Westfälische Wilhelms-Universität Münster

Department of Physics

Commented Course Programme in Physics

BSc in Physics

- Dekanat des Fachbereichs Physik -
September 2015

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 60,000 students live in this town that is known as Germany'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. They are 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 independent 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 large number of seminars and special courses with varying 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. Among the exercise classes belonging to the lectures of the third study year, there is always at least one given in English.

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.
Gernot Münster
Dean of Studies
Münster, September 2015

CONTACT

Advice for International Students

Mrs Astrid Burgbacher
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Schlossplatz 3
D-48149 Münster
Tel.: +49 (0) 251/ 83-2 22 54; Fax: +49 (0) 251 / 83-2 22 26
e-mail: International.applicants@uni-muenster.de
http://www.uni-muenster.de/international/incoming/index.html

Admissions Requirement and Studies

Studierendensekretariat
Schlossplatz 2
D-48149 Münster
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

Language Courses

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

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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Tel.: +49 (0) 251 / 83-7 96 46
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http://www.studentenwerk-muenster.de/

Information for ERASMUS Students [Incoming and Outgoing]

Westfälische Wilhelms-Universität Münster
International Office – ERASMUS Office
Leonardo Campus 11
D-48149 Münster
http://www.uni-muenster.de/ERASMUS/

Information for students and teachers concerning ERASMUS activities; contact person for ERASMUS partner universities

1.) LLL Institutional Coordinator
Mrs Anke Kohl
Tel.: +49 (0) 251 / 83-2 26 01; Fax: +49 (0) 251 / 83-2 21 13
e-mail: anke.kohl@uni-muenster.de

2.) Exchange Student Service
Tel.: +49 (0) 251 / 83-2 2113; Fax: +49 (0) 251 / 83-2 14 13
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3.) For Outgoing students
Heike Afhüppe
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For Language Courses and accommodation see above.

Department of Physics

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Description of Modules for the Study Programme

Physics

and

Physics with Specialisation "Scientific Instrumentation"

(Bachelor of Science)

Department of Physics
University of Münster

Recommended Study Organisation

<table>
<tr><th>Semester</th><th colspan="4">Modules</th></tr>
<tr><td>1. (WS)</td><td>Physics I
14 CP (PM)</td><td></td><td rowspan="2">Basics of Mathematics
16 CP (PM)</td><td rowspan="3">Interdisciplinary Studies
18 CP (WPM*)</td></tr>
<tr><td>2. (SS)</td><td>Physics II
14 CP (PM)</td><td></td></tr>
<tr><td>3. (WS)</td><td>Physics III
14 CP (PM)</td><td rowspan="2">Laboratory Course I
13 CP (PM)</td><td>Integration Theory
8 CP (PM)</td></tr>
<tr><td>4. (SS)</td><td>Atomic and Quantum Physics
10 CP (PM)</td><td rowspan="2">Computational Physics
9 CP (PM)</td><td>Measuring technology and signal processing
8 CP (PM)</td></tr>
<tr><td>5. (WS)</td><td>Structure of Matter
14 CP (PM)</td><td rowspan="2">Laboratory Course II
13 CP (PM)</td><td rowspan="2">Professional qualification
16 CP (WPM**)</td></tr>
<tr><td>6. (SS)</td><td></td><td>Exam Module
13 CP (WPM)</td></tr>
</table>

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

Module Descriptions

Module 1	**Physics I: Dynamics of Particles and Particle Systems (mandatory)**
Semester	1st semester, WS
Person in charge	Dean of Studies
Components (course, duration, CP, term, time)	Physics I (lecture, 6 h/w and exercises 4 h/w, 14 CP, WS) *Tue: 10:30-12:00, IG1 HS1* *Wed: 8:15-10:45, IG1 HS1* *Fri: 10:30-12:00, IG1 HS1* *Exercises:* *Take place at different times in several rooms, alternative date upon request*
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 processes; knowledge of related experimental devices and measurement techniques
Contents	Methodology of Physics: 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 Dynamics of Particles: Newton's laws; force, momentum and angular momentum; oscillations; work and energy; the concept of fields; conservation laws; principle of relativity; accelerating and rotating reference frames; motion in central force fields Particle Systems: centre of gravity and conservation laws; coupled oscillators; dynamics of rigid bodies; deformable bodies; elasticity theory; dynamics of fluids and gases; kinetic theory of gases; distribution functions; mechanical and acoustic waves; Doppler effect
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.
Prerequisites for attending	None

