workload	Contact hours: 4h x 15 = 60h, Independent studies: 90h, sum = 150h
Course projects / nongraded learning assignments (Studienleistungen)	Successful participation at exercises
Prerequisites for admission to examination	Course project
Examination	Development of a computer programm for the numerical solution of a relatively simple problem having a clear physical and/or numerical interest. The actual problem is chosen by the student from a number of alternatives proposed by the lecturer, which are related to the subjects treated in the lectures. Included is a short written report on the problem, algorithm, and analysis of the results. Alternatively the written report may be replaced by an oral presentation in the framework of a seminar, which includes a scientific discussion.
Number of credits	5 c
Responsible coordinator	Pastor
Lecturer(s)	Koch, Garcia, Pastor
Media	Practical work at computers
Literature	Subject dependent

Modul title	**MScNano LA1 Laboratory Astrophysics I**
Module type	Required elective module
Educational outcomes, competencies, qualifications objectives	-Students are familiar with fundamental methods and concepts of molecular physics and molecular spectroscopy. - They can apply these methods to basic problems of molecular spectroscopy - Students have knowledge about important molecules of astrophysical relevance. - Students are able to interpret simple spectra of gas phase molecules and apply this knowledge for identifying astrophysical molecules by means of interstellar observations. - Students gain specific knowledge about spectroscopic methods in application to laboratory astrophysics. - Students learn about classical approaches to spectroscopic problems and learn about modern concepts currently discussed in the field. -Students have knowledge about high resolution rotational spectroscopy. - Students learn to apply basic methods of spectroscopy to solve problems in lecture accompanying exercises.
Types of courses, contact hours	VL 2 SWS Ü 1 SWS
Contents	The lecture contains fundamental principles of laboratory astrophysics, in particular: 1) The molecular bond, a quantum physical approach. 2) Basics on Ro-vibrational spectroscopy, spectra oft two-atoms counting molecules 3) Rotational spectroscopy of symmetric tops (linear, symmetric, asymmetric) 4) Selection rules and transition dipole-moments 5) Spectra of linear , symmetric-, and asymmetric-top molecules 6) The non-rigid rotor approximation. 7) Degenerate states and centrifugal distortion 8) Analyzing molecular spectra with *PGopher* Lecture accompanying exercises deepen the subject matter.
Course title	Laboratory Astrophysics I / Laborastrophysik I Laboratory Astrophysics I – Exercises / Übungen zur Laborastrophysik I
Teaching methods	Lecture, exercises
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually, in winter semester
Language	English/German
Recommended skills	basic knowledge in physics and chemistry (bachelor student level)
Prerequisites for participation	none
Students workload	Contact time: 3h x 15 = 45h, independent studies: 135 h, sum = 180h
Course projects /nongraded learning assignments	Participation in "Laboratory Astrophysics I – Exercises"
Prerequisites for admission to examination	Successful participation in "Laboratory Astrophysics I – Exercises"
Examination	Oral examination (30 min)
Number of Credits	6 C
Responsible coordinator	Giesen
Lecturer(s)	Giesen / Herberth
Media	Blackboard, Power Point
Literature	- Spectra of Atoms and Molecules, Peter F. Bernath, Oxford University Press, Oxford 1995 - Atoms, Molecules and Photons, W. Demtröder, Springer, ISBN 10-3-540-20631-6 in Deutsch: Experimentalphysik 3, Springer Lehrbuch, ISBN 3-540-57096-9 - Microwave Molecular Spectra, W. Gordy, R.L. Cook, John Wiley & Sons, New York, ISBN 0-471-08681-9 - G. Herzberg, Vol. I, Spectra of diatomic molecules, Krieger Publishing Company, Malabar, Florida, ISBN 0-89464-270-7 - High-Resolution Laboratory Terahertz-Spectroscopy and Applications to Astrophysics; in Frontiers of - Molecular Spectroscopy, Jaan Laane (ed.), S. Schlemmer, T.F. Giesen, F. Lewen, and G. Winnewisser, Elsevier 2008 - Molecular Symmetry and Spectroscopy, Bunker and Jensen, NRC Research Press

Modul title	**MScNano LA2 Laboratory Astrophysics II**
Module type	Required elective module
Educational outcomes, competencies, qualifications objectives	Students ... are familiar with advanced methods and concepts of molecular physics and molecular spectroscopy. ... can apply these advanced methods to basic problems of molecular spectroscopy ... have knowledge about important molecules of astrophysical relevance. ... are able to interpret complex spectra of gas phase molecules and apply this knowledge for identifying astrophysical molecules by means of interstellar observations. ... gain specific knowledge about spectroscopic methods in application to laboratory astrophysics. ... learn about modern approaches to spectroscopic problems and learn about new concepts currently discussed in the field. ... have knowledge about high resolution vibrational spectroscopy --- learn to apply basic methods of spectroscopy to solve problems in lecture accompanying exercises
Types of courses, contact hours	VL 2 SWS Ü 1 SWS
Contents	The lecture contains fundamental principles of laboratory astrophysics, in particular: 1) Fundamental vibrational modes in molecules. 2) Molecular Symmetry (Point Symmetry groups) 3) Ro-vibrational transition selection rules. 4) Degenerate vibrational states 5) The Symmetry group of linear Molecules 6) Vibrational coupling and Tunneling phenomena 7) Analyzing molecular spectra with *PGopher* Lecture accompanying exercises deepen the subject matter.
Course title	Laboratory Astrophysics II / Laborastrophysik II Laboratory Astrophysics II – Exercises / Übungen zur Laborastrophysik II
Teaching methods	lecture, exercises, laboratory work
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually, in summer semester
Language	English/German
Recommended skills	basic knowledge in physics and chemistry (bachelor student level).
Prerequisites for participation	Laboratory Astrophysics I
Students workload	Contact time: 3 h x 15 = 45 h, independent studies: 135 h, Sum = 180 h
Course projects /nongraded learning assignments	Participation in "Laboratory Astrophysics II – Exercises"
Prerequisites for admission to examination	Successful participation in "Laboratory Astrophysics II – Exercises"
Examination	Oral examination (30 min)
Number of Credits	6 C
Responsible coordinator	Giesen
Lecturer(s)	Giesen / Herberth
Media	Blackboard, power point
Literature	- Fundamentals of Molecular Symmetry, Philip Bunker and Per Jensen, Institute of Physics, Bristol and Philadelphia, 2005 - Molecular Symmetry and Spectroscopy, 2nd ed., Philip Bunker and Per Jensen, NRC Research Press, Ottawa, 1998 - Spectra of Atoms and Molecules, Peter F. Bernath, Oxford University Press, Oxford 1995, ISBN 0-19-507598-6 - G. Herzberg, Vol. II, Spectra of diatomic molecules, Krieger Publishing Company, Malabar, Florida, ISBN 0-89464-270-7 - Molecular Vibrations, E.B. Wilson, J.C. Decius, P.C.Cross, Dover New York, 1955

Module title	**MScNano MMB Molecular Mechanisms of Biochemical Processes**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	- Basic knowledge of biochemistry to cellular systems as a basis for research in the molecular biosciences. Understanding of range of methods in state of the art biochemistry - Ability apply basic principles of molecular biosciences to specific biological and medical case studies (problem-solving skills) **Integrated key competencies:** <u>Communication competency</u> - Ability to reflect the significance of basic literature <u>Organisational competency:</u> - Selfcontained work with textbooks - Ability to independently prepare, design and present a seminar <u>Methodic competency:</u> - Familiarity with English literature and language
Types of courses, contact hours	VL 2 SWS S 1 SWS
Contents	- Structure and function of selected proteins - Molecular mechanisms of cellular receptors - G-protein coupled signaling pathways - Signal transduction by protein kinases - Receptor tyrosine kinases mediated signal transduction - Current methods of biochemistry - Bioinformatics - Interaction analysis - Biochemistry of components in human signaling pathways in healthy and diseased tissue
Course titles	Biochemistry II (lecture series) Biochemistry II (seminar)
Teaching methods	Lecture, seminar talks
Applicability	M.Sc. Nanoscience, B.Sc. Biologie, M.Sc. Biologie
Duration	one semester
Frequency	annually, each winter semester
Language	English, German
Recommended Skills	Basic knowledge in biochemistry
Prerequisites for participation	none
Students workload	Contact hours 3 h x 15 = 45 h, independent studies, 75 h, sum = 120 h
Course projects / assignments	Active participation in the seminar
Prerequisites for admission to examination	none
Examination	Presentation of a recent publication with subsequent discussion (30 min.)
Credits	4 C (including 1 C for integrated key competencies)
Responsible coordinator	Herberg
Lecturer(s)	Herberg, external scientific experts and coworkers
Media	Projector presentation
Literature	Current references were named from the respective lecturers. In general, the latest edition of the following textbooks is recommended: - Gomperts, Kramer, Tatham: Signal Transduction, Elsevier (2002), englisch - Jeremy Berg, John Tymozko and Lubert Stryer Deutsch: „Biochemie", Springer Spektrum / English: „Biochemistry", W. H. Freeman

Module title	**MScNano BCT Biocatalysis**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	- Deepening of biochemical, microbiological, molecular biological and genetic basics for the understanding of biotechnological applications. - Basic understanding of metabolic engineering and process engineering - Mastery of basic biotechnological methods - Understanding of the range of methods of modern biotechnology - Independent production of a literature review on topic **Integrated key competencies:** *Communication competency:* - Ability to reflect on the significance of the literature - Team skills *Organizational competency:* - Learning of independent working with biotechnology textbooks - Ability to independently prepare, design and presentation of structured seminar presentations - Ability to comply with the set targets *Methodic competency:* - Working knowledge of English literature and terminology
Types of courses, contact hours	VL 2 SWS; S 1 SWS
Contents	**Enzymology (VL):** Introduction to enzymology – Specificity – Cofactors – Kinetics – Inhibition Catalytic mechanisms Enzyme classes Production / Preparation of biocatalysts – Immobilization Bioreactor design Biocatalysis in non-conventional-media Enzymatic cascades Catalytic promiscuity Applications (for example): - Production of Artemisin, insulin, sitagliptin, antibiotics and other pharmaceutical products - CO_2 und H_2 fixation - Production of amino acids - Production of citric acid - Production of biosurfactants and biopolymers - CAZymes for the degredation / valorization of lignocellulosic biomass **Current Methods in Biotechnology (S):** - Cell lysis, isolation of proteins - Protein chromatography, electrophoresis - Expression systems (*E. coli* strains, *B. subtilis, P. pastoris* etc - GRAS Microorganisms) - Expression optimization and membrane proteins - *In vitro* (Cell free) protein synthesis - Phage display, autodisplay, mechanisms of secretion - Metabolic engineering - Genome-editing (ZFN, TALEN, CRISP-Cas Systems) - Analytics (UV, GC, HPLC) - Screening and selection methods - Structural analysis
Course titles	Enzymology (VL); Current Methods in Biotechnology (S)
Teaching methods	Lecture, Seminar
Applicability	M.Sc. Biology M.Sc. Nanostructure Sciences
Duration	one semester
Frequency	annually, in summer semester (after contacting the coordinator)
Language	English
Recommended skills	Fundamental knowledge in Biochemistry, Organic chemistry, Molecular biology and Genetics
Prerequisites for participation	none
Students workload	Contact time: 3 h x 15 = 45 h, Independent studies: 75 h, Sum = 120 h
Course projects / nongraded learning assignments	Active participation in the seminar – Preparation for the round table discussion. (See special information)
Prerequisites for admission to examination	none
Examination	Oral examination (30 min)
Number of credits	4 C

