



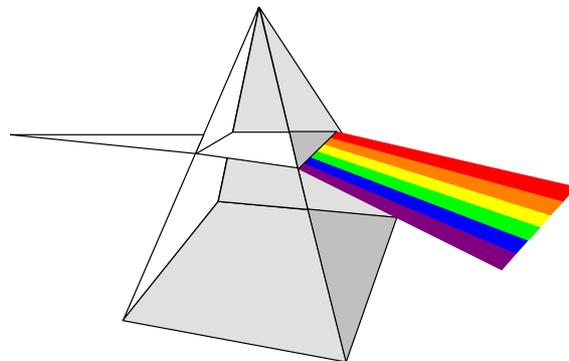
WESTFÄLISCHE
WILHELMS-UNIVERSITÄT
MÜNSTER

Department of
Physics



Commented Course Programme in Physics

BSc and MSc in Physics



INTRODUCTION

The Westfälische Wilhelms-Universität in Münster is located in the cultural centre of Westphalia in close vicinity to the Netherlands. The Treaty of Westphalia, signed in Münster in 1648, ended the Thirty Years' War and established the modern Netherlands. Therefore, we traditionally have strong ties to our Dutch neighbours. Nearly 50,000 students live in this town that is known as the country's bicycle capital. Its economy is based on the service industry and public administration. Students make up about 20% of city's population, ensuring a lively atmosphere. The Department of Physics warmly welcomes foreign students. We consider them an important factor in creating an open and colourful academic and social life on campus.

We invite foreign students to participate in courses offered by members of the department, comprising about 25 research groups, that cover a broad range of physics. These courses are open to full time, part time, and exchange students. Moreover, they are open to students studying physics, other natural sciences, mathematics and medicine, both at the undergraduate and graduate level.

As a guideline for the selection of appropriate courses the following list details the contents of lectures and laboratory courses, which are regularly taught during each academic year. Traditionally, the academic year at German universities is split into two semesters: a Winter Term beginning in mid-October and ending in mid-February, and a Summer Term beginning in mid-April and ending at the end of July. The sequence of courses is largely based on the assumption that students start their studies in the Winter Term of the academic year. In addition to the courses listed here, the department also offers a great number of seminars and special courses with changing subjects.

Most of the courses in the Bachelor program are taught in German. It is highly recommended that students have a basic working knowledge of German prior to entering the courses. In the laboratory courses, experiments are normally conducted in groups of two students under the supervision of an instructor. Here, English is accepted as a working language for the course work and reports. Courses in the Master program can be taught in English upon request.

In addition to the services provided by the Department of Physics, general support for foreign students is also provided through central university institutions, including the International Office (Akademisches Auslandsamt) and the Foreign Language Centre (Sprachenzentrum).

We look forward to seeing you in Münster.
Johannes P. Wessels
Department Chair
Münster, May 2010

CONTACT

Information for International Students

Advice for International Students

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<http://www.uni-muenster.de/Auslandsamt/en/incoming.html> - English

Admissions Requirement and Studies

Studierendensekretariat
Schlossplatz 2
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Tel. +49 (0) 251 / 83-2 22 37, -2 47 72
e-mail: studierendensekretariat@uni-muenster.de

for International Students (non EU-Citizens):

<http://www.uni-muenster.de/Studierendensekretariat/ausl.html>

for EU Citizens:

<http://www.uni-muenster.de/Studierendensekretariat/bewerbung.html>

Language Courses

Language Centre of the University of Münster
- Sprachenzentrum -
German as a Foreign Language
- Lehrgebiet Deutsch als Fremdsprache -
Hüfferstrasse 27 III
D-48149 Münster
Tel.: +49 (0) 251/83-3 21 08
Fax: +49 (0) 251/83-3 83 49
e-mail: lehrgebiet.daf@uni-muenster.de
<http://spzwww.uni-muenster.de/studieninformation/ldaf/stuvo/dsh.php>

Accommodation

Student Welfare Organisation - Studentenwerk Münster -
- Wohnraumverwaltung -
Bismarckallee 5
D-48151 Münster
Tel.: +49 (0) 251 / 83-7 95 60
e-mail: wohnen@studentenwerk-muenster.de
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Information for ERASMUS Students [Incoming and Outgoing]

Westfälische Wilhelms-Universität Münster
International Office – ERASMUS Office
Leonardo Campus 11
D-48149 Münster
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Information for students and teachers concerning ERASMUS activities;
contact person for ERASMUS partner universities

- 1.) LLL Institutional Coordinator
Mrs Anke Kohl
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For Language Courses and accommodation see above.

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Description of Modules for the Study Course

Physics

and

Physics with Specialisation “Scientific Instrumentation”

(Bachelor of Science)

**Department of Physics
University of Münster**

Recommended Study Organisation

Semester	Modules			
1. (WS)	Physics I 14 CP (PM)		Basics of Mathematics 18 CP (PM)	Interdisciplinary Studies 18 CP (WPM*)
2. (SS)	Physics II 14 CP (PM)			
3. (WS)	Physics III 14 CP (PM)	Laboratory Course I 10 CP (PM)	Integration Theory 9 CP (PM)	
4. (SS)	Atomic and Quantum Physics 10 CP (PM)		Computational Physics 8 CP (PM)	Applications of Physics 8 CP (PM)
5. (WS)	Structure of Matter 14 CP (PM)	Laboratory Course II 12 CP (PM)		Physical Differentiation 16 CP (WPM**)
6. (SS)	Autonomous Learning*** 5 - 10 CP (WPM)		Exam Module 13 CP (WPM)	

WS: Winter Term SS: Summer Term PM: Mandatory Module WPM: Elective Module

* Interdisciplinary module, which has a reasonable relation to the study of physics or will suit the professional qualification

** Study course physics: Quantum Theory and Statistical Physics,

Study course physics with specialisation "Scientific Instrumentation": Applications of Physical Measurement Methods

*** This module must be taken if parts of studies and exams were performed at universities other than the University of Münster and total credit amounts to less than 180 CP.

Module Descriptions

Physics I (mandatory module, 1. Semester)	11
Physics II (mandatory module, 2. Semester)	12
Physics III (mandatory module, 3. Semester)	13
Laboratory Course I (mandatory module, 3. and 4. Semester)	14
Computational Physics (mandatory module, 4. and 5. Semester)	15
Atomic and Quantum Physics (mandatory module, 4. Semester)	16
Structure of Matter (mandatory module, 5. Semester)	17
Applications of Physics (mandatory module, 4. Semester)	18
Laboratory Course II (mandatory module, 5. and 6. Semester)	19
Exam Module (includes bachelor thesis, elective module, 6. Semester)	20
Basics of Mathematics (mandatory module, 1. and 2. Semester)	21
Integration Theory (mandatory module, 3. Semester)	22
<u>Choice in “Physical differentiation”</u>	
Quantum Theory and Statistical Physics (elective module, 5. and 6. Semester)	23
Application of Physical Measurement Methods (elective module, 5. and 6. Semester)	24
<u>Choice in “Interdisciplinary Studies”</u>	
Geophysics (elective module)	25
Chemistry for Physicists (elective module)	26
Basics of Programming (elective module)	27
Medical Physics and Biophysics (elective module)	28
Basics of Economics (elective module)	29
Theoretical basics of psychology (elective)	30
Philosophy for Physicists (elective module)	31
Interdisciplinary Studies (elective module)	32
<u>If total credit amounts to less than 180 CP:</u>	
Autonomous learning (elective)	33