Module 2	**Physics II: Thermodynamics and Electromagnetism (mandatory)**
Semester	2nd semester, SS
Person in charge	Dean of Studies
Components (course, duration, CP, term, time)	Physics II (lecture, 6 h/w and exercises 2 h/w, 10 CP, SS) *Tue: 10:30-12:00, IG1 HS1, Wed: 8:15-10:45, IG1 HS1,* *Fri: 10:30-12:00, IG1 HS1* *Exercises:* *Thu: 8:30-10:00, various rooms, Fri: 8:30-10:00, various rooms* Theoretical Supplement to Physics II (2 h/w and exercises 1 h/w, 4 CP, SS) *Thu: 2:15-3:45, AP HS* *Exercises: Mo: 8:30-10:00, various rooms* *(alternative dates for exercises upon request)*
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 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 Theoretical amendment: deepened understanding of the main principles in classical mechanics, acquisition of the methods of analytical mechanics and their application to physical problems, introduction to the basics of linear and nonlinear dynamical systems
Contents	Thermodynamics: 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 Electric Charges and Currents: 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 Electromagnetism: 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 Theoretical Supplement: analytic mechanics and dynamic systems: 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
Requirements to meet	Successful participation in “Exercises for Physics II”
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.
Prerequisites for attending	Recommended: Physics I

Module 3	**Basics of Mathematics (mandatory)**
Semester	1st (WS) and 2nd (SS) semester
Person in charge	Dean of Studies (mathematics)
Components (course, duration, CP, term, time)	Mathematics for Physicists I (lecture, 4 h/w, 4 CP, WS) *Mon: 10:30-12:00, IG1 HS2, Thu: 10:30-12:00, IG1 HS2* Exercises for Mathematics for Physicists I (2 h/w, 4 CP, WS) *Tue: 8:30-10:00, various rooms* Mathematics for Physicists II (lecture, 4 h/w, 4 CP, SS) *Mon: 10:30-12:00, AP HS, Thu: 10:30-12:00, AP HS* Exercises for Mathematics for Physicists II (2 h/w, 4 CP, SS) *Tue: 8:30-10:00, various rooms* *(alternative dates for exercises upon request)*
Credit points/ Work load	16 CP /480 h (180 h in-class, 300 h self-study)
Learning targets	Basic concepts of analysis and linear algebra and ability to solve related problems
Contents	Complete induction, mathematical nomenclature Vector Spaces: dimension, subspace, linear systems of equations. convergence of series and progressions, real numbers, euclidean and normed vector spaces,complex numbers, exp and log, roots, powers, trigonometric functions, unitary vector spaces. Differentiable functions of one variable, mean value theorem and applications, curves, differentiable functions of several variables, gradients, vector fields Integration in one-dimension: antiderivative, Taylor theorem, improper integrals, arc length, line integrals Series of Functions: different types of convergence, normed vector spaces, topology of metric spaces, interchange of limiting processes Linear Transformations: dimension formula, matrix representation, determinants, volumes, vector product, eigenvalues, normal forms Differentiable Mappings: inverse theorem, implicit functions, Lagrange multipliers
Requirements to meet	Successful participation in the exercises for “Mathematics for Physicists I” Successful participation in the exercises for “Mathematics for Physicists II” Passed exam at the end of the Winter semester “Mathematics for Physicists I”
Exam	Normally two hour final exam following the lecture “Mathematics for Physicists II” The final mark of this subject will be calculated considering the best mark among the modules “mathematics for physicists II” and “Integration theory”. If this is to be applied to this module, it counts 11% of the final mark.
Prerequisites for attending	None