Responsible coordinator	Pavlidis
Lecturer(s)	Pavlidis and colleagues
Media	Projections, Power-Point Presentation, Round-Table discussion
Literature	The updated literature will be announced by the lecturers. Generally, we would suggest the current edition of the following titles: - A. Illanes „Enzyme Biocatalysis – Principles and Applications“ – Springer - Drauz, Gröger & May „Enzyme Catalysis in Organic Synthesis: A Comprehensive Handbook, Volume 1“ Wiley-VCH - W. Aehle „Enzymes in Industry – Production and Applications“, Wiley-VCH - K. Faber „Biotransformations in Organic Chemistry – A textbook“, Springer - Bommarius & Riebel „Biocatalysis – Fundamentals and Applications“, Wiley-VCH
Special Information	In the seminar current methods in biotechnology will be discussed in a Round Table with the lecturer and the students. For each seminar students have to prepare themselves for the respective topic.

Module title	**MScNano SEP Sensory Physiology**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	State of the art knowledge in sensory physiology
Types of courses, contact hours	VL 2 SWS S 2 SWS
Contents	Structure and function of all sensory systems: vision, mechanoperception; hearing, chemosensory systems, nociception, temperature-sense; magnetoperception, electrical sense. Circadian modulation of sensory systems; Neuropeptide function in sensory systems.
Course titles	Sensory Physiology Seminar Basics of / Advanced Studies in Chronobiology and Ollfaction
Teaching methods	Lecture and interactive seminar
Applicability	B.Sc. Nanostrukturwissenschaften, M.Sc. Nanoscience, B.Sc. Biologie, M.Sc. Biologie
Duration	one semester or two semesters, depending on the seminar selected
Frequency	annually, VL winter semester; seminar winter semester or summer semester
Language	German or English
Recommended Skills	Basics in Animal Physiology
Prerequisites for participation	none
Students workload	Contact hours: 60 h, self-studies 90 h, sum 150 h
Course projects / nongraded learning assignments	Regular and active participation in the seminar
Prerequisites for admission to examination	none
Examination	Seminar: oral, ca. 30 min
Credits	5 C
Responsible coordinator	Stengl
Lecturer(s)	Stengl
Media	Projector
Literature	Eckert: Tierphysiologie, 4. Aufl., Thieme 2002, Insect Olfaction (ed. Hansson), Springer ; Englische Originalliteratur

Module title	MScNano GCO Seminar Basics of Chronobiology and Olfaction
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Background knowledge for the advanced courses in Neurobiology with focus in Chronobiology and Sensory Physiology of Chemoreceptive Sciences. Critical reading of original science literature and understanding of the essence of experimental outcomes
Types of courses, contact hours	S 2 SWS
Contents	Introduction to Insect Neurobiology; Introduction to the function of neuropeptides; Introduction to Chronobiology and insect circadian rhythms; Introduction to olfaction.
Course titles	Basics of Chronobiology and Olfaction
Teaching methods	Seminar
Applicability	B.Sc. Nanostrukturwissenschaften, M.Sc. Nanoscience, B.Sc. Biologie, M.Sc. Biologie
Duration	one semester
Frequency	annually, winter semester, Tuesdays
Language	English or German
Recommended Skills	-
Prerequisites for participation	none
Students workload	Contact hours: 90 min every Tuesday during the WS = 30 h, self-study 60 h, sum 90 h
Course projects / nongraded learning assignments	Regular and active participation in the seminar
Prerequisites for admission to examination	none
Examination	Oral presentation, Seminar, ca. 30 min
Credits	3 C
Responsible coordinator	Stengl
Lecturer(s)	Stengl
Media	Projector
Literature	Original English literature

Module title	**MScNano SCO Advanced Seminar in Chronobiology and Olfaction**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	State of the art knowledge in neurobiology with focus in chronobiology and sensory physiology of chemoreceptive sciences. Critical reading of original science literature and understanding of the essence of experimental outcomes.
Types of courses, contact hours	S 2 SWS
Contents	Specific, current literature in insect neurobiology; Specific, current literature in neuropeptide research; Specific, current literature in chronobiology, insect circadian rhythms; Specific, current literature in olfaction.
Course titles	Advanced Seminar in Chronobiology and Olfaction
Teaching methods	Seminar
Applicability	B.Sc. Nanostrukturwissenschaften, M.Sc. Nanoscience, M.Sc. Biologie
Duration	one semester
Frequency	annually, winter semester and summer semester: Wednesday-Seminar
Language	English
Recommended Skills	Basics in Neurobiology
Prerequisites for participation	none
Students workload	Contact hours: 90 min every Wednesday during the WS or SS = 30 h, 60 h self-study, sum 90 h
Course projects / nongraded learning assignments	Regular and active participation in the seminar
Prerequisites for admission to examination	none
Examination	Oral presentation, Seminar, ca. 30 min
Credits	3 C
Responsible coordinator	Stengl
Lecturer(s)	Stengl
Media	Projector
Literature	Original English literature

Module title	**MScNano SNE Seminar Basics of Neuroethology**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Basic knowledge in Neuroethology, understanding the neural basis of behavior
Types of courses, contact hours	S 2 SWS
Contents	Neurons as building blocks of behavior; Echolocation in bats, prey location in barn owls; feature analysis in toads; mate calling in crickets; flight in locusts; escape behavior in crayfish; development of learning in songbirds; associative learning in honeybees; learning and memory in simple reflex systems in Aplysia; molecular genetics of learning and memory in Drosophila; spatial navigation in rats.
Course titles	Basics of Neuroethology
Teaching methods	Seminar
Applicability	M. Sc. Nanoscience, B.Sc. Nanostrukturwissenschaften
Duration	one semester
Frequency	annually, summer semester, tuesdays
Language	English
Recommended Skills	-
Prerequisites for participation	none
Students workload	Contact hours: 45 h, independent studies: 45 h, total: 90 h
Course projects / nongraded learning assignments	Regular and active participation at the seminar
Prerequisites for admission to examination	none
Examination	Seminar, oral presentation, ca. 30 min
Credits	3 C
Responsible coordinator	Stengl
Lecturer(s)	Stengl
Media	Projector
Literature	Behavioral Neurobiology, Carew

Module title	**MScNano MMM Molecular Methods - Microbiology**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	- Apply fundamental and solid knowledge in molecular microbiology, in particular as applied to cellular systems as a basis for research microbial biosciences. - Critical understanding of the methodic repertoire with emphasis in current postgenomic microbial molecular microbiology **Integrated key competencies:** Interdisciplinary studies: - Apply basic principles of molecular microbiology to concrete biological case studies on nanostructured objects / structures Communication competency - Critically reflect significance of experimental data from original literature to develop problem-solving strategies Organisational competency: - Independent work with literature and oral presentation of microbiological phenomena/problems
Types of courses, contact hours	VL 2 SWS S 1 SWS
Contents	- Research into microbial genomics (strategies, systems, models, tools etc) - Postgenomic function analysis in molecular microbiology - Model system *Saccharomyces cerevisiae* - Bioinformatics & interaction analytics - Generation and construction of genome-wide mutant collections - Functional & comparative genomics - Microarrays & Transkriptomcs - Proteomics, interactomics, localisome - Genomic islands, phathogenomics - Synthetic microbiology
Course titles	Microbiology II (VL) Seminar Microbiology II (S)
Teaching methods	Lecture plus seminar talks (see special information, each summer semester)
Applicability	M.Sc. Nanoscience, B.Sc. Nanostrukturwissenschaften, M.Sc. Biologie
Duration	one semester
Frequency	annually in summer semester
Sprache	English and German
Recommended Skills	Basic, fundamental knowledge in microbiology
Prerequisites for participation	none
Students workload	Contact hours: 3 h x 15 = 45 , independent studies: 75 h, sum = 120 h
Course projects/assignments	Active participation in the seminar
Prerequisites for admission to examination	none
Examination	Seminar talk in English (ca 30 min. with discussion)
Credits	4 C (1 C for Integrated key competencies)
Responsible coordinator	Schaffrath
Lecturer(s)	Schaffrath and co-workers
Media	Projector presentation
Literature	Actual literature references are to be provided by respective lecturers
Special information	The nature of the seminar (either block seminar at the end of semester or weekly during the semester) associated with the lecture will be notified separately (see Microbiology black board). For organization, see a separate list of candidate participants.