Module	Physics I: Dynamics of Particles and Particle Systems (mandatory)
Semester	1 st semester, WS
Person in charge	Dean of Studies
Components (course, duration, CP, term)	Physics I (lecture, 6 h/w and exercises 4 h/w, 14 CP, WS)
Credit points/ Work load	14 CP / 420 h (150 h in-class, 270 h self-study)
Learning targets	Understanding of phenomena and processes in nature; comprehension, mathematical representation and critical reflection of physical laws Introduction to the basic concepts of physics: experimentation, mathematical description, numerical modelling and visualisation of mechanical and relativistic processes; knowledge of related experimental devices and measurement techniques
Contents	<u>Methodology of physics</u> : what is physics? The role of theory and experiment; physical quantities and unit systems; measurements and uncertainties; vectors and fields; complex numbers; expansions; differential equations <u>Dynamics of particles</u> : Newton's laws, force; momentum and angular momentum; oscillations; work and energy; the concept of fields; conservation laws; accelerating and rotating reference frames; motion in central force fields, harmonic oscillations <u>Particle systems</u> : centre of gravity and conservation laws; coupled oscillators; dynamics of rigid bodies; deformable bodies; elasticity theory; dynamics of fluids and gases; mechanical and acoustic waves; Doppler effect <u>Relativity</u> : Introduction in relativistic mechanics
Requirements to meet	Successful participation in "Exercises for Physics I"
Exam	3-hour written exam The final mark of this subject will be calculated considering the two best marks among the modules Physics I, Physics II and Physics III. If this is to be applied to this module, it counts 11% of the final mark.

Module	Physics II: Thermodynamics and Electromagnetism (mandatory)
Semester	2 nd semester, SS
Person in charge	Dean of Studies
Components (course, duration, CP, term)	Physics II (lecture, 6 h/w and exercises 2 h/w, 10 CP, SS) Theoretical supplement to Physics II (2 h/w and exercises 1 h/w, 4 CP, SS)
Credit points/ Work load	14 CP / 420 h (165 h in-class, 255 h self-study)
Learning targets	<p>Understanding of phenomena and processes in nature; comprehension, mathematical representation and critical reflection of physical laws</p> <p>Introduction to basic concepts of physics: experimentation, mathematical description, numerical modelling and visualisation; application to thermodynamic and electromagnetic processes; knowledge of related experimental apparatuses and measurement techniques</p> <p>Theoretical amendment: deepened understanding of the main principles in classical mechanics, acquisition of the methods of analytical mechanics and its application to physical problems, introduction to the basics of linear and nonlinear dynamic systems</p>
Contents	<p><u>Thermodynamics</u>: kinetic theory of gases, distribution functions; temperature and heat; state variables; entropy and its statistical interpretation; the laws of thermodynamics; heat engines; transport phenomena; real gases; state of aggregation; phase transitions</p> <p><u>Electric charges and currents</u>: basic phenomena; electric fields and potentials; voltage; electric fields in matter and at interfaces (electrostatic induction and dielectricity), dc circuits; electric work and power; conduction phenomena in solids, liquids and gases</p> <p><u>Electromagnetism</u>: electric currents and magnetic fields; magnetic fields in matter; types of magnetisms; forces acting on current-carrying conductors; induction and induction devices; electromagnetism in vacuum and in matter; Lorentz force; Hall effect; ac resistances and circuits; oscillating circuits</p> <p><u>Theoretical supplement</u>: constraints and generalized coordinates, d'Alembert and Hamilton principle, Lagrangian formulation of mechanics, phase space, Hamiltonian mechanics, canonical transformations, Poisson bracket, basics of linear and nonlinear dynamic systems</p>
Requirements to meet	Successful participation in "Exercises for Physics II"
Exam	<p>4-hour written exam</p> <p>The final mark of this subject will be calculated considering the two best marks among the modules Physics I, Physics II and Physics III. If this is to be applied to this module, it counts 11% of the final mark.</p>

Module	Physics III: Waves and Quanta (mandatory)
Semester	3 rd semester, WS
Person in charge	Dean of Studies
Components (course, duration, CP, term)	Physics III (lecture, 6 h/w and excercises 2 h/w, 10 CP, WS) Theoretical supplement to Physics III (lecture 2 h/w and excercises 1 h/w, 4 CP)
Credit points/ Work load	14 CP / 420 h (165 h in-class, 255 h self-study)
Learning targets	Understanding of phenomena and processes in nature; comprehension, mathematical representation and critical reflection of physical laws Introduction to the basic concepts of physics: experiment, mathematical description, numerical modelling and visualisation; application to optical, wave physical and quantum physical processes; knowledge of related experimental apparatuses and measurement techniques Theoretical amendment: understanding of the main principles of special relativity, application to relativistic problems in mechanics and electrodynamics
Contents	<u>Electromagnetic waves</u> : Maxwell's equations, generation of electromagnetic waves, electromagnetic waves in vacuum, in insulators, and in conductors; wave propagation; wave packets; phase and group velocity; measurement of the velocity of light; relativistic formulation of electrodynamics <u>Optics</u> : Interaction of light with matter; polarisation and crystal optics; geometrical optics; optical instruments; wave optics; interference and diffraction; near-field and far-field optics; applications of interference and diffraction phenomena; Michelson-Morley experiment; nonlinear optics <u>Quanta</u> : black body radiation; Planck's law of radiation; photo effect; laser; Compton effect; wave-particle dualism; uncertainty relation; Franck-Hertz experiment; Stern-Gerlach experiment <u>Theoretical supplement</u> : basics of special relativity, mathematical formulation, 4-vectors, covariant formulation of mechanics and electrodynamics
Requirements to meet	Successful participation in "Exercises to Physics III"
Exam	4-hour written exam The final mark of this subject will be calculated considering the two best marks among the modules Physics I, Physics II and Physics III. If this is to be applied to this module, it counts 11% of the final mark.

Module	Laboratory Course I (mandatory)
Semester	3 rd (WS) and 4 th (SS) semester
Person in charge	Prof. Dr. M. Donath
Components (course, duration, CP, term)	1. Laboratory course in mechanics and electromagnetism (4 h/w, 6 CP, WS) 2. Laboratory course in optics, thermal und atomic physics (4 h/w, 6 CP, SS)
Credit points/ Work load	12 CP / 360 h (120 h laboratory course, 240 h preparation and follow-up work)
Learning targets	Inductive understanding of phenomena and processes in nature; basic comprehension of experimental methods in classical mechanics, thermal physics, electromagnetism, optics and atomic physics Practical experience in working with experimental setups for basic fields of experimental physics
Contents	Selected experiments in classical mechanics, thermal physics, electromagnetism, optics, and atomic physics
Requirements to meet	Successful completion of all required experiments in 1. and 2.
Exam	Preparation, execution and written analysis of all experiments completed within the module parts (1. and 2.) will be evaluated. Based on the evaluation a final grade is issued in both semesters. The average of the individual semester grades yields to the overall grade for the module. This module's grade does <i>not</i> count for the subject's overall grade.