Module 4	**Physics III: Waves and Quanta (mandatory)**
Semester	3rd semester, WS
Person in charge	Dean of Studies
Components (course, duration, CP, term, time)	Physics III (lecture, 6 h/w and exercises 2 h/w, 10 CP, WS) *Mon: 10:30-12:00, IG1 HS1, Wed: 10:30-12:00, IG1 HS1* *Thu: 10:30-12:00, IG1 HS1* *Exercises: Tue: 8:30-10:00, various rooms* Theoretical Supplement to Physics III (lecture 2 h/w and exercises 1 h/w, 4 CP, WS), *Thu: 2:15-3:45, HS 2* *Exercises: Fri: 8:30-10:00, various rooms* *(alternative dates for exercises upon request)*
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	Electromagnetic Waves: 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; Michelson-Morley experiment. Optics: 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; nonlinear optics Quanta: black body radiation; Planck's law of radiation; photo effect; laser; Compton effect; wave-particle dualism; statistical interpretation of wave functions; uncertainty relation; Franck-Hertz experiment; Theoretical Supplement: 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.
Prerequisites for attending	Recommended: Physics I, Physics II

Module 5	**Integration Theory (mandatory)**
Semester	3rd semester, WS
Person in charge	Dean of Studies (mathematics)
Components (course, duration, CP, term, time)	Mathematics for Physicists III (lecture, 4 h/w, 4 CP, WS) *Tue: 10:30-12:00, AP HS, Fri: 10:30-12:00, AP HS* Exercises for Mathematics for Physicists III (2 h/w, 4 CP, WS) *Wed: 8:30-10:00, various rooms* *(alternative date for exercises upon request)*
Credit points/ Work load	8 CP /240 h (90 h in-class, 150 h self-study)
Learning targets	Basic concepts of integration theory and ability to solve related problems
Contents	Ordinary Differential Equations: Picard-Lindelöf theorem, linear differential equations, examples. Measure and Integration theory: transformation rule, the Lebesgue integral, convergence theorems, theorem of Fubini The integral theorems of Stokes, Gauß and Green in two and three dimensions. Complex Analysis: Cauchy integral theorem, power series, residue theorem Fourier series, convergence in the mean, Hilbert space L^2 and Fourier transformation
Requirements to meet	Successful participation in the exercises for “Mathematics for Physicist III”
Exam	Normally two hour written exam. The final mark of this subject will be calculated considering the best mark among the modules “mathematics for physicists II” and “Integration theory”. If this is to be applied to this module, it counts 11% of the final mark.
Prerequisites for attending	Contents of the module “Basics of Mathematics”

Module 6	**Laboratory Course I (mandatory)**
Semester	3rd (WS) and 4th (SS) semester
Person in charge	Prof. Dr. M. Donath
Components (course, duration, CP, term, time)	1. Laboratory Course in Mechanics and Electromagnetism (4 h/w, 7 CP, WS) 2. Laboratory Course in Optics, Thermal und Atomic physics (4 h/w, 6 CP, SS) *Mon, Tue or Thu: 1:00-5:00, various laboratories*
Credit points/ Work load	13 CP / 390 h (120 h laboratory course, 270 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; ability to interpret the measurements and to write a report
Contents	Selected experiments in classical mechanics, thermal physics, electromagnetism, optics, and atomic physics. Evaluation and recording of the experiments with common calculation programs and text processing programs.
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. The module grade does *not* count for the subject's overall grade.
Prerequisites for attending	Recommended: Physics I, Physics II