Module title	**MScNano NTN Nanosystem Technology and Nanophotonic Device Fabrication**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … know the huge application potential of micromachiningg, microsystem technology and opto-electronic components … know how to solve problems using technological fabrication tools. … understand principles of success in nature and can transform them to other scientific fields in micro- and nano system technology … are able to reflect and work scientifically … concluded methodology … have an impression of production cost with respect to micromachined self-assembly vs machine assembly vs human resource based assembly …know economic aspects and strategic planning in companies, energy consumption, required fabrication processes and required human resources related to microsystem technology and micromachining systems … have understood the reasons why we miniaturize in nanoelectronics and in nano system technology …realized in which cases wet or dry etching has advantages … identified analogies between subnanoscale systems like atoms assembled by electrostatic forces and cosmic systems assembled by gravity forces … understood the consequences of scaling for fundamental forces … realized mathematical analogies in the differential equations describing of sinusoidal varying excitation in mechanical and electrical oscillators … understand the complex interaction of plasma and their use in dry etching processes … learn to approach research and development in the area of nanosystems and technological fabrication machines … know the energy consumption of nano systems during operation and potentials to save energy ... know important application areas and research topics of nanosystems and technological fabrication machines … know further analogies in mechanics, electronics and photonics ... know interdisciplinary relations in nanosystems ... aquired basic knowledge about the fundamentals of nanosensors and nanoactuators … realized the potential of smart personal environments … understand the fundamentals in micromachining, micro-optoelectro-mechanical systems (MOEMS) and optical MOEMS … understand the fundamentals of semiconductor technology including specific processes, schemes and required instrumentation ... realize market trends … establish synergies between engineering disciplines and natural sciences … understand thin layer and clean room technologies … realize design, fabrication and use of nanoelectronic, (opto-)electronic and micromachined devices Research and development in the area of nanosystem technology and nano-fabrication technology. **Integrated key competencies:** Interdisciplinary studies: Students are able to identify the mutual relationship between nanosystems (nanosensors and nanoactuators) and e.g. medicine, engineering, metrology, high bit-rate communication, lighting, economy and society
Types of courses, contact hours	V 4 SWS
Contents	- Introduction to micromachining, microsystem techniques, miniaturization, packaging - Crystal growth: semiconductor wafers, thin layer epitaxy Lithography: optical, X-ray, electron-beam, ion-beam, EUVL, nano imprint - Plasma processing and vacuum technology Deposition techniques: evaporation, sputtering, plasma assisted techniques - Dry and wet-chemical etching and clean room technology Fabrication technology of electronic devices (planar transistor, electronic integrated chips), optoelectronic devices (semiconductor lasers, gratings) and micro-optoelectromechanical systems (MOEMS) - Introduction to micromachining, microsystem techniques, miniaturization, packaging and nanotechnology - Reasons for miniaturization and integration, types of micromachining - Sensors and actuators - Large variety of MEMS and MOEMS examples: membranes, springs, resonator elements, cantilevers, valves, manipulation elements, gripping tools, light modulators, optical switches, beam splitters, projection displays, micro optical bench, data distribution, micromachined tunable filters and lasers, - Displays: micromachined (micromirror) displays, laser display technology, vacuumelectronics - Micromirror arrays for smart windows

	- Nanoscale bio- and chemosensors - Drug delivery systems - Lab on a chip production methodology - Basics of nanofluidics for computing Lab tour in the clean room.
Course titles	Technology of electronic and optoelectronic devices Nanosystem technology
Teaching methods	Lecture
Applicability	B.Sc. Nanoscience M. Sc. Nanoscience
Duration	one semester
Frequency	annually in summer semester
Language	English
Recommended Skills	Fundamental knowledge in electronic devices (diodes, transistor) and optoelectronic devices (semiconductor laser, LEDs, solar cells)
Prerequisites for participation	none
Students workload	Course attendance: 60 h, independent studies, 120 h, sum = 180 h
Course projects / nongraded learning assignments (Studienleistungen)	none
Prerequisites for admission to examination	none
Examination	Oral exam (30min)
Number of credits	6 C
Responsible coordinator	Hillmer
Lecturer(s)	Hillmer, Kusserow
Media	Blackboard, projector, hands-on in experiments in the lecture hall and for demonstrators.
Literature	German: - S. Büttgenbach: Mikromechanik - Einführung in Technologie und Anwendungen, 2. Auflage, Teubner, 1994 - T. Fauster, L. Hammer, K. Heinz und A. Schneider: Oberflächenphysik - Grundlagen und Methoden, Oldenbourg Verlag, ISBN 978-3-486-72135-5 Additional: - W. Menz und J. Mohr: Mikrosystemtechnik für Ingenieure, 2. Aufl., VCH Verlag, 1997 - Optik, Eugene Hecht, De Gruyter, 6. Auflage - I. Ruge und H. Mader: Halbleitertechnologie, Serie Halbleiter-Elektronik, Band 4, Springer Verlag, 1991 - H. Hultzsch: Optische Telekommunikationssysteme, Damm Verlag, 1996 - H. Beneking: Halbleiter Technologie, Teubner, Stuttgart, ISBN 3-519-06133-3, 1991 English: - R. Williams: Modern GaAs Processing Methods, Artech House, Inc., ISBN 0-89006-343-5, 1990 Additional: - W. Menz, J. Mohr and O.Paul: Microsystem Technology, VCH Verlag, 2001 - H. I. Smith: Submicron- and nanometer-structures technology, 2nd edition, NanoStructures Press, 437 Peakham Road, Sudbury, MA 01776, USA, 1994 - K. Iga, S. Kinoshita: Process technology for semiconductor lasers, Springer, Series in Material Science 30, 1996 - D. V. Morgan and K. Board: An introduction to semiconductor microtechnology, 2nd edition John Wiley & Sons, Chichester 1994

Module title	**MScNano SEN Nanosensorics**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... have acquired a thorough knowledge about methods to analyze nanostructures ... understand the fundamental principles of the common measurement techniques ... know the application fields of different measurement techniques ... gained experience in working with typical characterization methods ... are able to investigate nanostructures in respect to various properties ... are able to present and discuss own scientific work
Types of courses, contact hours	VL 2 SWS P i 2 SWS
Contents	**Nanosensorics** Microscopy, resolution limits and advanced methods Scanning probe microscopy (AFM,STM, SNOM, …) Electron microscopy (SEM, TEM, FIB) Thin-Film characterization by ellipsometry Characterization of semiconductors (photo luminescence, laser gain, X-ray and electron diffraction, Raman spectroscopy) **Nanosensorics Lab** Experimental work, including ellipsometry, SEM and laser gain measurement
Course titles	Nanosensorics Nanosensorics lab training
Teaching methods	Lecture, laboratory work
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually, start in winter semester
Language	VL: English, exam can be given in English or German P i: English or German
Recommended Skills	Fundamental knowledge in optics, electrodynamics, solid state physics, quantum physics
Prerequisites for participation	none
Students workload	Contact time: 60h, Independent studies: 90h, Sum = 150h
Course projects / nongraded learning assignments (Studienleistungen)	Report on experiments with oral tests on comprehension
Prerequisites for admission to examination	none
Examination	Two examination parts: Oral exam (VL) Laboratory reports (P i) (weighted 1:1)
Number of credits	5 C
Responsible coordinator	Kusserow
Lecturer(s)	Kusserow, Hillmer, Wilke
Media	Blackboard, projector, laboratory equipment
Literature	Bhushan (Ed.):Springer Handbook of Nanotechnology, Springer Verlag Träger (Ed.): Springer Handbook of Lasers and Optics, Springer Verlag Göpel, Ziegler:Struktur der Materie, Teubner Verlag Lawes: Scanning electron microscopy and X-ray microanalysis, Wiley Reimer: Scanning electron microscopy, Springer Verlag Brent: Transmission electron microscopy and diffractometry of materials, Springer Verlag Reimer: Transmission electron microscopy, Springer Verlag Giannuzzi: Introduction to Focused Ion Beams, Springer Verlag Dror: Scanning force microscopy, Oxford University Press Wiesendanger: Scanning probe microscopy, Springer Verlag Stroscio: Scanning tunneling microscopy, Academic Press Bai: Scanning tunneling microscopy and its applications, Springer Verlag Paesler: Near field optics, Wiley Kittel: Introduction to solid state physics, wiley Ibach: Solid-state physics, Springer Verlag Ashcroft: Solid state physics, Brooks/Cole Bauer: Optical characterization of epitaxial semiconductor layers, Springer Verlag Schroder: Semiconductor material and device characterization, Wiley Tompkins (Ed.): Handbook of ellipsometry, W.Andrew Pub./Springer Azzam: Ellipsometry and polarized light, North-Holland

Module title	MScNano NPH Nanophotonics
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … have acquired a thorough knowledge of the optical principles and properties of nanostructures … know about the various properties of the applied materials and their interaction with electromagnetic waves … know the main applications oft hin-film optics, photonic crystals, plasmonics, effectiveindex models and the optical near field … are able to apply general models and analogies to different fields of science
Types of courses, contact hours	VL 3 SWS
Contents	Principles of periodical nano structures in optics Special topics of thin-film optics Two- and threedimensional photonic crystals and their applications as, e.g. wave guides, filter, laser, in optical fibers or using Fano resonances Metallic nano structures and their applications. Plasmonics, optical surface states, wave guides, optical antennas, the optical near field. Methods of effective refractive indices Discussion of important material properties of metalls, dielectrica and semiconductors regarding nanophotonics.
Course titles	Nanophotonik
Teaching methods	Lecture
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually in summer semester
Language	German
Recommended Skills	Fundamental knowledge in electrodynamics, optics, solid-state and quantum physics
Prerequisites for participation	none
Students workload	Contact time: 45 h, Independent studies: 75 h, Summe = 120 h
Course projects / nongraded learning assignments (Studienleistungen)	none
Prerequisites for admission to examination	none
Examination	Oral exam
Number of credits	4 C
Responsible coordinator	Kusserow
Lecturer(s)	Kusserow
Media	Blackboard, projector, lecture script
Literature	L. Novotny and B. Hecht, Principles of Nano-Optics, Cambridge University Press, 2012 J. Jahns and S. Helfert, Introduction to Micro- and Nanooptics, Wiley VCH Verlag, 2012 J. D. Joannopoulos et al., Photonic Crystals: Molding the Flow of Light, Princeton University Press, 2008 S. A. Maier, Plasmonics: Fundamentals and Applications, Springer, 2007 S. Enoch and N. Bonod, Plasmonics: From Basics to Advanced Topics, Springer, 2012 Special literature

Module title	**MScNano SDT Semiconductor Devices: Theory and Modelling**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … acquire knowledge about the function of electronic and nano electronic devices … are able to describe their function by mathematical models … can explain diodes, light emitting diodes (LEDs), solar cells, and field effect transistors (FET) … can assess the effects of quantization in novel nano scale electronic devices. … acquire the ability to apply mathematical models for the simulation of semiconductor devices and assess their limits of validity
Types of courses, contact hours	VL 2 SWS Ü 1 SWS
Contents	Theory and simulation of contemporary semiconductor devices: - Nano scale electronics and quantum mechanical effects in semiconductor devices - Introduction to semiconductor theory - Junction diodes - Insulating gate field effect transistors - Light emitting diodes - Photo detectors and solar cells
Course titles	Semiconductor Devices: Theory and Modelling
Teaching methods	Lecture
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually, in the summer semester
Language	English, exams can be optionally taken in German
Recommended Skills	Bachelor level knowledge of mathematics (partial differential equations), quantum mechanics, and solid-state physics.
Prerequisites for participation	none
Students workload	Contact time: 45 h, Independent studies: 135 h, Total = 180 h
Course projects / nongraded learning assignments (Studienleistungen)	none
Prerequisites for admission to examination	none
Examination	Oral exam about lecture contents (0,5 h)
Number of credits	6 C
Responsible coordinator	Witzigmann
Lecturer(s)	Witzigmann, Römer
Media	Blackboard, projector
Literature	- Sze, S. M.: Semiconductor Devices: Physics and Technology, Wiley 2002. - Chuang, S. L.: Physics of Photonic Devices, Wiley 2009. - Cohen-Tannoudji, C.: Quantum Mechanics, Wiley-VCH. - Singh, J.: Semiconductor Devices: Basic Principles, Wiley.