Module	Computational Physics
Semester	4. and 5. semester
Person in charge	Dean of Studies
Components (course, duration, CP, term)	Introduction to scientific programming (lecture 2 h/w and exercises 1 h/w, SS, 4 CP) and / or Numerical solving of physical problems (lecture 2 h/w and exercises 1 h/w, WS, 4 CP) or computer based experimentation (experimental exercises, WS, SS, 4 CP) or participation in a class of the ZIV corresponding to 4 CP which is to be connected to the study of physics (in consultation with the person in charge of this module)
Credit points/ Work load	8 CP / 240 h (90 h in-class, 150 h self-study)
Learning targets	Introduction to scientific programming: use of computers to solve physical problems, algorithmic formulation of problems, understanding the possibilities and limits of numerical simulations Numerical solution of physical problems: learning of basic algorithms to solve problems from different parts of Physics Computer based experimentation: Use of computers to control experiments and to obtain and handle measured data
Contents	<u>Introduction to scientific programming</u> : Introduction to operating systems and programming languages, transformation of physical problems to algorithmic form, number display, numerical solutions to physical problems, analysis of convergence, numerical differentiation and integration <u>Numerical solving of physical problems</u> : Systems of linear equations, Eigenvalue problems, Fast-Fourier transformation, ordinary and partial differential equations, integral equations, Monte-Carlo methods <u>Computer based experimentation</u> : Computer controlled data acquisition and handling using a convenient language (voice recording, music, noise etc., fourier analysis including the windowfunction, analogue and digital signal filters, correlation function, practical application of the sampling theorem)
Requirements to meet	Successful participation in the exercises to the introduction of scientific programming Successful participation in the exercises to numerical solution of physical problems or the hardware practical course or a class at the ZIV
Exam	Commented solution of a problem from "Introduction to scientific programming" The grade does <i>not</i> count for the subject's overall grade.

Module	Atomic and Quantum Physics (mandatory)
Semester	4 th semester, SS
Person in charge	Dean of Studies
Components (course, duration, CP, term)	Introduction to Quantum Physics (lecture, 4 h/w, 4 CP, SS) Atomic and Molecular Physics (lecture, 2 h/w, 2 CP, SS) Exercises for Atomic and Quantum Physics (2 h/w, 4 CP, WS)
Credit points/ Work load	10 CP / 300 h (120 h in-class, 180 h self-study)
Learning targets	Basic understanding of quantum mechanics and atomic physics; Mathematical solutions of problems in quantum mechanics and atomic physics; Advanced knowledge of the quantum nature of matter
Contents	<u>Quantum mechanics</u> : Basic principles (wave-particle dualism, probability interpretation, Schrödinger equation, wave packets); simple potential problems; harmonic oscillator (eigenvalues and eigenfunctions); hydrogen atom (physics of angular momenta, radial equation, energy spectrum); atoms in electric and magnetic fields; spin (phenomena and formal description); approximation methods; indistinguishability (Bosons and Fermions) <u>Atomic and molecular physics</u> : atomic nature of matter; experimental methods of atomic physics; models of atoms; hydrogen atom; atoms with more than one electron; atoms in external fields; elementary structure of simple molecules; current topics in atomic and molecular physics
Requirements to meet	Successful participation in the exercises for “Atomic and Quantum Physics”
Exam	3-hour written exam Counts 8% to the subject's overall grade.

Module	Structure of Matter (mandatory)
Semester	5 th semester or later, WS and SS
Person in charge	Dean of Studies
Components (course, duration, CP, term)	Physics of Condensed Matter (lecture 4 h/w and exercises 1 h/w, 6 CP, WS) Nuclear and Particle Physics (lecture 3 h/w and exercises 1 h/w, 5 CP, WS) Exercises to Nuclear and Particle Physics (1 h/w, 2 CP, WS) Astrophysics and Cosmology (lecture 1 h/w, 1 CP, WS) Seminar (2 h/w, 2 CP, WS, SS)
Credit points/ Work load	14 CP / 420 h (180 h in-class, 240 h self-study)
Learning targets	Advanced knowledge of the structure of matter
Contents	<u>Physics of condensed matter</u> : structure and bonding of solids, methods of structure determination, lattice vibrations (phonons), thermal, magnetic and optical properties of solids, electronic and optical properties of metals and semiconductors, semiconductor interfaces, superconductivity <u>Nuclear and particle physics</u> : interaction of radiation and matter, particle detectors and particle accelerators, drop and Fermi gas model, dispersion and nuclear reactions, gamma and beta disintegration, nuclear fission, nuclear fusion, nucleosynthesis, symmetries and conservation laws, quantum numbers, static quark model, basic interactions <u>Cosmology and astrophysics</u> : experimental methods, star formation, Hertzsprung-Russell diagram, neutron stars, black holes, Schwarzschild radius, supernovae, evolution of the universe, background radiation, structure formation, Hubble parameter
Requirements to meet	Successful participation in the exercises for “Physics of Condensed Matter” Successful participation in the exercises for “Nuclear and Particle Physics” Successful participation (including talk/presentation) in seminar
Exam	30-45 minute oral exam Counts 10% to this subject's overall grade.

Module	Applications of Physics (mandatory)
Semester	4 th semester
Person in charge	Dean of Studies
Components (course, duration, CP, term)	Applied Physics, (lecture 4 h/w and exercises 2 h/w, 8 LP, SS)
Credit points/ Work load	8 CP/ 240 h (90 h in-class study, 150 h self-study)
Learning targets	Basic knowledge in electronics, optoelectronics, automatic control engineering and communication technology; Practice in analog and digital standard methods; Analysis of data by use of computers; Comprehension of interaction between physics and engineering technologies
Contents	<u>Applied Physics</u> : Electronic and optoelectronic components; analog and digital electronic circuits, steering and controlling; data analysis; basics of systems technology (methods in Fourier space); stochastic processes and noise; digital and analog signal processing; correlation procedures; storage and transformation of information; temporal, spatial and spatio-temporal information; linear and nonlinear systems; use of basic physics in information technology, life science, energy production and environmental studies
Requirements to meet	Successful participation in the exercises for “Applied Physics”
Exam	30-45 minute oral exam Counts 7% to this subject's overall grade.

Module	Laboratory Course II (mandatory)
Semester	5 th and 6 th semester, WS and SS
Person in charge	Dean of Studies
Components (course, duration, CP, term)	<ol style="list-style-type: none"> 1. Exercises in the Institute of Physics (WS SS) 2. Exercises in the Institute of Applied Physics (WS, SS) 3. Exercises in the Institute of Nuclear Physics (WS, SS) 4. Exercises in the Institute of Material Physics (WS, SS)
Credit points/ Work load	12 CP/ 360 h (96 h in-class, 264 h self-study)
Prerequisites	<p>Modules Physics I, Physics II and Experimental Exercises I</p> <p>Recommended: Modules Physics III, Atomic and Quantum Physics and Application of physics</p>
Learning targets	<p>Advanced analog and digital metrological methods and analysis of data using computers, acquisition of practical skills on ambitious experimental set-ups for different topics in experimental physics</p> <p>Advanced atom and solid state physics, devices and measuring methods of atomic and solid state physics</p> <p>Basic electronics, optoelectronics, controlling, and information technologies</p> <p>Advanced nuclear and particle physics, nuclear-physical devices and measuring methods</p> <p>Functional materials, devices and measuring methods in material physics</p>
Contents	Selected experiments to learn about measuring techniques and experimental and theoretical aspects of different sections of physics
Requirements to meet	Successful completion including lab report of all required experiments
Exam	<p>Preparation, execution and written analysis of all experiments from all four module parts is considered a general exam and thus will be graded. Overall grade for the module is determined by averaging on individual grades.</p> <p>Counts 8% to this subject's overall grade.</p>

Module	Exam Module (elective)
Semester	6 th semester, WS and SS
Person in charge	Supervisor of Bachelor thesis
Components (course, duration, CP, term)	Self-directed work on the bachelor thesis (12 CP) Preparation and execution of the final talk (1 CP)
Credit points/ Work load	13 CP/ 390 h (in-class and self-study)
Learning targets	In courses related to the bachelor thesis or through private studies, the student will be introduced into scientific research and the functional and methodical basics for the bachelor thesis. With the bachelor thesis, the student should demonstrate the ability to deal with a current problem of physics using scientific methods within the given timeline and to present the results appropriately.
Requirements to meet	Preparation of written thesis and final talk about the thesis lasting 30 minutes. The two examiners of the thesis have to be present during oral presentation.
Exam	The module grade is the grade of the bachelor thesis. Counts 10% to this subject's overall grade.