Module 7	**Atomic and Quantum Physics (mandatory)**
Semester	4th semester, SS
Person in charge	Dean of Studies
Components (course, duration, CP, term)	Introduction to Quantum Mechanics (lecture, 4 h/w, 4 CP, SS) *Mon: 10:30-12:00, IG1 HS2, Thu: 10:30-12:00, IG1 HS2* Atomic and Molecular Physics (lecture, 2 h/w, 2 CP, SS) *Wed: 10:30-12:00, IG1 HS2* Exercises for Atomic and Quantum Physics (2 h/w, 4 CP, SS) *Tue: 8:30-10:00, various rooms* *(alternative dates for exercises upon request)*
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	Introduction to Quantum Mechanics: Schrödinger equation; wave packets; simple potential problems; harmonic oscillator (eigenvalues and eigenfunctions); hydrogen atom (physics of angular momenta, radial equation, energy spectrum); spin (phenomena and formal description); approximation methods; indistinguishability (Bosons and Fermions) Atomic and Molecular Physics: atomic nature of matter; Stern-Gerlach experiment; 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 7% to the subject's overall grade.
Prerequisites for attending	Recommended: Physics I, Physics II, Physics III

Module 8	**Measuring technology and signal processing**
Semester	4th semester, SS
Person in charge	Prof. Dr. Fallnich, Prof. Dr. Demokritov
Components (course, duration, CP, term, time)	Foundations of Signal Processing, (lecture 4 h/w and exercises 2 h/w, 8 CP, SS) *Tue: 10:30-12:00, AP HS, Fri: 10:30-12:00, AP HS* *Exercises: Thu: 8:30-10:00, various rooms* *(alternative date for exercises upon request)*
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 analogue and digital standard methods; Analysis of data by use of computers; Comprehension of interaction between physics and engineering technologies
Contents	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.
Prerequisites for attending	None

Module 9	**Computational Physics**
Semester	4th and 5th Semester
Person in charge	Prof. Dr. Doltsinis
Components (course, duration, CP, term, time)	Introduction to Scientific Programming (lecture 2 h/w and exercises 1 h/w, SS, 5 CP), *Thu: 2:15-3:45, IG1 HS2* *Exercises: Take place at different times, alternative date upon request* and Numerical solving of Physical Problems (lecture 2 h/w and exercises 1 h/w, WS, 4 CP), *Tue: 2:15-3:45, IG1 HS2* with exercises or Computer based Experimentation (experimental exercises, WS or 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) or Project in the interdisciplinary course “Nonlinear modelling in natural sciences” (WS or SS, 4CP)
Credit points/ Work load	9 CP / 270 h (90 h in-class, 180 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 solving 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	Introduction to Scientific Programming: Introduction to operating systems and programming languages, transformation of physical problems to algorithmic form, number representations, numerical solutions to physical problems, analysis of convergence, numerical differentiation and integration Numerical solving of Physical Problems: Systems of linear equations, Eigenvalue problems, Fast-Fourier transformation, ordinary and partial differential equations, integral equations, Monte-Carlo methods Computer based Experimentation: Computer controlled data acquisition and handling using a convenient language (voice recording, music, noise etc., Fourier analysis including the window function, analogue and digital signal filters, correlation functions, practical application of the sampling theorem) Nonlinear modelling in natural sciences Basics in nonlinear dynamics, theory an modelling of complex systems, scientific programming, interdisciplinary cooperation in small groups
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	Written exam: “Introduction to scientific programming” The grade does *not* count for the subject's overall grade.
Prerequisites for attending	Recommended: Physics I, Physics II, Physics III

Module 10	**Structure of Matter (mandatory)**
Semester	5th semester or later, WS and SS
Person in charge	Dean of Studies
Components (course, duration, CP, term, time)	Physics of Condensed Matter (lecture 4 h/w, 4 CP, WS) *Wed: 10:30-12:00, IG1 HS2, Fri: 8:30-12:00, IG1 HS2* Exercises to Physics of Condensed Matter (1 h/w, 2CP, WS) *Wed: 9:15-10:00, various rooms* Nuclear and Particle Physics (lecture 3 h/w, 3 CP, WS) *Wed: 12:15-1:00, AP HS, Thu: 10:30-12:00, AP HS* Exercises to Nuclear and Particle Physics (1 h/w, 2 CP, WS) *Wed: 9:15-10:00, various rooms* Astrophysics and Cosmology (lecture 1 h/w, 1 CP, WS) *Thu: 12:15-1:00, IG1 HS2* Seminar (2 h/w, 2 CP, WS or SS) *(alternative dates for exercises upon request)*
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 and its exploration, knowledge of the used experimental and mathematic tools, ability to identify and to apply physical structures advantageously, ability to become acquainted with a physical topic and to present it orally.
Contents	Physics of Condensed Matter: structure and bonding of solids, methods of structure determination, reciprocal lattice, lattice vibrations (phonons), thermal, magnetic and optical properties of solids, electronic properties of metals and semiconductors, band structure, semiconductor interfaces, superconductivity Nuclear and Particle Physics: interaction of radiation and matter, particle detectors and particle accelerators, liquid drop and Fermi gas model, scattering and nuclear reactions, gamma and beta decay, nuclear fission, nuclear fusion, nucleosynthesis, symmetries and conservation laws, quantum numbers, static quark model, basic interactions Astrophysics and Cosmology: 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 12% to this subject's overall grade.
Prerequisites for attending	Recommended: Physics I, Physics II, Physics III, Atomic and Quantum Physics