Module title	**MScNano CE1 Computational Electromagnetics I**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... learn how to use computers for simulating wave optic devices ... acquire knowledge about the design and operation of numerical methods for solving Maxwell's equations ... are able to assess and apply computational electromagnetic methods practically ... can estimate numerical errors and artefacts as well as and stability limits ... are able to set up simulations for practical electromagnetic wave propagation problems and interpret the results ... are able to implement computational electromagnetic methods
Types of courses, contact hours	VL 2 SWS Ü 1 SWS P i 2 SWS
Contents	Theory and application of grid based numerical methods for electromagnetic field theory problems: - Finite difference time domain (FDTD), - Finite element method (FEM), - Error and stability criteria - Boundary conditions and termination of the simulation domain - Modelling sources of radiation - Methods for periodic structures - Eigenproblems, Green's functions, and mode expansion
Course titles	Numerical Methods in Electromagnetic Field Theory I Lab Course Numerical Methods in Electromagnetic Field Theory I
Teaching methods	Lecture, laboratory work
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually, in the winter semester
Language	English, exams can be optionally taken in German
Recommended Skills	Bachelor level knowledge of mathematics and physics, particularly differential calculus and electromagnetic theory.
Prerequisites for participation	none
Students workload	Contact time: 75 h, independent studies: 105 h, total 180 h
Course projects / nongraded learning assignments (Studienleistungen)	Submission of the lab report
Prerequisites for admission to examination	none
Examination	Combined examination, oral exam about lecture contents (0,5 h), assessment of the laboratory report according to criteria of scientific documentation (weighted 4:2)
Number of credits	6 C
Responsible coordinator	Witzigmann
Lecturer(s)	Witzigmann, Römer
Media	Blackboard, projector, computer lab
Literature	Taflove, A., Hagness, S.: Computational Electrodynamics, The Finite-Difference Time-Domain Method, 3rd Edition, Artech House, Norwood, Mass., USA, 2005. Jin, J., The Finite Element Method in Electromagnetics, Wiley-IEEE Press, 2007 Peterson, A. F., S. L. Ray, R. Mittra, Computational Methods for Electromagnetics, IEEE Press, Piscataway, New Jersey, USA, 1998. Zienkiewicz, O. C.: The Finite Element Method, McGraw-Hill, 1979. Press, W. H., Teukolsky, S. A., Vetterling, W. T., Flannery B. P.: Numerical Recipes in C, Cambridge, 1998.

Module title	**MScNano CE2 Computational Electromagnetics II**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... learn how to simulate electronic devices ... acquire knowledge about the design and operation of numerical methods for the simulation of semiconductor devices ... acquire knowledge about the simulation of quantization effects and light matter interaction in semiconductor devices ... are able to assess and apply different approaches for semiconductor device simulation in practical problems ... can assess numerical errors and artefacts ... are able to set up and run semiconductor device simulations with professional Technology CAD software and interpret the simulation results ... acquire knowledge to implement semiconductor transport simulation tools.
Types of courses, contact hours	VL 2 SWS Ü 1 SWS P i 2 SWS
Contents	- Theory and application numerical methods for comprehensive semiconductor device simulation: - Discretization of systems of partial differential equations, - Carrier transport: drift/diffusion model, Boltzmann transport equation, hydrodynamic model, and Monte-Carlo method - Modelling of contacts and boundary conditions - Simulation of quantization processes and **kp**-theory - Simulation of optoelectronic devices and light-matter interaction in semiconductors - Practical semiconductor device simulation exercises in the computer lab with professional Technology CAD software.
Course titles	Numerical Methods in Electromagnetic Field Theory II Numerical Methods in Electromagnetic Field Theory II exercises Lab Course Numerical Methods in Electromagnetic Field Theory II
Teaching methods	Lecture, laboratory work
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	annually, in the summer semester
Language	English, exams can be optionally taken in German
Recommended Skills	Bachelor level knowledge of mathematics and physics, particularly differential calculus and quantum mechanics.
Prerequisites for participation	none
Students workload	Contact time: 75 h, Independent studies: 105 h, Total = 180 h
Course projects / nongraded learning assignments (Studienleistungen)	Submission of the lab report
Prerequisites for admission to examination	none
Examination	Combined examination, oral exam about lecture contents (0,5 h), assessment of the laboratory report according to criteria of scientific documentation (weighted 4:2)
Number of credits	6 C
Responsible coordinator	Witzigmann
Lecturer(s)	Witzigmann, Römer
Media	Blackboard, projector, computer lab
Literature	- Chuang, S. L.: Physics of Photonic Devices, Wiley 2009. - Selberherr, S.: Analysis and Simulation of Semiconductor Devices, Springer 1984. - Jacoboni, C., Lugli, P.: The Monte Carlo Method for Semiconductor Device Simulation, Springer 1989. - Press, W. H., Teukolsky, S. A., Vetterling, W. T., Flannery B. P.: Numerical Recipes in C, Cambridge, 1998**.**

Module title	**MScNano STN Special Topics in Nanoscience**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … have aquired knowledge about a special field in nanoscience not covered in other modules
Types of courses, contact hours	VL 2 SWS
Contents	Lecture on a special topic given by a junior scientist, Privatdozent or extraordinary professor. Contents vary according to the lecturer. Examples of topics are: carbon nanostructures and their applications, soft matter physics, liquid crystals, biomineralization and biomaterials etc.
Course titles	varying titles
Teaching methods	Lecture with integrated seminar or exercises, depending on lecturer
Applicability	M.Sc. Nanoscience, B.Sc. Nanostrukturwissenschaften
Duration	one semester
Frequency	irregularly
Language	English or German
Recommended Skills	
Prerequisites for participation	none
Students workload	Contact time: 2 h x 15 = 30 h, Independent studies: 30 h, Sum = 60 h
Course projects / nongraded learning assignments (Studienleistungen)	Short oral exam about the contents of the lecture or short presentation, will be announced by the lecturer
Prerequisites for admission to examination	n/a
Examination	none
Number of credits	2 C
Responsible coordinator	Fuhrmann-Lieker
Lecturer(s)	varying
Media	Blackboard, projector, etc.
Literature	Special literature

Module title	**MScNano NUM Mathematics IV Numerical analysis**
Module type	Required module
Educational outcomes, competencies, qualification objectives	Students ... know how to use mathematical terminology in the framework of numerical analysis. ... are able to connect different topics in numerical analysis in an appropriate manner.
Types of courses, contact hours	VL 3 SWS Ü 1 SWS
Contents	Numerical methods for solving systems of linear and nonlinear equations Interpolation Numerical integration Numerical methods for differential equations
Course titles	Höhere Mathematik IV: Numerische Mathematik
Teaching methods	Lectures, exercises, electronic learning platform
Applicability	B.Sc. Nanostrukturwissenschaften M. Sc. Nanoscience
Duration	one semester
Frequency	annually, in summer semester
Language	German
Recommended Skills	Mathematics I, Mathematics II
Prerequisites for participation	none
Students workload	Contact hours 60 h, independent studies 120 h, sum = 180 h
Course projects / nongraded learning assignments	- Submission of solved practice problems. Additional requirements may be fixed by the lecturer at the beginning of the course
Prerequisites for admission to examination	Nongraded learning assignments are obligatory for attendance in written exams
Examination	Written exams (120-180 min)
Credits	6 C
Responsible coordinator	Meister
Lecturer(s)	All lecturers of the institute of mathematics
Media	Blackboard, projector, electronic learning platform
Literature	Hanke-Bourgeois: Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens Plato: Numerische Mathematik kompakt Köckler, Schwarz: Numerische Mathematik Meister: Numerik linearer Gleichungssysteme

Module title	**MScNano ABT Applied Biotechnology**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... get a basic understanding of biotechnology ... get an overview of different biotechnological fields and their applications. ... are introduced to the scientific thinking and theoretical approach of molecular biology. ... learn strategies for independent work with textbooks and bioinformatics tools are developed **Integrated key competencies:** Students ... understand the interdisciplinarity and significance of different fields by the wide applications of biotechnology, research literature and retrieve information from databases (interdisciplinary studies) ... develop strategies for synergistic work in teams and to structure their own work (communication, organisational) ... learn strategies suitable for the independent work with textbooks (organisational) ... utilizing online tools and retrieving data from online databases (methodic)
Types of courses, contact hours	VL 1 SWS; S 1 SWS
Contents	**Applied Biotechnology (VL):** - Introduction to biotechnology - Industrial biotechnology - Medical biotechnology - Plant and animal biotechnology - Environment Biotechnology - Aquatic biotechnology - Biotechnology in analysis **Bioinformatic methods of biotechnology (S):** - Databases for genes and proteins - Homology models and evaluation - Structure-based alignment - Virtual cloning - Protein purification
Course titles	(a) Applied Biotechnology (VL); Bioinformatic methods of biotechnology (S)
Teaching methods	Lecture, seminar
Applicability	B.Sc. Biologie M.Sc. Biologie M. Sc. Nanoscience
Duration	one semester
Frequency	annually, block seminar each winter semester after arrangement and availability
Language	English
Recommended Skills	Good basic knowledge in biochemistry and genetic
Prerequisites for participation	none
Students workload	Contact hours 2 h x 15 = 30 h, , independent studies, 60 h, sum = 90 h
Course projects / nongraded learning assignments	none
Prerequisites for admission to examination	none
Examination	Either an oral examination on the lectures (30 min) or preparation of a report on the application of the seminar topics on a concrete example, followed by a 10-minute discussion. The form of examination will be announced at the beginning of the course.
Number of Credits	3 C
Responsible coordinator	Dr. D. Bertinetti
Lecturer(s)	Dr. Ioannis Pavlidis and coworkers
Media	Projector, laboratory experiments, electronic learning platform, protocols
Literature	Current references were named from the respective lecturers. In general, the latest edition of the following textbooks is recommended:

	- R. Renneberg „Biotechnologie für Einsteiger“, Spektrum akademischer Verlag - W.J. Thieman, „Biotechnologie“, Pearson Studium - Clark & Pazdernik, „Molekulare Biotechnologie“, Spektrum akademischer Verlag
Special information	none

	MScNano W-MMC
Code	**Machine Learning for Materials and Chemistry**
Module type	Wahlpflichtmodul / Required elective module
Educational outcomes, competencies, qualification objectives	Studierende - haben einen Einblick in modernes maschinelles Lernen für Anwendungen in Materialwissenschaften und Chemie - können Methoden des maschinellen Lernens selbständig auf Forschungsfragen anwenden/implementieren - sind in der Lage, Spezialliteratur des angewandten maschinellen Lernens zu lesen und sie einem fortgeschrittenen Publikum zu präsentieren Students … have insight into modern machine learning for applications in materials science and chemistry … are able to apply/implement machine learning methods to research questions ... are able to read special research literature in applied machine learning and present it to an advanced audience
Types of courses, contact hours	VL 2 SWS Ü 2 SWS
Contents	Lecture: - Data sets and problem categories - Mapping practical problems in materials and chemistry to machine learning applications - Regression - Classification - Clustering - Deep Learning - Kernel Methods - Derivatives in chemical space - Representations for molecules and materials - Training procedures and hyperparameter optimization Exercise: - Brief introduction in the scripting language Python. - Implementation of Machine Learning models in Python - Practical application of to design problems of materials science or Chemistry
Course titles	Machine Learning for Materials and Chemistry (VL), Applied Machine Learning for Materials and Chemistry (Ü)
Teaching methods	Lecture, exercises
Applicability	
Duration	one semester
Frequency	anually
Language	English
Recommended Skills	Fundamental knowledge in physics or chemistry on Bachelor level
Prerequisites for participation	None
Students workload	150 h (Kontaktzeit 60 h, Selbststudium 90 h) (Contact time: 60 h, Independent studies: 90 h)
Course projects / nongraded learning assignments (Studienleistungen)	Successful participation at exercises
Prerequisites for admission to examination	None
Examination	Klausur (1-2 h) oder mündliche Prüfung (30 min) written (1-2 h) or oral exam (30 min)
Number of credits	5 C
Lehreinheit	Chemie
Responsible coordinator	von Rudorff
Lecturer(s)	von Rudorff
Media	Slides, code sessions, videos
Literature	The updated literature will be announced in the lecture.

Module title	**MScNano IOM Research Internship Organometallic Chemistry**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... have experienced practical training in advanced methods that are typical for Organometallic Chemistry ... gained insight into possible research topics in Organometallic Chemistry ... have an idea of the scientific approach and methodology of Organometallic Chemistry **Integrated key competencies:** Communication competency: Students have developed communication skills in scientific expert discussions and are able to work in a research team Organisational competency: Students have learned the basics of project planning and management
Types of courses, contact hours	P i 10 SWS
Contents	Participation in a research project carried out in the research group of Organometallic Chemistry Practical training in one or more of the following experimental and theoretical methods: - Preparation and handling of air-sensitive compounds (Schlenk, glove-box and cannula techniques) - Preparation of functional materials - Catalysis - Spectroscopic methods - Electrochemical methods - X-ray crystallography - DFT calculations
Course titles	Research Internship Organometallic Chemistry
Teaching methods	Laboratory work
Applicability	M.Sc. Nanoscience
Duration	4 weeks
Frequency	upon arrangement
Language	English
Recommended Skills	Fundamental knowledge in Molecular Inorganic and Organometallic Chemistry at Bachelor level
Prerequisites for participation	none
Students workload	Contact time: 150 h, independent studies 30 h
Course projects / nongraded learning assignments (Studienleistungen)	(implied) Participation in a research project
Prerequisites for admission to examination	none
Examination	Written report and short presentation (talk or poster) on project, weighted 1:1
Number of credits	6 C (including 2 C for integrated key competencies)
Responsible coordinator	Siemeling
Lecturer(s)	Siemeling, Bruhn, Leibold and co-workers
Media	Laboratory equipment
Literature	Special literature in Inorganic and Organometallic Chemistry and other scientific journals

Module title	**MScNano IHM Research Internship Hybrid Materials**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … are able to perform basic chemical operations, like preparation, isolation and characterization of organo-element compounds in the context of hybrid materials ... gained insight into possible research topics in organo-element chemistry and hybrid materials ... have an idea of the scientific approach and methodology of organo-element chemistry and hybrid materials **Integrated key competencies:** <u>Communication competency:</u> Students have developed communication skills in scientific expert discussions and are able to work in an interdisciplinary research team <u>Organisational competency:</u> Students are acquainted with important aspects of scientific project planning and handling
Types of courses, contact hours	P i 10 SWS
Contents	Participation in a research project conducted in the research group of Chemical Hybrid Materials. Guided experimental work involving synthetic and analytic aspects in combination with independent achievements (learning assignments)
Course titles	Research Internship Hybrid Materials
Teaching methods	Laboratory work
Applicability	M.Sc. Nanoscience
Duration	4 weeks
Frequency	by appointment
Language	English
Recommended Skills	Fundamental knowledge in inorganic chemistry (lab and theory) on Bachelor level
Prerequisites for participation	available lab resources
Students workload	Contact time: 150 h, independent studies 30 h
Nongraded learning assignments (Studienleistungen)	Adequate conduction, documentation (written report)and assessment of experiments and experimental results
Prerequisites for admission to examination	Fulfillment of learning assignments
Examination	Short presentation with oral exam
Number of credits	6 C (including 2 C for integrated key competencies)
Responsible coordinator	Pietschnig
Lecturer(s)	Pietschnig
Media	Experimental work in laboratory; Presenting results to specialists
Literature	Scientific publications

Module title	**MScNano IPC Research Internship Physical Chemistry**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... have experienced practical training in advanced methods that are typical for physical chemistry ... gained insight into possible research topics in physical chemistry ... have an idea of the scientific approach and methodology of physical chemistry **Integrated key competencies:** <u>Communication competency:</u> Students have developed communication skills in scientific expert discussions and are able to work in a research team <u>Organisational competency:</u> Students have learned the basics of project planning and management
Types of courses, contact hours	P i 10 SWS
Contents	Participation in an actual research project conducted in the research group of physical chemistry Practical training in one or more of the following experimental and theoretical methods: - Preparation of functional materials - Sample preparation for physicochemical experiments - Spectroscopic methods - Electrochemical methods - Thermoanalytical methods - Simulation of physicochemical structures or processes
Course titles	Research Internship Physical Chemistry Seminar Physical Chemistry
Teaching methods	Laboratory work
Applicability	M.Sc. Nanoscience
Duration	4 weeks
Frequency	upon arrangement
Language	English
Recommended Skills	Fundamental knowledge in physical chemistry on Bachelor level
Prerequisites for participation	none
Students workload	Contact time: 150 h, independent studies 30 h
Nongraded learning assignments (Studienleistungen)	(implied) Participation in a research project
Prerequisites for admission to examination	none
Examination	Written report and short presentation (talk or poster) on project, weighted 1:1
Number of credits	6 C (including 2 C for integrated key competencies)
Responsible coordinator	N.N. (head Physical Chemistry)
Lecturer(s)	N.N., Fuhrmann-Lieker
Media	Laboratory equipment
Literature	Special literature in physicochemical and other journals

Module title	**MScNano IOC Research Internship Organic Chemistry**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... have experienced practical training in advanced methods that are typical for organic chemistry ... gained insight into research topics in organic-nanoscopic chemistry ... have an idea of the scientific approach and methodology of organic-nanoscopic chemistry **Integrated key competencies:** <u>Communication competency:</u> Students have developed communication skills in scientific expert discussions and are able to work in a research team <u>Organisational competency:</u> Students have learned the basics of project planning and management
Types of courses, contact hours	P i 10 SWS
Contents	Participation in an actual research project conducted in the research group ‚Chemistry of Mesoscopic Systems' Practical training in one or more of the following experimental methods: - Advanced organic synthesis (functional dyes, molecular wires, etc.) - Preparation of organic/inorganic hybrid materials - Photophysical and photochemical investigations (light-induced energy and/or electron transfer) - Nanoparticle characterization (dynamic light scattering, particle tracking, Zetapotentials) - Spectroscopic methods (NMR, mass spectrometry, UV/Vis/NIR absorbance and fluorescence) - Electrochemical methods (cyclovoltammetry)
Course titles	Research Internship Organic Chemistry
Teaching methods	Laboratory work
Applicability	M.Sc. Nanoscience
Duration	4 weeks
Frequency	upon arrangement
Language	English
Recommended Skills	Sound knowledge in organic chemistry (experimental and theoretical)
Prerequisites for participation	none
Students workload	Contact time: 150 h, independent studies 30 h
Nongraded learning assignments (Studienleistungen)	(implied) Participation in a research project
Prerequisites for admission to examination	none
Examination	Written report and short presentation (talk or poster) on project, weighted 1:1
Number of credits	6 C (including 2 C for integrated key competencies)
Responsible coordinator	Faust
Lecturer(s)	Faust and team members of the group ‚Chemistry of mesoscopic Systems'
Media	Laboratory equipment
Literature	Special literature in organic chemistry and chemistry journals

Module title	MScNano INM Research Internship Physics of Nanostructured Materials and Devices
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... have experienced practical training in advanced methods of physical research on nanostructured materials and devices ... gained insight into possible research topics in physics of nanostructure materials and devices ... have an idea of the scientific approach and methodology in nanophysics **Integrated key competencies:** Communication competency: Students have developed communication skills in scientific expert discussions and are able to work in a research team Organisational competency: Students have learned the basics of project planning and management
Types of courses, contact hours	P i 10 SWS
Contents	Participation in an actual research project conducted in the research group of Technological Physics at Institute of Nanostructure Technologies and Analytics (INA) Practical training in one or more of the following research topics: - Optical Properties of Single Semiconductor Quantum Dots - Nanostructured optical gain materials for optoelectronic devices - Investigation of the morphology of nanostructured materials, e.g. by AFM, SEM or XRD - Properties of optoelectronic devices made of nanostructured materials, like QD laser or optical amplifiers - Properties of nano-patterned nanocrystalline diamond - Surface functionalization of diamond for biological or chemical application
Course titles	Research Internship Physics of Nanostructured Materials and Devices
Teaching methods	Laboratory work
Applicability	M.Sc. Nanoscience
Duration	4 weeks
Frequency	upon arrangement
Language	English
Recommended Skills	Fundamental knowledge in physics and nanoscience on Bachelor level
Prerequisites for participation	none
Students workload	Contact time: 150 h, independent studies 30 h
Nongraded learning assignments (Studienleistungen)	(implied) Participation in a research project
Prerequisites for admission to examination	none
Examination	Written report and short presentation (talk or poster) on project, weighted 1:1
Number of credits	6 C (including 2 C for integrated key competencies)
Responsible coordinator	Reithmaier, Popov, Benyoucef
Lecturer(s)	N.N.
Media	Laboratory equipment
Literature	Special literature in nanophysics and other journals