Module	Basics of Mathematics (mandatory)
Semester	1 st (WS) and 2 nd (SS) semester
Person in charge	Dean of Studies (mathematics)
Components (course, duration, CP, term)	Mathematics for physicists I (lecture, 4 h/w, 5 CP, WS) Exercises for mathematics for physicists I (2 h/w, 4 CP, WS) Mathematics for physicists II (lecture, 4 h/w, 5 CP, SS) Exercises for mathematics for physicists II (2 h/w, 4 CP, SS)
Credit points/ Work load	18 CP / 540 h (180 h in-class, 360 h self-study)
Learning targets	Basic concept of analysis and linear algebra and ability to solve related problems
Contents	<p>Complete induction, mathematical nomenclature</p> <p><u>Vector space</u>: dimension, subspace, linear systems of equations</p> <p><u>Real numbers</u>: convergence of series and progressions, Euclidean and standardized vector spaces,</p> <p>Complex numbers, exp and log, radicals, powers, trigonometric functions, unitary vector spaces</p> <p>Differentiable functions with one variable, mean value theorem and applications, curves, differentiable functions with multiple variables, gradients, vector fields</p> <p><u>Integration in one-dimension</u>: antiderivative, Taylor theorem, improper integrals, arc length, line integrals</p> <p><u>Series of functions</u>: different types of convergence, standardized vector spaces, topology of metrical spaces, permutation of limiting value processes</p> <p><u>Linear transformation</u>: dimension formula, matrix representation, determinants, volumes, vector product, eigenvalue, normal forms</p> <p><u>Differentiable representations</u>: inverse theorem , implicit functions, Lagrange multiplier</p>
Requirements to meet	<p>Successful participation in the exercises for “mathematics for physicists I”</p> <p>Successful participation in the exercises for “mathematics for physicists II”</p> <p>Passed exam at the end of the Winter semester “mathematics for physicists I”</p>
Exam	Normally two hour final exam following the lecture “mathematics for physicists II”

Module	Integration Theory (mandatory)
Semester	3 rd semester, WS
Person in charge	Dean of Studies (mathematics)
Components (course, duration, CP, term)	Mathematics for physicists III (lecture, 4 h/w, 5 CP, WS) Exercises for mathematics for physicists III (2 h/w, 4 CP, WS)
Credit points/ Work load	9 CP / 270 h (90 h in-class, 180 h self-study)
Prerequisites	Content of the module “basics of mathematics”
Learning targets	Basic concept of integration theory and ability to solve related problems
Contents	<p><u>Ordinary differential equations</u>: Picard-Lindelöf theorem, linear differential equation, examples.</p> <p><u>Measure and integration theory</u>: measure continuation theorem, the Lebesgue integral, convergence theorems, theorem of Fubini</p> <p>The integral theorems of Stokes, Gauß and Green in two- and three-dimensions.</p> <p><u>Theory of functions</u>: Cauchy integral theorem, power series, residual theorem</p> <p>Fourier series, convergence in the mean, L^2 as Hilbert space and Fourier transformation</p>
Requirements to meet	Successful participation in the exercises for “mathematics for physicist III”
Exam	Normally two hour exam.

Module	Quantum Theory and Statistical Physics (elective)
Semester	5 th (WS) and 6 th (SS) semester
Person in charge	Dean of Studies
Components (course, duration, CP, term)	Quantum Theory (lecture 4 h/w and exercises 2 h/w, 8 CP, WS) Statistical Physics (lecture 4 h/w and exercises 2 h/w, 8 CP, SS)
Credit points/ Work load	16 CP / 480 h (180 h in-class, 300 h self-study)
Learning targets	Advanced understanding of quantum theory and statistical physics to describe systems on the basis of their fundamental microscopic properties Advanced knowledge of the mathematical structure of quantum theory and the statistical approach to many-particle systems Mathematical solutions to problems in quantum theory and statistical physics
Contents	<u>Quantum theory</u> : mathematical framework of quantum theory; symmetries and conservation laws; postulates and measurement process; addition of angular momentum and spin-orbit coupling; approximation methods for time-independent and time-dependent problems, Fermi's golden rule; stationary scattering theory; second quantisation; quantised light field and spontaneous emission; EPR paradox, hidden variables and Bell's inequality <u>Statistical physics</u> : fundamentals of probability theory and mathematical statistics; statistical description of many-particle systems; statistical ensembles; relation between statistical physics and phenomenological thermodynamics; entropy and information; thermodynamic potentials; classical ideal gas; ideal quantum gases (Fermi and Bose gas); real gases; magnetic systems and phase transitions; statistics and kinetics of non-equilibrium systems; transport processes
Requirements to meet	Successful participation in the exercises for "Quantum Theory" Successful participation in the exercises for "Statistical Physics" Successful written tests at the end of each of the Exercises
Exam	30-45 minute oral exam Counts 12% to this subject's overall grade.

Module	Application of Physical Measurement Methods (elective
Semester	5 th and 6 th semester, WS and SS
Person in charge	Dean of Studies
Components (course, duration, CP, term)	6 module parts in four-week block courses
Credit points/ Work load	16 CP/ 480 h (180 h in-class, 300 h self-study)
Learning targets	<p>Modern measuring techniques at selected examples of electronics, photonics, microscopy, spectroscopy, vacuum engineering, radiation measuring technique and material physics. Specific analysis of the methods with regard to measuring quality, measuring limitations and errors</p> <p>Basic principles of electronic measuring and control technology through practical application of instrumentation hardware and software Imaging methods.</p> <p>Safe and reliable application of laser, optical and fiber-optical elements, vacuum apparatus, radiation sources and detectors.</p>
Contents	<p><u>Electronics</u>: analysis of components of analog and digital electronics (diode, transistor, operation amplifier, gate, flip-flops, shift register); cooperation of the components in computer-aided measuring techniques</p> <p><u>Laser and optical measuring techniques</u>: properties of laser radiation (coherence, mode structure); analysis of chosen problems of interferometry, holography and speckle measurement technology</p> <p><u>Microscopy</u>: modern methods of microscopy: high-resolution (transmission) electron microscopy, scanning force microscopy, scanning tunnelling microscopy</p> <p><u>Spectroscopy</u>: modern methods of electron, laser and ion spectroscopy</p> <p><u>Vacuum techniques</u>: introduction to pumps and pump systems; methods of vacuum measurement technology</p> <p><u>Radiation techniques</u>: physics of ionising radiation, detectors, methods of radioactive dating, medical applications, basics of radiation protection</p> <p><u>Techniques of material physics</u>: X-ray/neutron diffractometry, X-ray spectroscopy, atom probe tomography, calorimetry, thin-film deposition method, ion beam-assisted preparation techniques in electron microscopy</p>
Requirements to meet	Successful participation in each module part
Exam	<p>The module grade is based on the overall evaluation of the documentation of the experimental work performed in the six module parts</p> <p>Counts 12% to overall grade.</p>