Module 11	**Laboratory Course II (mandatory)**
Semester	5th and 6th semester, WS and SS
Person in charge	Dean of Studies
Components (course, duration, CP, term, time)	1. Exercises in the Institute of Physics (3 CP,WS SS) 2. Exercises in the Institute of Applied Physics (3 CP, WS, SS) 3. Exercises in the Institute of Nuclear Physics (3 CP, WS, SS) 4. Exercises in the Institute of Material Physics (4 CP, WS, SS) *Mon: 9:00-5:00, various laboratories*
Credit points/ Work load	13 CP/390 h (120 h in-class,270 h self-study)
Learning targets	Advanced analogue 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 Basic knowledge of electronics, optoelectronics, controlling, and information technologies Advanced knowledge of atomic and solid state physics, devices and measuring methods of atomic and solid state physics Advanced knowledge of nuclear and particle physics, nuclear-physical devices and measuring methods Advanced knowledge of functional materials, devices and measuring methods in material physics
Contents	Selected experiments to learn about measuring techniques and experimental and theoretical aspects of different sections of physics. Ability to experiment with complex measurement techniques and computer based data acquisition and to evaluate the results.
Requirements to meet	Successful completion including lab report of all required experiments
Exam	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. Counts 9% to this subject's overall grade.
Prerequisites for attending	Physics I, Physics II and Laboratory Course I Recommended: Physics III, Atomic and Quantum Physics, and Measuring technology and signal processing

Module 12	**Exam Module (elective)**
Semester	6th 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 in written and oral form.
Contents	A topic of research suggested by a supervisor in agreement with the department is dealt with. The bachelor project can be done at university or as an internship at industry.
Requirements to meet	Preparation of written thesis and final talk about the thesis lasting 30 minutes. The two examiners of the thesis have to participate in the oral presentation.
Exam	The module grade is the grade of the bachelor thesis. Counts 10% to this subject's overall grade.

Module 13	**Quantum Theory and Statistical Physics (elective)**
Semester	5th (WS) and 6th (SS) semester
Person in charge	Dean of Studies
Components (course, duration, CP, term, time)	Quantum Theory (lecture 4 h/w and exercises 2 h/w, 8 CP, WS) *Tue: 10:30-12:00, IG1 HS2, Fri: 10:30-12:00, IG1 HS2* *Exercises: Thu: 2:15-3:45, various rooms* Statistical Physics (lecture 4 h/w and exercises 2 h/w, 8 CP, SS) *Tue: 10:30-12:00, TP HS 404, Fri: 10:30-12:00, IG1 HS2* *Exercises: Thu: 2:15-3:45, various rooms* *(alternative dates for exercises upon request)*
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 Ability to find mathematical solutions to problems in quantum theory and statistical physics
Contents	Quantum Theory: 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, atoms in electric and magnetic fields, Fermi's golden rule; stationary scattering theory; second quantisation; quantised radiation field and spontaneous emission; EPR paradox, hidden variables and Bell's inequality Statistical Physics: 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 10% to this subject's overall grade.
Remark	This module is essential to start directly with the master's degree of physics.
Prerequisites for attending	Physics I, Physics II, Laboratory Course I, recommended: Physics III, Atomic and Quantum Physics