Module title	**MScNano ITS Research Internship Thin Films and Synchrotron Radiation**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … have experienced practical training in advanced methods that are typical for experimental physics … gained insight into the operation of vacuum equipment … gained insight into possible research topics in the group „Experimentalphysik IV“ … have an idea of the scientific approach and methodology **Integrated key competencies:** Communication competency: Students have developed communication skills in scientific expert discussions and are able to work in a research team Organizational competency: Students have learned the basics of project planning and management
Types of courses, contact hours	P i 10 SWS
Contents	Participation in an actual research project conducted in the research group of „Experimentalphysik IV“. Topics originate from research projects of either „Functional thin films“ or „Physics with Synchrotron radiation“ depending on students preferences and availability. Practical training in one or more of the following experimental and theoretical methods: Functional thin films: - Preparation of functional materials - Sample modification by multiple methods, i.e. ion bombardment, lithography - Sample characterization Physics with Synchrotron radiation: - Spectroscopic methods - Planning and realization of experimental setups - Data analysis skills
Course titles	Research Internship Thin Films and Synchrotron Radiation
Teaching methods	Laboratory work
Applicability	M.Sc. Nanoscience
Duration	4 weeks
Frequency	upon arrangement
Language	German and/or English
Recommended Skills	Fundamental knowledge in physics on Bachelor level
Prerequisites for participation	none
Students workload	Contact time: 150 h, independent studies 30 h
Nongraded learning assignments (Studienleistungen)	(implied) Participation in a research project
Prerequisites for admission to examination	none
Examination	Oral presentation on project in the group’s seminar
Number of credits	6 C (including 2 C for integrated key competencies)
Responsible coordinator	Ehresmann
Lecturer(s)	Post-Docs and PhD students of the group
Media	Laboratory equipment
Literature	Scientific publications (journals, theses) on the respective topic

Module title	MScNano IUP Research Internship Ultrashort Laser Pulses
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... will be able to conduct experiments in ultrafast laser physics, to classify the results against the background of physical phenomena and, above all, to identify the experimental method for nanostructure science. ... will be able to discuss complex natural sciences topics and own research results against the background of current international research and to present (talk with discussion) in a written and/or oral way **Integrated key competencies:** - Handling of physical high technology with significance for nanostructure science - Development of the ability to work in a team - Communication skills in German and English - International and intercultural experience - Time management - Acting according to the rules of good scientific practice
Types of courses, contact hours	P i 6 SWS (including 2 for integrated key competencies)
Contents	According to agreement and availability, students can work on the following topics: - Development of aspects of ongoing research work - Development of small interdisciplinary research work, especially in cooperation with biologists, chemists and engineers - Small enhancements/extensions or improvements of the existing experimental setup
Course titles	Research Internship Ultrashort Laser Pulses
Teaching methods	Internship in the laboratory
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	upon arrangement
Language	German / English
Recommended Skills	none
Prerequisites for participation	none
Students workload	Contact time: 90 h Independent studies: 90 h Sum: 180 h
Nongraded learning assignments (Studienleistungen)	(implied) Participation in a research project
Prerequisites for admission to examination	none
Examination	Internship report or oral presentation (around 30 minutes including discussion)
Number of credits	6 C (including 2 C for integrated key competencies)
Responsible coordinator	Baumert
Lecturer(s)	Baumert
Media	Laboratory equipment
Literature	Advice in finding relevant literature will be given

Module title	**MScNano IQO Research Internship Nanoscale Quantum Optics**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … have experienced practical training in advanced methods that are used in quantum optics experiments ... gained insight into the use of nanoscale quantum systems for sensing applications ... have an idea of the scientific approach and methodology of nanoscale quantum optics **Integrated key competencies:** Communication competency: Students have developed communication skills in scientific expert discussions and are able to work in a research team Organisational competency: Students have learned the basics of project planning and management
Types of courses, contact hours	P i 10 SWS
Contents	Participation in an actual research project conducted in the research group of Light-Matter Interaction Practical training in one or more of the following experimental and theoretical methods: - Nano scale experiments are performed - Experimental control sequences will be prepared - Data aquisition - Development and improvement of optics and electronics - Simulation of quantum optical processes
Course titles	Research Internship Nanoscale Quantum Optics
Teaching methods	Laboratory work
Applicability	M.Sc. Nanoscience
Duration	4 weeks
Frequency	upon arrangement
Language	English
Recommended Skills	Fundamental knowledge of Quantum mechanics on Bachelor level
Prerequisites for participation	none
Students workload	Contact time: 150 h, independent studies 30 h
Course projects / nongraded learning assignments (Studienleistungen)	(implied) Participation in a research project
Prerequisites for admission to examination	none
Examination	Written report and short presentation (talk or poster) on project, weighted 1:1
Number of credits	6 C (including 2 C for integrated key competencies)
Responsible coordinator	Singer
Lecturer(s)	Singer
Media	Laboratory equipment
Literature	Special literature and other journals will be distributed

Module title	**MScNano IBC Research Internship Biochemistry**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	- Solid knowledge in Biochemistry, in particular as applied to cellular systems as a basis for research in molecular biosciences. - Critical understanding of methods in current biochemistry - Selfcontained experimental work according to instructions. - Safe and competent handling biochemical laboratory equipment. - Ability to optimize the work processes and organization. - Skills to identify relevant nano structures / processes for implementation in the nanostructure sciences **Integrated key competencies:** Interdisciplinary studies: - Apply basic principles of molecular biosciences to concrete biological case studies on nanostructured objects / structures Communication competency - Critically reflect significance of experimental data (problem-solving skills). - Teamwork Organisational competency: - Independent work with literature - Oral presentation of results. Methodic competency: - Ability to document experiments and generatiom ofdetailed scientific protocols) - Critical review of published data
Types of courses, contact hours	P i 5 SWS / 11 SWS S 1 SWS
Contents	- Molecular mechanisms of intracellular signal transduction. - Basic methods in protein biochemistry - Standard biochemical methods (SDS-PAGE, chromatography) - Recent research topic of the department.
Course titles	(a) Research Internship Biochemistry (practicum) (b) Current Topics in Biochemistry (seminar)
Teaching methods	Laboratory work, seminar, seminar talks
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	each semester. Limited availability, see specific information
Language	English, German
Recommended Skills	Solid knowledge in biochemistry and related subjects.
Prerequisites for participation	none
Students workload	Short variant with 6 C: Contact hours 6 h x 15 = 90 h, independent studies, 90 h, sum = 180 h Long variant with 12 C: Contact hours 12 h x 15 = 180 h, independent studies, 180 h, sum = 360 h
Course projects / assignments	Active participation in the lab course. The research internship includes the participation in the seminar of the department "Current Topics in Biochemistry" (beginning 4 weeks before the beginning of internship), and the colloquium "Molecular Aspects of biology" during the internship period.
Prerequisites for admission to examination	Molecular mechanism of biochemical processes
Examination	Seminar talk in English (ca. 30 min. with discussion) in the seminar „Current topics in biochemistry“
Credits	Short variant 6 C (including 2 C for integrated key competencies) Long variant 12 C (including 2 C for integrated key competencies)
Responsible coordinator	Herberg
Lecturer(s)	Herberg and Coworkers
Media	Projector, laboratory experiments, protocols
Literature	Current references arelisted by the respective lecturers.

Module title	**MScNano IBP Research Internship Biophysics**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... have experienced practical training in advanced methods that are typical for biophysics and biophysical chemistry ... gained insight into possible research topics in biophysics ... have an idea of the scientific approach and methodology of biophysics **Integrated key competencies:** <u>Communication competency:</u> Students have developed communication skills in scientific expert discussions and are able to work in a research team <u>Organisational competency:</u> Students have learned the basics of project planning and management
Types of courses, contact hours	P i 10 SWS
Contents	Participation in an actual research project conducted in the research group of physical chemistry Practical training in one or more of the following experimental and theoretical methods: - Site-directed mutagenesis on plasmid DNA for the expression of mutated proteins - Expression and isolation of proteins and mutant forms of proteins - Site-specific spectroscopic labelling and purification of labelled proteins for biophysical analyses - Distance determinations on the nanometer scale by ESR/EPR-spectroscopy and fluorescence energy transfer (FRET) - Preparation of model membranes, like lipid bilayers with integral and peripheral proteins - Biophysical and spectroscopic investigations on protein folding, protein stability, membrane protein insertion, protein-protein and protein-lipid interactions, protein structure-function relationships, molecular chaperones - Circular dichroism spectroscopy - Fluorescence spectroscopic methods - Electron spin resonance (ESR) methods - Electrophoresis -Analyses of kinetics and thermodynamics of biomolecular interactions to examine structure, mechanism and biophysical principles of biological systems.
Course titles	Research Internship Biophysics
Teaching methods	Laboratory work
Applicability	M.Sc. Nanoscience
Duration	4.5 weeks / 9 weeks
Frequency	Winter (WS-) and Summer semester (SS), in the semester break upon arrangement
Language	English
Recommended Skills	Fundamental knowledge in biophysics, physical chemistry, and molecular biology/genetics on Bachelor level
Prerequisites for participation	none
Students workload	Short variant with 6 C : Contact time: 150 h, independent studies 30 h Long variant with 12 C: Contact time: 300 h, independent studies 60 h
Nongraded learning assignments (Studienleistungen)	(implied) Participation in a research project
Prerequisites for admission to examination	none
Examination	Written report and short presentation (talk or poster) on project, weighted 1:1
Number of credits	Short variant 6 C (including 2 C for integrated key competencies) Long variant 12 C (including 2 C for integrated key competencies)
Responsible coordinator	Kleinschmidt
Lecturer(s)	Kleinschmidt and coworkers
Media	Laborausstattung, schriftliche Versuchsanleitungen und ausgesuchte Originalliteratur, Computer + Beamer, Präsentationssoftware, Bücher *Laboratory equipment, instructions and descriptions of experimental methods, selected original literature, computer + projector, presentation software, and Textbooks*
Literature	Artikel aus Fachjournalen / *Articles from scientific journals* *z. B. Biochem. Mol. Biol. Edu.; Biophysical J.; J. Mol. Biol.; Biochemistry; J. Biol. Chem., etc.* *Schriftliche Anleitung zu den Experimenten* Lehrbücher / *Textbooks* *Adam, Läuger, Stark* (2009) Physikalische Chemie und Biophysik, Springer* *Mäntele, Biophysik (2012), UTBT aschenbuch* *Pfützner* (2012): Angewandte Biophysik Springer* *Hammes, Hammes-Schiffer Physical Chemistry for the Biological Sciences (2015), Wiley* *Jackson*, Molecular and cellular Biophysics (2006), Cambridge Univ. Press*