Module	Geophysics (elective)
Semester	1 st semester or later
Person in charge	Prof. Dr. U. Hansen, Prof. Dr. C. Thomas
Components (course, duration, CP, term)	Introduction to geophysics (lecture, 2 h/w, 2 CP, WS) Exercises for introduction to geophysics (1 h/w, 2 CP, WS) Geophysical basics I (lecture, 2 h/w, 2 CP, SS) Exercises for geophysical basics I (1 h/w, 2 CP, SS) Geophysical basics II (lecture, 2 h/w, 2 CP, WS) Exercises for geophysical basics II (1 h/w, 2 CP, WS) International field course (5 h/w, 6 CP)
Credit points/ Work load	18 CP / 540 h (210 h in-class, 330 h self-study)
Learning targets	Overview of geophysical functions and the most important methods including simple practical demonstrations and exercises. International field course: application and knowledge of selected methods of applied geophysics (seismic, geoelectrics, electromagnetics, magnetics, gravimetry) and first steps of data evaluation and data interpretation.
Contents	Important components of the Earth's system, development, present properties, and significant processes Seismology and seismological methods for investigations of the inner structure of the Earth; basic principles of the seismic investigation methods Gravitational field and gravimetry, magnetic field and magnetics as well as electric and electromagnetic methods for investigations of the Earth
Requirements to meet	Active participation and work on exercises
Exam	1. two hour exam at the end of "Introduction to geophysics" (condition: 50% right solutions of the exercises) 2. three hour exam at the end of "geophysical basics II" (content of I and II) (condition: 50% right solutions of the exercises) 3. excursions report at the end of the field course The module grade is given by the average of the two exam grades and the grade for the excursion report. If one has not participated in the field course, the final exam to "Introduction to Geophysics" is weighted 34%, the grade from the exam "Geophysical basics I and II" and "Advanced Geophysics III" 66%. This module's grade counts 10% to the overall grade.

Module	Chemistry for Physicists (elective)
Semester	1 st (WS) and 2 nd (SS) semester
Person in charge	Dean of Studies (chemistry)
Components (course, duration, CP, term)	General chemistry (lecture, 5 h/w, 5 CP, WS) Exercises for general chemistry (4 h/w, 4 CP, WS/SS) Introductory chemical laboratory for students with chemistry as a minor (in the free period, 4 h/w, 6 CP, WS/SS) Inorganic chemistry (lecture, 3 h/w, 3 CP, SS)
Credit points/ Work load	18 CP / 540 h (240 h in-class, 300 h self-study)
Prerequisites	Laboratory: the first written exam to the exercise for "inorganic chemistry" passed with at least 40%. The second exam must be written after the laboratory.
Learning targets	Fundamental terms describing important chemical substances and their reactions and quantitative treatment Relevant inorganic and organic substances and their role in engineering, biosphere and environment as well as their physical-chemical properties; Reactivity and properties of the most important basic materials in environment and ecological systems, basic competence in evaluation of quantitative chemical data (units of concentration, equilibrium constant); Risk potential of chemical substances, secure working practice in chemical laboratories, knowledge and competences to obtain chemical data and information; Ability to work autonomously on related chemical problems
Contents	1. Semester: atomic structure, chemical bonds (covalent, metallic and ionic bonds), symmetry relations, gases, liquids and solutions, stoichiometry and description of mass conversion in chemical reactions, thermal equilibrium, energy conversion and kinetics of chemical reactions, acids and bases, redox reaction, solubility. Construction of inorganic bonds (alkane series, alkenes, alkynes, aromatics), substituent effects, homolysis and heterolysis, basic types of organic reactions (substitution, addition, elimination), organic acids and bases, carbonyl reactivity. An introduction to the chemical way of thinking: School knowledge will be reviewed and explored in more depth. 2. Semester: elemental chemistry, emphasising relevant technical processes; relationships within the periodic table, chemical bonds and structural chemistry; molecular, solid state chemistry and material science aspects; coordination chemistry with Ligand field theory.
Requirements to meet	Regular and active participation in exercises and laboratory, successful participation in both exams
Exam	30-45 minute oral exam Counts 10% to overall grade.

Module	Basics of Programming (elective)
Semester	1 st and 2 nd semester or later (beginning WS)
Person in charge	Prof. Dr. A. Clausing, Prof. Dr. K. Hinrichs
Components (course, duration, CP, term)	computer science I (lecture, 4 h/w, 5 CP, WS) Exercises for "computer science I" (2 h/w, 4 CP, WS) computer science II (lecture, 4 h/w, 5 CP, SS) Exercises for "computer science II" (2 h/w, 4 CP, WS)
Credit points/ Work load	18 CP / 540 h (210 h in-class, 330 h self-study)
Learning targets	Conventional abstraction and formalization mechanisms used in computer science Development of programs in higher level computer languages Creation of algorithms and data structures; implementation and analysis (concerning the consumption of resources)
Contents	Overview of computer science, introduction to fundamental terms and ways of thinking in computer science, introduction to a functional and an object-orientated computer language, representation, structure and interpretation of calculations, systems and their descriptions, abstract data types and data structures, creation and analysis of algorithms, fundamental terms of calculability, searching and sorting, schedule structures, trees and graphs, address calculation method
Requirements to meet	Successful participation in the exercises for computer science I and II
Exam	two hour written exam Counts 10% to overall grade

Module	Medical Physics and Biophysics (elective)
Semester	2 nd and 3 rd semester or later (beginning SS)
Person in charge	Dr. K. Dreisewerd, Dr. M. Mormann
Components (course, duration, CP, term)	<p>Molecular biophysics of cells and tissue I (lecture, 2 h/w, 2 CP, SS)</p> <p>Molecular biophysics of cells and tissue II (lecture, 2 h/w, 2 CP, WS)</p> <p>Biophysical methods of molecular biology, cell biology and physiology (lecture, 2 h/w, 2 CP, SS)</p> <p>Biophysical methods of molecular biology, cell biology and physiology (laboratory, 5 h, 8 CP, SS)</p> <p>Selected topics of medical physics and biophysics (compact seminar, 15h, 1 CP, every semester)</p> <p>One of three electives</p> <p>1) Biomedical analytics</p> <p>Basics and applications of biomedical mass spectrometry I and II (lecture, 2 h/w; 2 CP, WS and SS)</p> <p>Seminar basics, methods and applications of the laser and electrospray mass spectrometry (seminar, 1 h/w; 1 CP, every semester)</p> <p>2) Laser microscopy</p> <p>Fluorescence microscopy I and II (lecture, 2 h/w, 2 CP, SS and WS)</p> <p>Basics, methods and cell biological appliances of the confocal microscopy (Seminar, 1 h/w; 1 CP, WS/SS)</p> <p>3) Electron microscopy and microanalysis</p> <p>Electron and scanning probe microscopic methods for advanced students (lecture, 1 h/w and laboratory 1 h/w, every semester, 3 CP)</p>
Credit points/ Work load	18 CP / 540 h (240 h in-class, 300 h private study)
Learning targets	Basics of medical physics and biophysic; biophysical standard methods
Contents	<p>Molecular biophysics of cells and tissues, biophysical methods of molecular biology, cell biology and physiology</p> <p>1) basics and applications of biomedical mass spectrometry (laser and electrospray mass spectrometry)</p> <p>2) basics, methods and cell biological applications of confocal microscopy</p> <p>3) electron and scanning probe microscopically methods for advanced students</p>
Requirements to meet	<p>Completion of lab reports</p> <p>Successful participation (including own talk/presentation) in seminar</p>
Exam	30-45 minute oral exam