Module 14	**Scientific Instrumentation (elective)**
Semester	5th and 6th semester, WS and SS
Person in charge	Dean of Studies
Components (course, duration, CP, term)	6 module parts in four-week block courses: Electronics (2 CP, 30 h in class, 30 h self-study) Laser and Optical Measurement Techniques (3 CP, 30 h in class, 60 h self-study) Microscopy (3 CP, 30 h in class, 60 h self-study) Spectroscopy and Vacuum Technology (2 CP, 30 h in class, 30 h self-study) Radiation Technology (3 CP, 30 h in class, 60 h self-study) Techniques of Material Physics (3 CP, 30 h in class, 60 h self-study)
Credit points/ Work load	16 CP/ 480 h (180 h in-class, 300 h self-study)
Learning targets	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 Basic principles of electronic measuring and control technology through practical application of instrumentation hardware and software Imaging methods: Safe and reliable application of laser, optical and fiber-optical elements, vacuum apparatus, radiation sources and detectors.
Contents	Electronics: analysis of components of analogue and digital electronics (diode, transistor, operation amplifier, gate, flip-flops, shift register); cooperation of the components in computer-aided measuring techniques Laser and Optical Measuring Techniques: properties of laser radiation (coherence, mode structure); analysis of chosen problems of interferometry, holography and speckle measurement technology Microscopy: modern methods of microscopy: high-resolution (transmission) electron microscopy, atomic force microscopy, scanning tunnelling microscopy Spectroscopy and Vacuum Technology: modern methods of electron, laser and ion spectroscopy, introduction to pumps and pump systems; methods of vacuum measurement technology Radiation Technology: physics of ionising radiation, detectors, methods of radioactive dating, medical applications, basics of radiation protection Techniques of Material Physics: X-ray/neutron diffractometry, X-ray spectroscopy, atom probe tomography, calorimetry, thin-film deposition method, ion beam-assisted preparation techniques in electron microscopy
Requirements to meet	Successful participation in each module part
Exam	The module grade is based on the overall evaluation of the documentation of the experimental work performed in the six module parts Counts 10% to overall grade.
remark	By electing this module the bachelor certificate is issued with the amendment: “Speciality: Scientific Instrumentation”. To start with the master programme of physics the module “Quantum Theory and Statistical Physics” needs to be elected in the beginning of the masters programme. The achievements in this module can then be considered in the optional subjects of the master programme.
Prerequisites for attending	Recommended: Physics I, Physics II, Physics III, Applications of Physics

Module 15a	**Chemistry for Physicists I (Chemistry for Scientists) (elective)**
Semester	1st (WS) or 3rd (WS)
Person in charge	Dean of Studies (Chemistry), Prof. Dr. Wiemhöfer
Components (course, duration, CP, term)	- Chemistry for Scientists (lecture, 4 h/w, 90 h self-study, 5 CP, WS) - Theoretical Exercises in preparation for the Introductory Chemical Laboratory Course (2 h/w, 60 h self-study, 3 CP, WS) - Introductory Chemical Laboratory Course for Scientists (5 h/w, 75 h self-study, 5 CP, in the free period)
Credit points/ Work load	13 CP /390 h (165 h in-class, 225 h self-study)
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	Basics in organic and inorganic chemistry: Inorganic Chemistry: atomic structure, chemical bonds (covalent, metallic and ionic bonds), thermal equilibrium, acids and bases, redox reaction, characteristics of selective elements Organic Chemistry: structure of organic compounds, fundamental types of organic reactions (substitution, addition, elimination) Exercises: Topics of Lecture, Laboratory Course: Basic concepts in chemical working, different classes of substances and types of reaction, qualitative analysis (detection reactions)
Requirements to meet	Regular and active participation in exercises and laboratory, successful participation in the exam
Exam	90 minute written exam Counts 8% to overall grade.