	Roberts, Encyclopedia of biophysics (2013) (6 Bände/Volumes), Springer *Weigh, T. A.* (2007), Applied Biophysics: A Molecular Approach for Physical Scientists, Wiley* *Raicu* (2008) Integrated Molecular and Cellular Biophysics, Springer* *C.R. Cantor and P.R. Schimmel, (1980) Biophysical Chemistry, W.H. Freeman* ** as e-book available*

Module title	**MScNano INE Research Internship Molecular or Organismic Neuroscience**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Advanced course with own research topic in Neurobiology with focus on neuropeptide functions in the brain of insects, chronobiology, sensory physiology, sex-pheromone transduction; insect neuroscience **Integrated key competencies:** <u>Methodic competency:</u> Students have the ability to apply their knowledge and understanding, and problem solving abilities to actual research work
Types of courses, contact hours	P i 6/12 SWS
Contents	Current research in Chronobiology, Olfaction, or Endocrinology of Insect Neuroscience Practical labwork employing techniques in either molecular genetics, neurophysiology, immunocytochemistry, neuroanatomy, behavioral assays, ELISAs, RIAs, patch clamp, tip recordings; calcium-imaging, FRET.
Course title	Advanced Research in Neurobiology
Teaching methods	Lab work
Applicability	M.Sc. Nanoscience
Duration	4 weeks (6 credits) or 8 weeks (12 credits)
Frequency	will be arranged
Language	English
Recommended Skills	Basics of Neurobiology, basics of Chronobiology and Olfaction
Prerequisites for participation	none
Students workload	Contact time: 150/300 h, Independent studies: 30/60 h
Nongraded learning assignments	(implied) Participation in a research project
Prerequisites for admission to examination	none
Examination	Written report and short presentation (talk or poster) on project, weighted 1:1
Number of credits	6 or 12 C (including 2 C for integrated key competencies)
Responsible coordinator	Stengl
Lecturer(s)	Stengl and coworkers
Media	Laboratory equipment
Literature	Pub med original literature

Module title	MScNano IMI Research Internship Microbiology
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	- Solid knowledge in Molecular Microbiology, in particular to be applied for investigation of cellular and sub-cellular systems as a basis for research in Molecular Biosciences - Critical understanding of methods in Molecular Microbiology - Selfcontained experimental work according to instructions - Safe and competent handling biochemical laboratory equipment - Ability to optimize their work processes and organization - Skills to identify relevant nano structures, machines and processes from Microbial Sources for implementation in the nanostructure sciences **Integrated key competencies:** 1. Interdisciplinary studies: - Apply basic principles of molecular microbiology to concrete biological case studies related to nanostructured objects, macromolecular machines and structures 2. Communication competency - Critically reflect significance of experimental data (problem-solving skills). - Teamwork 3. Organisational competency: - Independent work with literature - Oral presentation of results 4. Methodic competency: - Ability to document experiments and generate detailed scientific protocols - Critical review of published data
Types of courses, contact hours	P i 5 SWS / 11 SWS S 1 SWS
Contents	Participation in an actual research project conducted in the research group of Microbiology Practical training in one or more of the following experimental and theoretical methods: - Microbial growth and proliferation control - Genetics and mechanisms of plasmid-associated microbial competition systems - Basic methods in Molecular Microbiology - Standard microbial and biochemical methods (protein detection % purification, protein-protein interaction) - Recent research topic of the Microbiology group
Course titles	Research Internship Microbiology (practical) 'Microbiological Seminar' (seminar)
Teaching methods	Laboratory work, seminar, seminar talks
Applicability	M.Sc. Nanoscience
Duration	4 weeks / 8 weeks
Frequency	Each semester, however limited availability upon arrangement
Language	English / German
Recommended Skills	Fundamental and solid knowledge in Microbiology and related subjects at Bachelor level
Prerequisites for participation	none
Students workload	Short variant with 6 C: Contact hours 6 h x 15 = 90 h, independent studies, 90 h, sum = 180 h Long variant with 12 C: Contact hours 12 h x 15 = 180 h, independent studies, 180 h, sum = 360 h
Nongraded learning assignments (Studienleistungen)	Active participation in the lab course. The research internship includes participation in the group's Molecular Microbiology Seminar and a written report based on the notes taken during the practical work in the student's lab journal.
Prerequisites for admission to examination	none
Examination	Seminar talk in English (~30 min plus discussion) in the 'Microbiological Seminar' of the Schaffrath group
Number of credits	6 C (including 2 C for integrated key competencies) – Short variant with 6C 12 C (including 2 C for integrated key competencies) – Long variant with 12 C
Responsible coordinator	Schaffrath
Lecturer(s)	Schaffrath and coworkers
Media	Projector, laboratory equipment and experiments, protocols and lab journal
Literature	Special literature in Molecular and Cellular Microbiology journals provided through responsible lecturer(s)

Module title	**MScNano ICB Research Internship Cell Biology**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … have acquired a thorough knowledge about the biology of nanosystems … know how to define the state of the art by identifying and analyzing relevant literature … are able to conduct experimental planning without close supervision … have gained independence in molecular and cell-biological techniques … are able to critically analyze data and to present and discuss their results **Integrated key competencies:** <u>Methodic competency:</u> Students have the ability to apply their knowledge and understanding, and problem solving abilities to actual research work
Types of courses, contact hours	P i 6 SWS / 12 SWS
Contents	Construction of plasmid vectors by molecular biology methods Making of transgenic organisms Preparation of proteins and analysis Measurement of physiological properties down to the single cell level by biochemical, spectroscopic and microscopic methods
Course titles	Research Internship Cell Biology
Teaching methods	Laboratory work
Applicability	M.Sc. Nanoscience
Duration	two weeks, full time / four weeks full time
Frequency	throughout the year, by appointment
Language	English
Recommended Skills	Fundamental knowledge in biology on Bachelor level with respect to the interdisciplinary scientific paradigm of nanoscience
Prerequisites for participation	Nanobiology
Students workload	Short variant with 6 C: Contact time: 90 h, Independent studies: 90 h, Sum = 180 h Long variant with 12 C: Contact time: 180 h, Independent studies: 180 h, Sum = 360 h
Course projects / nongraded learning assignments (Studienleistungen)	Report on experiments with oral tests on comprehension
Prerequisites for admission to examination	none
Examination	30 min presentation in seminar style
Number of credits	6 C / 12 C (including 2 C for integrated key competencies)
Responsible coordinator	Maniak
Lecturer(s)	Maniak and co-workers
Media	Projector, laboratory equipment
Literature	Relevant literature will be handed out as suitable for the current research project.

Module title	**MScNano IDG Research Internship Developmental Genetics**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	- Solid knowledge in genetics and molecular biology as a basis to genetically manipulate the model system Drosophila - Application of novel microscopy methods to visualise subcellular structures in cells and tissues in living organisms - independent experimental work - Safe and competent handling of equipment in a Molecular Biology laboratory. - Ability to optimize the work processes and organization. - Skills to use software for analysis of imaging data and its quantification. **Integrated key competences:** 1. Interdisciplinary studies: - Acquisition of the ability to apply specific software to analyse and quantify complex datasets obtained from high resolution microscopy 2. Communication competence - Ability to discuss and evaluate data obtained from molecular biology and microscopy (problem-solving skills). - Teamwork 3. Organisational competence: - Independent analysis of the literature - Oral presentation of own experimental data considering data published by others. 4. Methodological competence: - Documentation of experimental Data and procedures by generating detailed laboratory journals - Critical review and presentation of published data
Types of courses, contact hours	P i 5 SWS / 11 SWS S 1 SWS
Contents	- Molecular mechanisms of signaling networks in cellular morphogenesis - Key methods in genetics, molecular biology, microscopy and data analysis - High resolution microscopy of living tissues - Analysis of microscopy data sets and their quantification using imaging analysis software - Research on a recent topic of the laboratory The research internship includes the participation in the seminar of the department "Current Topics in Developmental Genetics" (beginning 4 weeks before the beginning of internship), and the colloquium "Cell- and Developmental Genetics of Drosophila" during the internship period.
Course titles	(a) Research Internship Developmental Genetics (practical) (b) Current topics of Developmental Genetics (seminar)
Teaching methods	Laboratory work, seminar, seminar talks
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	each semester. Limited availability, see specific information
Language	English, German
Recommended Skills	Solid knowledge in genetics and cell biology and related subjects.
Prerequisites for participation	none
Students workload	Short variant with 6 C: Contact hours 6 h x 15 = 90 h, independent studies 90 h, sum = 180 h Long variant with 12 C: Contact hours 12 h x 15 = 180 h, independent studies 180 h, sum = 360 h
Nongraded learning assignments (Studienleistungen)	(implied) Participation in a research project
Prerequisites for admission to examination	none
Examination	Seminar talk in English (ca. 30 min. with discussion) in the seminar „Current topics in Developmental Genetics“
Number of credits	Short variant 6 C (including 2 C for integrated key competencies) Long variant 12 C (including 2 C for integrated key competencies)
Responsible coordinator	Müller
Lecturer(s)	Müller and Coworkers
Media	Projector, blackboard, laboratory experiments, protocols
Literature	Current references are listed by the respective lecturers.
Special information	Places in this Modul are limited. An interview is required for all interested candidates with the coordinator of the modul to discuss possible research topics and how personal interest of the student matches with the research goals of the department. Registration for this interview

	should take place in each of the preceding semester (Appointments to be made in the office of the Developmental Genetics group).