Module	Basics of Economics (elective)
Semester	1 st and 2 nd semester
Person in charge	Prof. Dr. A. Pfingsten, Prof. Dr. W. Ströbele
Components (course, duration, CP, term)	<p>Basics of Economics (9 CP):</p> <ul style="list-style-type: none"> - Introduction to Economics (lecture, 2 h/w, 3 CP, WS) - Financial Mathematics (lecture, 1 h/w, 2 CP, WS) - Investment and Finance (lecture, 3 h/w, 3 CP, WS) - Exercises (2 h/w, 1 CP, WS) <p>Microeconomics I (9 CP):</p> <ul style="list-style-type: none"> - Introduction to Political Economics (lecture, 2 h/w, 3 CP, WS) - Microeconomics (lecture with proseminar, 6 h/w, 6 CP, SS)
Credit points/ Work load	18 CP / 540 h (240 h in-class, 300 h self-study)
Learning targets	<p>Understanding and application of fundamental economic terms, assigning problems into proper context, development of simple means of problem solving, solving problems in investment and finance.</p> <p>The module introduces to basics of microeconomics.</p>
Contents	<p><u>Basics of economics</u>: Overview of basic questions and methods of economics as well as of managerial functions; special focus on investment and finance decisions including finance mathematical tools.</p> <p><u>Microeconomics</u>: Basic questions of economic activity, markets and market failure, household and consumer economics (budget optimization, demand of goods, labour supply, insurance and insecurity), theory of the firm (theory of production, minimal costs combination, supply of goods, factor demand)</p> <p><u>Markets I</u>: perfect competition (comparative static, Cobb-Web-theorem), theorems of welfare economics, imperfect markets, monopoly and dominant firms</p>
Exam	Written exams in "Basics of Economics" and "Microeconomics". Total grade of the module by arithmetic averaging.

Module	Theoretical basics of psychology (elective)
Semester	1 st - 4 th semester
Person in charge	Dr. C. Dirksmeier
Components (course, duration, CP, term)	<p>1. Biological psychology I (lecture, 2 h/w, 3 CP, WS)</p> <p>2. Biological psychology II (lecture, 2 h/w, 3 CP, SS)</p> <p>3. Basics I: general psychology and cognitive neuroscience (lecture, 4 h/w, 8 CP, SS)</p> <p>4. selective one of the following parts of psychology: differential psychology, development psychology or social psychology (lecture/seminar, 2 h/w, 4 CP, WS or SS)</p>
Credit points/ Work load	18 CP / 540 h
Learning targets	The students obtain basic knowledge of biological conditions of behaviour and basic knowledge of theories, experimental methods and research outcomes of general psychology and cognitive neuroscience. They learn the most important methods of biopsychology and general psychology and are able to classify their possibilities and limits. Furthermore they obtain basic knowledge of methodical and theoretical concepts in one of the following parts: differential psychology, development psychology or social psychology.
Contents	This module introduces the central concepts, research methods and -outcomes of biopsychology, general psychology and cognitive neuroscience. Therefore, the lecture of biopsychology is dedicated to basics of general neurophysiology, physiology of senses such as behaviour relevant structures of the nerve system. Afterwards, the following lecture is dedicated to electrophysiologic and image-guided methods of biopsychology such as the biological basics of different integrative functions of the nerve system. Contents of the lectures general psychology and cognitive neuroscience are the psychological structures and processes which arrange a connection between absorbing information and behaviour (perception, converting, storing and production). Priority is given to structures and processes which are common among all human beings.
Exam	<p>Participation in lecture/seminar to 4.</p> <p>A written exam (90 min) or oral exam (30 min) chosen by the examiner to lectures 1. - 3.</p> <p>This modul's grade is given by the average of the three parts.</p> <p>This modul's grade counts 10% to the overall grade.</p>

Module	Philosophy for Physicists (elective module)
Term	1 st and 2 nd semester
Module Supervisor	Supervisors of the modules A (Argument and text) and E (knowing and being) of the two-subjects-bachelor in philosophy
Components (course, duration, CP, term)	<p>Winter term</p> <p>Lecture: <i>Logic and theory of argumentation</i> (2 h/w, 1 CP, WS)</p> <p>Seminar/tutorial: <i>Logic and theory of argumentation</i> (2 h/w, 4 CP, WS)</p> <p>Lecture: <i>Epistemology</i> (2 h/w, 1 CP, WS)</p> <p>Seminar/tutorial: <i>Epistemology</i> (2 h/w, 4 CP, WS)</p> <p>Summer term</p> <p>Seminar/tutorial: <i>Logic, language and text</i> (2 h/w, 4 CP, SS)</p> <p>Seminar/tutorial: <i>Metaphysics</i> (2 h/w, 4 CP, SS)</p>
Credit points/ Work load	18 CP / 540 h (180 h in-class, 350 h self-study)
Learning targets	After having studied the elective module 'Philosophy for Physicists' students shall be able to discern issues and problems of Theoretical Philosophy with respect to their content and formal structure. They will have learnt to analyze and classify philosophical arguments and to examine their validity and soundness. In particular, oral and written presentation skills are practiced. In order to achieve these educational objectives, basic knowledge and proficiency of formal logic and theory of argumentation will be imparted.
Contents	<p>The contents of the elective module Philosophy for Physicists are mainly related to Theoretical Philosophy and comprise the following areas: Logic (propositional logic, predicate logic), Theory of Argumentation, Philosophy of Language, Epistemology, Philosophy of Science and Ontology. All of these are relevant for a philosophical propaedeutics within a programme of study in the natural sciences.</p> <p>The most important epistemological and metaphysical views as well as central positions in the philosophy of science are classified under both a systematical and an historical perspective. Moreover, contemporary questions and topics of Theoretical Philosophy are discussed. Especially epistemological issues (as, e.g., concerning the range of knowledge, the reasons for claims of knowledge, the distinction between explaining and understanding) are to be evaluated in the light of their historical development.</p>
Requirements to meet	Regular attendance of the lectures, regular and active participation in the four seminars/tutorials
Exam	<p>At least sufficient („4,0“) exam results (written tests or essays) in the four seminars/tutorials. Total module grade calculated as average of the four individual marks</p> <p>This module's grade is given by the average of each part.</p> <p>Counts 10% to overall grade.</p>

Module	Interdisciplinary Studies (elective)
Semester	1 st to 4 th semester
Person in charge	Choice of student
Components (course, duration, CP, term)	In agreement with person in charge for the module and dean of the faculty of physics Lecture (1 h/w equates to 1 CP) Exercises to lecture (1 h/w equates to 2 CP) Experimental exercises/laboratory (1 h/w equates to 1,5 CP) Seminars (1 h/w equates to 1 CP) In total at least 12 h/w
Credit points/ Work load	18 CP / 540 h
Conditions	After consulting the person in charge
Learning targets	After consulting the person in charge
Contents	After consulting the person in charge
Study/Exam achievements	After consulting the person in charge At least two study achievements must be completed, one of them examinable. If two or more exams are passed, the module grade will be given by the average of each part's grade. Counts 10% to overall grade.