Module 15b	**Chemistry for Physicists II (Inorganic Chemistry for Scientists) (elective)**
Semester	2nd (SS) or 4th (SS)
Person in charge	Changing according to the responsibility for the lectures
Components (course, duration, CP, term)	- Inorganic Chemistry I (lecture, 3 h/w, 75 h self-study, 4 CP, SS) - Seminars (1 h/w, 15 h self-study, 1 CP, SS)
Credit points/ Work load	5 CP /150h (60 h in-class, 90 h self-study)
Learning targets	On the basis of “Chemistry for Scientists I”, the students get a deepening overview of the chemistry of the elements, i.e. discussion of binding characteristics, relationships within the periodic table, with the emphasis on technically relevant processes.
Contents	On the basis of „Chemistry for Scientists I”: structural chemistry of the main group elements, fundamentals of chemistry of metals, typical reactions and detection reactions, technically important procedures Seminar: topics of the lecture, deepening understanding with the aid of examples
Requirements to meet	Regular and active participation in exercises and laboratory, successful participation in the exam
Exam	90 minute written exam Counts 4% to overall grade.

Module 16	**German as a Foreign Language (elective)**
Semester	1st to 3rd semester
Person in charge	Coordinator of the language centre
Components (course, duration, CP, term)	Conversation Exercises and Exercises for Listening Comprehension, level B2 (6 CP, 4 h/w, WS) Exercises for Reading Comprehension, level B2 (3 CP, 2 h/w, WS) Natural Science Terminology, level C1 (3 CP, 2 h/w, SS) Tandem Course in Natural Science Terminology (6 CP, 4 h/w, SS/WS)
Credit points/ Work load	18 CP / 540 h
Learning targets	Ability to deal with study-oriented communication situations. The oral and written expressive powers are technical language-oriented. Graduation in this modules equals a faculty of speech level DSH-2.
Contents	1. Conversations and discussions about social and study-relevant topics. 2. Treatment of everyday life-texts and specialized texts with help of reading strategies. 3. Treatment of authentic specialized texts from different areas of sciences. 4. Learning of technical language in a tandem with the aim to create a project (suitable for the subject).
Exam	Written examination in 1,2 and 3 (90 min each) and a talk and presentation to 4 (40-60 min) Counts 12% to overall grade
Prerequisites for attending	Only foreign student with a language competence in German of level DSH-1 (C-Test, at least 45 points). If this level is not reached at the entrance test, the students would take part in preparatory language courses.

Module 17	**Introduction to Business Administration (elective)**
Semester	1st to 3rd semester
Person in charge	Prof. Dr. A. Pfingsten, Prof. Dr. W. Berens
Components (course, duration, CP, term)	Business Administration I: - Introduction to Business Administration (lecture, 2 h/w, 60 h self-study, 2 CP) - Financing (lecture, 2 h/w, 60 h self-study, 3 CP) - Investment (lecture, 3 h/w, 30 h self-study, 3 CP) - Tutorial on Business Administration I (1 h/w, 15 h self-study, 1 CP) Business Administration II: - Accounting and Annual Financial Statement (lecture, 2 h/w, 60 h self-study, 3 CP) - Foundations of Accounting (lecture 3 h/w, 75 h self-study, 4 CP) - Tutorial on Foundations of Corporate Accounting (exercises, 1 h/w, 45 h self-study, 2 CP)
Credit points/ Work load	18 CP / 540 h (195 h in-class, 345 h self-study)
Learning targets	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.
Contents	Business Administration I: Overview of basic questions and methods of business administration as well as of managerial functions; special focus on investment and finance decisions including finance mathematical tools. Business Administration II: Basics in accounting
Exam	2 hour written exam in “Introduction to Business Administration" “Financing”and “Investment”, counts 50% to overall grade, 2 hour written exam in “Accounting and Annual Financial Statement” and “Foundations of Accounting”, counts 50% to overall grade.