Module title	**MScNano INP Research Internship Nanophotonics**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … have experienced practical training in advanced topics of nanophotonics ... gained insight into possible research topics in nanophotonics ... have an idea of the scientific approach and methodology of nanophotonics **Integrated key competencies:** Communication competency: Students have developed communication skills in scientific expert discussions and are able to work in a research team Organisational competency: Students have learned the basics of project planning and management
Types of courses, contact hours	P i 10 SWS
Contents	Participation in an actual research project conducted in the nanophotonics research group Practical training in one or more of the following experimental and theoretical methods: - advanced thin-film optics - photonic crystals - laser elements based on novel design approaches - alternative plasmonic materials - fabrication technology and characterization of nanophotonic devices
Course titles	Research Internship Nanophotonics
Teaching methods	Laboratory work
Applicability	M.Sc. Nanoscience
Duration	4 weeks
Frequency	upon arrangement
Language	English
Recommended Skills	Fundamental knowledge in optics, solid state physics and nanotechnology on Bachelor level
Prerequisites for participation	none
Students workload	Contact time: 150 h, independent studies 30 h
Nongraded learning assignments (Studienleistungen)	(implied) Participation in a research project
Prerequisites for admission to examination	none
Examination	Written report and short presentation (talk or poster) on project, weighted 1:1
Number of credits	6 C (including 2 C for integrated key competencies)
Responsible coordinator	Kusserow
Lecturer(s)	Kusserow
Media	Laboratory equipment
Literature	Special literature

Module title	MScNano ICA Research Internship Biocatalysis
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	- Understanding and practical application of molecular biological methods for cloning and mutagenesis, procaryotic overexpression systems, biocatalytic processes - Experience in bioinformatic analysis and analytic methods to evaluate enzymatic activity - Research experience in the field of biocatalysis - Safe and competent handling of biochemical laboratory equipment. - Ability to combine methods from molecular biology, organic chemistry, bioinformatics and bioprocess engineering. - Having experienced the connection between molecular biology, biochemistry, organic chemistry and bioinformatics. **Integrated key competencies:** <u>Communication competency</u> - Training in English, both in reading (literature) and speaking (weekly presentations in seminar) - Teamwork. <u>Organisational competency:</u> - Independent experimental planning and working, after proper introduction, and literature screening (English), without constant monitoring. - Optimization of workflow and organization of the workplace in the laboratory (week plan).- Independent work with primary literature. - Time management. <u>Methodic competency:</u> - Understanding and application of the principles of scientific work and hypothesis-oriented research. - Ability to independently prepare, design and present clear seminar lectures. - Acquisition of problem-solving competence. - Acquisition of the ability to document experiments and results (detailed scientific protocols). - Code of good scientific practice concerning the experimental data. - Ability to review critically published data.
Types of courses, contact hours	P 5 SWS S 1 SWS
Contents	- Molecular biology methods for cloning and mutagenesis. - Procaryotic overexpression systems (*E. coli*). - Biocatalytic processes. - Bioinformatic analysis. - Analytic methods to evaluate enzymatic activity. - Working on an actual research topic of the Group of Biotechnology.
Course titles	(a) Research Internship Biocatalysis (lab course) (b) Current Topics in Biochemistry (seminar)
Teaching methods	laboratory work, seminar, seminar talks
Applicability	M.Sc. Nanoscience
Duration	one semester
Frequency	each semester. Limited availability, see special information
Language	bilingual (English, German)
Recommended Skills	good knowledge in Enzyme Technology, Biochemistry, and Organic Chemistry.
Prerequisites for participation	none
Students workload	Contact hours 6 h x 15 = 90 h, independent studies 90 h, sum = 180 h
Course projects / assignments	Active participation in the practical course including the seminar "Current Topics in Biochemistry" (starting 4 weeks before the beginning of internship) and the colloquium "Molecular Aspects of biology" during the internship period.
Prerequisites for admission to examination	Required elective module “Biocatalysis”
Examination	Seminar talk in English (ca. 30 min with discussion) in the seminar „Current Topics in Biochemistry“, with discussion
Credits	6 C (including 2 C for integrated key competencies)
Responsible coordinator	Pavlidis
Lecturer(s)	Pavlidis and coworkers
Media	beamer, laboratory experiments, protocols, power-point presentations
Literature	Current references will be provided by the respective lecturers, according to the specific topic of the research internship.
Special Information	The available places are distributed after a 15 min discussion with the candidates. The registration for the discussion/interview takes place once every semester (announces at Group of Biotechnology).

Module title	**MScNano ICC Research Internship Construction Chemistry**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... have experienced practical training in advanced methods that are typical for analyzing raw materials for structural materials or structural materials itself ... gained insight into possible research topics in structural materials and construction chemistry ... have an idea of the scientific approach and methodology in construction chemistry **Integrated key competencies:** Communication competency: Students have developed communication skills in scientific expert discussions and are able to work in a research team Organisational competency: Students have learned the basics of project planning and management
Types of courses, contact hours	P i 10 SWS
Contents	Participation in an actual research project conducted in the research group of structural materials and construction chemistry Practical training in one or more of the following experimental and theoretical methods: - Preparation and mixing procedure of inorganic structural materials - Characterization methods for raw materials on micro- and nanoscale - Spectroscopic methods - Electrochemical methods - Thermoanalytical methods - microscopic methods (ESEM, AFM, µ-CT, light microscopy)
Course titles	Research Internship Construction Chemistry
Teaching methods	Laboratory work
Applicability	M.Sc. Nanoscience
Duration	6 weeks
Frequency	upon arrangement
Language	English
Recommended Skills	Fundamental knowledge in physical chemistry on Bachelor level
Prerequisites for participation	none
Students workload	Contact time: 150 h, independent studies 30 h
Nongraded learning assignments (Studienleistungen)	Participation in a research project
Prerequisites for admission to examination	none
Examination	Written report and short presentation (talk or poster) on project, weighted 1:1
Number of credits	6 C (including 2 C for integrated key competencies)
Responsible coordinator	Wetzel
Lecturer(s)	Wetzel
Media	Laboratory equipment
Literature	Special literature

Module title	**MScNano INA Research Internship Nanoprocessing and -analysis**
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … have experienced practical training in advanced topics of nanoprocessing … gained experience with clean room processes ... gained insight into possible research topics in nanoprocessing ... have an idea of the scientific approach and methodology of nanoprocessing **Integrated key competencies:** Communication competency: Students have developed communication skills in scientific expert discussions and are able to work in a research team Organizational competency: Students have learned the basics of project planning and management
Types of courses, contact hours	P i 10 SWS
Contents	Participation in an actual research project conducted in the technological electronics research group Practical training in one or more of the following experimental and theoretical methods: - advanced thin-film techniques - clean room work - analysis optical properties and surface structures (e.g. white light interferometry, SEM, AFM) - processing of surface structures - lithography methods (e.g. optical lithography, nanoimprint lithography)
Course titles	Research Internship nanoprocessing and -analysis
Teaching methods	Laboratory work
Applicability	M.Sc. Nanoscience
Duration	4 weeks
Frequency	upon arrangement
Language	English
Recommended Skills	Basis knowledge in physics, chemistry, experimental work in nanotechnology on Bachelor level
Prerequisitesforparticipation	None
Studentsworkload	Contact time: 150 h, independent studies 30 h
Nongradedlearningassignments (Studienleistungen)	(implied) Participation in a research project
Prerequisites for admission to examination	None
Examination	Written report and short presentation (talk or poster) on project, weighted 1:1
Numberofcredits	6 C (including 2 C for integrated key competencies)
Responsiblecoordinator	Hillmer
Lecturer(s)	Hillmer
Media	Laboratory equipment
Literature	Special literature

Module title	MScNano ISS Research Internship Surface Science
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students ... have experienced practical training in advanced methods that are typical for surface science ... gained insight into the operation of ultra-high vacuum systems ... gained insight into possible research topics in surface science ... have an idea of scientific approaches and methodology in surface science **Integrated key competencies:** Communication competency: Students have developed communication skills in scientific expert discussions and have trained to work in a research team
Types of courses, contact hours	P i 10 SWS
Contents	Participation in a research project in surface science. Topics depend on current research projects. Practical training in one or more of the following experimental and theoretical methods: - sample preparation - Low energy electron diffraction (LEED) - Angle-resolved photoemission (ARPES) - Scanning tunneling microscopy and spectroscopy (STM, STS) - data analysis
Course titles	Research Internship Surface Science
Teaching methods	Laboratory work
Applicability	M.Sc. Nanoscience
Duration	4 weeks
Frequency	upon arrangement
Language	English and/or German
Recommended Skills	Fundamental knowledge in physics on Bachelor level
Prerequisites for participation	none
Students workload	Contact time: 150 h, independent studies 30 h
Nongraded learning assignments (Studienleistungen)	(implied) Participation in a research project
Prerequisites for admission to examination	none
Examination	Presentation of about 30 minutes plus discussion in the group seminar.
Number of credits	6 C (including 2 C for integrated key competencies)
Responsible coordinator	Matzdorf
Lecturer(s)	Matzdorf and coworkers
Media	Laboratory equipment
Literature	Scientific publications and textbooks on the respective topic

Module title	MScNano LAP Research Internship Laboratory Astrophysics
Module type	Required elective module
Educational outcomes, competencies, qualification objectives	Students … have experienced practical training in methods that are typical for laboratory astrophysics ... gained insight into possible research topics in molecular physics and spectroscopy ... have an idea of the scientific approach and methodology of laboratory astrophysics **Integrated key competencies:** Communication competency: Students have developed communication skills in scientific expert discussions and are able to work in a research team Organisational competency: Students have learned the basics of project planning and management
Types of courses, contact hours	P i 10 SWS
Contents	Participation in an actual research project conducted in the research group of laboratory astrophysics Practical training in the laboratory or in theoretical methods relevant for molecular spectroscopy in astrophysics
Course titles	Research Internship laboratory astrophysics
Teaching methods	Laboratory work or theoretical work
Applicability	M.Sc. Nanoscience
Duration	4 weeks
Frequency	upon arrangement
Language	English
Recommended Skills	Fundamental knowledge in physics, especially on molecular spectroscopy on Bachelor level
Prerequisites for participation	none
Students workload	Contact time: 150 h, independent studies 30 h
Nongraded learning assignments (Studienleistungen)	(implied) Participation in a research project
Prerequisites for admission to examination	none
Examination	Written report or short presentation (talk or poster) on project
Number of credits	6 C (including 2 C for integrated key competencies)
Responsible coordinator	Giesen
Lecturer(s)	Giesen
Media	Laboratory equipment
Literature	Special literature in molecular spectroscopy, laboratory astrophysics and related journals