Module	Autonomous Learning (elective)
Semester	6 th Semester, WS and SS
Person in charge	Dean of Studies
Components (course, duration, CP, term)	according to agreement with the person in charge, 5 - 10 CP
Credit Points/ Work load	5 - 10 CP / 150 - 300 h (private study)
Learning targets	This module must be taken if parts of the studies were completed at a university other than the Westfälische Wilhelms-Universität Münster and the student has less than 180 CP. Learning targets, competences and content will be defined by the Study Advisory Service.
Exam	Generally 30 – 45 minute oral exam Whether, and if yes, in which part the module's grade counts to the overall grade is to be determined in each case individually.

Description of Modules for the Study Course

**Physics
(Master of Science)**

**Department of Physics
University of Münster**

Recommended Study Organisation

Semester	Module			
1. (WS)	Physical elective studies 10-18 CP (WPM)	Physical Specialisation I 14 - 18 CP (WPM)	Physical Specialisation II 14 - 18 CP (WPM)	Interdisciplinary Studies 12 - 15 CP (WPM)
2. (SS)				
3. (WS)	Professional Specialisation 15 CP (WPM)		Methodology und Project Planning 15 CP (WPM)	
4. (SS)	Master Thesis 30 LP (WPM)			

WS: Winter Term SS: Summer Term PM: Mandatory Module WPM: Elective Module

The total credit of the modules “Physical elective studies”, “Physical Specialisation I and II” and “Interdisciplinary Studies” must amount to at least 60 CP.

Module Descriptions

Choice for two “Modules of Physical Specialisation” (elective, 1. and 2. Semester)

Physical elective studies	37
Functional Nanosystems	38
Nuclear and Particle Physics	39
Material Physics	40
Nonlinear Physics	41
Photonics and Applied Physics of Waves	42
Physics of Low-Dimensional Solids	43

Modules of Research Period (elective modules, 3. and 4. Semester)

Professional Specialisation	44
Methodology and Project Planning	45
Master Thesis	46

Module	Physical elective studies (elective)
Semester	1 st and 2 nd semester
Person in charge	Dean of Studies
Components (course, duration, CP, term)	<p>Courses of free choice among:</p> <p>Lectures (1 h/w, corresponds to roughly 1 CP)</p> <p>Exercises to lectures (1 h/w, corresponds to roughly 1 CP)</p> <p>Experimental exercises/practical course (1 h/w, corresponds to roughly 1,5 CP)</p> <p>Seminars (1 h/w, corresponds to roughly 1 CP)</p> <p>to match a total count of 10-18 h/w</p>
Credit points/ Work load	10-18 CP/ 340-540 h (ca 1/3 presence and 2/3 self studies)
Prerequisites	Consultation of person in charge of each course
Learning targets	This module permits students to obtain knowledge of free choice. With the chosen courses the students are able to integrate new knowledge and decide further specialisation of physical elective modules I and II well-grounded.
Contents	Consultation of person in charge of each course
Exam	<p>To obtain the CPs for a single course, it may be obligatory to hand in successfully a work.</p> <p>One has to absolve at least one exam relevant course, e.g. a seminar, to get the CPs allocated.</p> <p>The module's grade does not count to the overall grade.</p>

Module	Functional Nanosystems (elective)
Semester	1 st and 2 nd semester
Person in charge	Prof. Dr. H. Fuchs, Prof. Dr. H. Arlinghaus
Components (course, duration, CP, term)	14 – 18 CP, according to agreement with the person in charge, consisting of: <ul style="list-style-type: none"> - laboratory course in nanophysics (6 CP) - at least 2 advanced lectures in nanophysics (4 CP) - at least 1 seminar (2 CP) - at least 1 more course by choice (2 CP)
Credit points/ Work load	14 – 18 CP / 420 – 540 h (ca. 1/3 in-class, 2/3 self-study)
Learning targets	Advanced knowledge in modern analytical methods for the characterisation of nanostructures and their functionalities
Contents	Basics of nanophysics (fundamental atomic and molecular interactions, nanomaterials, nanofabrication, functional properties) with an emphasis on modern analytical tools
Requirements to meet	Successful participation (including talk/presentation) in a seminar in nanophysics Successful completion of a laboratory course
Exam	30 – 45 minute oral-exam This module's grade counts 1/6 to the overall grade.

Module	Nuclear and Particle Physics (elective)
Semester	1 st and 2 nd semester
Person in charge	Prof. Dr. G. Münster
Components (course, duration, CP, term)	In agreement with the person in charge: <ul style="list-style-type: none"> - Laboratory course (at least 5 CP) - At least two advanced lectures in nuclear and particle physics (at least 6 CP) - at least one seminar in nuclear and particle physics (at least 2 CP)
Credit points/ Work load	14 – 18 CP / 420 – 450 h (approx. 1/3 in-class, 2/3 self-study)
Learning targets	Advanced knowledge and methods of nuclear and particle physics
Contents	Experimental techniques of nuclear and particle physics Advanced knowledge about the fundamental constituents of matter and their interactions Aspects of the Standard Model of elementary particle physics
Requirements to meet	Successful completion of the laboratory course Successful participation (including talk/presentation) in a seminar in nuclear and particle physics Possibly: successful completion of marked written exercises or exams.
Exam	30 – 45 minute oral-exam

Module	Material Physics (elective)
Semester	1 st and 2 nd semester
Person in charge	Prof. Dr. G. Schmitz
Components (course, duration, CP, term)	<p>Obligatory parts:</p> <ul style="list-style-type: none"> - Lecture with exercises: 'Material Physics I' (4 CP) - Lecture with exercises: 'Material Physics II' (4 CP) - Laboratory course: 'Practical exercises in Material Physics' (5 CP) - one seminar (2 CP) <p>Alternative parts: In agreement with person in charge: Advanced lectures or seminars in the area of material physics, or experimental and theoretical solid state physics with a total amount of up to 5 CP</p>
Credit points/ Work load	15-18 CP / 450-540 h (about 1/3 in-class, 2/3 self-study)
Learning targets	The module teaches profound knowledge of physical concepts and methods in material science. Courses should enable students to perform active research in current problems of material physics.
Contents	<p>Laboratory course: Experimental methods and basic physical properties of materials</p> <p>Material Physics I and II: Structure and lattice defects, thermodynamics and constitution, diffusion and atomic transport, phase transformations and reaction kinetics, mechanical properties, functional materials.</p> <p>Advanced lectures may include: 'Atomic transport', 'Physics of soft matter and biological materials', 'Polymer physics', 'Semi-conductor physics', 'Mechanics of materials', 'Nano-structured materials', 'Simulation methods in material science'</p>
Requirements to meet	<ul style="list-style-type: none"> - Successful completion of the laboratory course - Successful participation in validated courses
Exam	30 – 45 minute oral-exam

Module	Nonlinear Physics (elective)
Semester	1 st and 2 nd semester
Person in charge	Prof. Dr. Cornelia Denz Prof. Dr. S. Linz
Components (course, duration, CP, term)	In agreement with the person in charge: <ul style="list-style-type: none"> - Basic and advanced lectures in suitable combination (at least 4 CP) - at least one seminar in nonlinear physics (at least 2 LP) - Experimental exercises in nonlinear physics (at least 4 CP) More CPs can be obtained according to each student's main focus in experimental or theoretical nonlinear Physics chosen from lectures, laboratory classes or seminars. In agreement with the person in charge, CPs in laboratory classes can be archived as well in research projects working on a nonlinear physical problem ("Mini-research") or by making a project participating in a practical course in an enterprise or an external research facility under scientific guidance of a university professor of this module.
Credit points/ Work load	14 - 18 CP/ 480 - 540 h (approx. 1/3 in-class, 2/3 self-study)
Learning targets	Basic concepts of nonlinear physics, the role of nonlinearities in different physical, chemical or biological systems, relevant methods for theoretical and/or experimental analysis of nonlinear systems, application of a higher computer language to problems in theoretical or experimental physics, obtain ability of application to concrete theoretical and experimental physical problems.
Contents	The module offers theoretical and experimental contents. Possibility to focus either on the theoretical or the experimental part. Each combination includes basic principles of nonlinear physics, such as signatures of nonlinear and complex systems, emergence, self-organisation, stability, bifurcations, attractors or pattern formation as well as specific examples of nonlinear systems. Use of typical nonlinear model equations (i.e. Swift-Hohenberg-equation, complex Ginzburg-Landau-equation, nonlinear Schrödinger-equation) and discussion of their generic characteristics and applications to concrete systems.
Requirements to meet	Successful participation in a one-hour-exercise Successful participation (including talk/presentation) in a seminar Solving experimental and theoretical problems, including documentation of the solutions
Exam	30 – 45 minute oral exam Counts 1/6 to overall grade.

Module	Photonics and magnonics (elective)
Semester	Recommended for 1 st and 2 nd semester
Person in charge	Prof. Dr. C. Denz
Components (course, duration, CP, term)	In agreement with person in charge 14-18 CP among the following: - basic lectures with exercises and advanced lectures in photonics and magnonics (at least 4 CP) - Experimental exercises in photonics and magnonics(4 CP) - At least one seminar in photonics and magnonics (at least 2 CP) Alternatively in agreement with person in charge CPs in experimental exercises can be obtained by participating in a research project to an application relevant problem (“Mini-research”) or by doing a practical course in an enterprise or an external research facility unter scientific guidance of a university professor of this module.
Credit points/ Work load	14 - 18 CP/ 480 - 540 h (approx. 1/3 in-class, 2/3 self-study)
Learning targets	Exemplary learning of transmission of basic physical knowledge to application oriented problems at the example of photonics; advanced knowledge in optics, photonics and the application of waves; Importance of factors (e.g. economic and social) outside of physics
Contents	Applied problems on the basis of certain examples; Systematic and advanced treatment of a problem either in optics, photonics or the application of waves.
Requirements to meet	Successful completion of exercises for any course in the modulus Successful participation (including talk/presentation) in a seminar in photonics and applied physics of waves Successful completion of an applied problem, including a documentation of the solution for “Experimental exercises on photonics and applied physics of waves” or in one of the above-mentioned projects.
Exam	30 – 45 minute oral-exam Counts 1/6 to overall grade.

Module	Physics of low-dimensional solids (elective)
Semester	1 st and 2 nd semester
Person in charge	Prof. Dr. T. Kuhn, Prof. Dr. M. Donath
Components (course, duration, CP, term)	In agreement with person in charge 18 CP among the following: <ul style="list-style-type: none"> - Lecture "Introduction to solid state theory" with exercises (3+2 CP) - At least one advanced lecture in the field of modern experimental solid state physics (at least 2 CP) - At least one seminar related to current problems in experimental or theoretical solid state physics (2 CP) - Experimental exercises in solid state spectroscopy (4 CP) - Optionally additional advanced courses in experimental or theoretical solid state physics
Credit points/ Work load	18 CP / 540 h (approx. 1/3 in-class, 2/3 self-study)
Learning targets	Advanced knowledge of physical phenomena in low-dimensional solid state systems Application of experimental and theoretical techniques for analysis and description Understanding of qualitatively new effects resulting from spatial confinement and of their relevance for applications
Contents	Selected phenomena in solid state physics, in particular regarding low-dimensional systems
Requirements to meet	Successful participation in the exercises for „Introduction to solid state theory“ Successful participation (including talk/presentation) in a seminar related to current problems in experimental or theoretical solid state physics Successful participation in the "Experimental Exercises for solid state spectroscopy" or a successful participation in the exercises for an advanced lecture in solid state theory
Exam	30 – 45 minute oral-exam Counts 1/6 to overall grade.

Module	Professional Specialisation
Semester	3 rd semester
Person in charge	Master thesis supervisor
Components (course, duration, CP, term)	<ul style="list-style-type: none"> - Advanced lectures (1 h/w corresponds to 1 CP) - Exercises for advanced lectures (1 h/w corresponds to 2 CP) - Laboratory course / internship (1 h/w corresponds to 1,5 CP) - Seminars (1 h/w corresponds to 1 CP) <p>Approximately 5 h/w in total.</p> <ul style="list-style-type: none"> - Self-studies
Credit points/ Work load	14 - 18 CP / 360-540 h (approx. 1/3 in-class, 2/3 self-study)
Learning targets	<p>Basics of independent academic work taught through advanced research oriented courses.</p> <p>This module integrates the student with a working group to encourage teamwork and optimal use of information.</p>
Contents	Independently gathering information and background knowledge and gaining familiarization with the topic of the master thesis
Exam	<p>30 to 45 minute oral exam</p> <p>This module's grade does not count to overall grade.</p>

Module	Methodology und Project Planning
Semester	3 rd semester
Person in charge	Master thesis supervisor
Components (course, duration, CP, term)	In agreement with the person in charge: <ul style="list-style-type: none"> - laboratory course (1 h/w corresponds to 1,5 CP) - Computational physics course - Research and group seminars (1 h/w corresponds to 1 CP) - Self-studies
Credit points/ Work load	15 CP / 450 h
Learning targets	Technical and mathematical knowledge required for the master thesis
Contents	Introduction to academic work and to scientific and methodical basics required for master thesis This module integrates the student with a working group to encourage teamwork and optimal use of information
Exam	30 to 45 minute oral exam This module's grade does not count to overall grade.

Module	Master Thesis
Semester	4 th semester
Person in charge	Master thesis supervisor
Components (course, duration, CP, term)	Independent work on master thesis (30 CP)
Credit points/ Work load	30 CP / 900 h
Prerequisites	At least 60 CP obtained in master studies
Learning targets	The master thesis completes scientific education. It demonstrates that the student is capable of independent research work applying state of the art methodology. The goal to perform a research project in a current field of physical research under guidance of the scientific supervisor.
Contents	Every student has to work on a current scientific problem in the field of her/his choice under guidance of the supervisor.
Exam	30 minute concluding presentation of the master thesis (second examiner must attend) The thesis grade determines the module grade. The grade conforms with § 15 Abs. 2. Counts ½ to overall grade.