Module 18	**Introduction to computer science (elective)**
Semester	1st and 2nd semester or later (beginning WS)
Person in charge	Prof. Dr. A. Clausing, Prof. Dr. K. Hinrichs
Components (course, duration, CP, term, time)	Computer Science I (lecture, 4 h/w, 5 CP, WS) *Mon: 2:15-3:45, Einsteinstraße 64, M1* *Thu: 2:15-3:45, Einsteinstraße 64, M1* Exercises for “Computer Science I” (2 h/w, 4 CP, WS) *Thu: 8:30-10:00, 12:30-2:00, Fri: 8:30-10:00, 12:30-2:00 or 2:15-3:45, various rooms* Computer Science II (lecture, 4 h/w, 5 CP, SS) *Mon: 8:30-10:00, Einsteinstraße 64, M1* *Thu: 8:30-10:00, Einsteinstraße 64, M1* 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 in Computer Science I Two hour written exam in Computer Science II Counts 12% to overall grade
Prerequisites for attending	None

Module 19	**Introduction to Economics (elective)**
Semester	1st to 3rd semester
Person in charge	Prof. Dr. M. Bohl, Prof. Dr. B. Kempa, Prof. Dr. U. van Suntum
Components (course, duration, CP, term)	Macroeconomics I (lecture, 4 h/w, 120 h self-study, 6 CP) Tutorial on Macroeconomics I (exercises, 2 h/w, 60 h self-study, 3 CP) Microeconomics I (lecture, 4 h/w, 120 h self-study, 6 CP) Tutorial on Microeconomics I (exercises, 2 h/w, 60 h self-study, 3 CP)
Credit points/ Work load	18 CP / 540 h (180 h in-class, 360 h self-study)
Learning targets	Basic concepts of economics; understanding and applicating essential theories and models; assessing states, trends and economic interventions; solving problems in economics independently.
Contents	Microeconomics I: The course “Microeconomics” deals with the theory of the household on the one hand (optimal household behavior, demand for goods, factor supply, insurance and uncertainty) and with the theory of the firm on the other (theory of production, least cost combination, supply of goods, factor demand). Moreover, theorems of welfare economics and incomplete markets are discussed. The aim of the exercises is to deepen the theoretical understanding acquired in the courses by providing problem sets that are solved by the students. Macroeconomics I: The fundamental macroeconomic concepts for a national economy are described and explained. The basis is the national account system. This is followed by theoretical and at empirically supported analysis of the relationships of the goods, financial and labor markets,through which the concept and structure of the business cycle is explained. On this basis, the causes and effects of important economic phenomena, such as unemployment, are examined, and the prospects and limits of economic measures are identified.
Exam	Written exams in “Macroeconomics " and “Microeconomics” (duration of each: 1 hour). Total grade of the module by arithmetic averaging.

Module 20	**Geophysics (elective)**
Semester	1st to 3rd semester
Person in charge	Prof. Dr. U. Hansen, Prof. Dr. C. Thomas
Components (course, duration, CP, term, time)	Introduction to Geophysics (lecture, 2 h/w, 2 CP, WS, 30 h self-study), *Wed: 2:15-3:45, AP HS* Exercises for Introduction to Geophysics (1 h/w, 2 CP, WS, 45 h self-study) *Tue: 1:15-2:00, Wed: 10:15-11:00 or Wed: 1:15-2:00, GEO 315* Geophysical basics I (lecture, 2 h/w, 2 CP, SS, 30 h self-study), *Thu: 12:30-2:00, AP HS* Exercises for Geophysical basics I (1 h/w, 2 CP, SS, 45 h self-study) Geophysics for Advanced Students I (lecture, 2h/w, 2 CP, WS, 60 h self-study), *Thu: 4:00-5:30, IG1 88h* Exercises for Geophysics for Advanced Students I (1 h/w, 3 CP, WS, 45 h self-study) Geophysical basics II (lecture, 2 h/w, 2 CP, WS, 30 h self-study), *Thu: 12:15-1:45, GEO 315* Exercises for Geophysical basics II (1 h/w, 3 CP, WS, 75 h self-study)
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. First steps in data analysis.
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	Successful participation in the exercises
Exam	4 hour written exam
Prerequisites for attending	None

Module 21	**Philosophy for Physicists (elective)**
Semester	1st - 3rd semester
Person in charge	Supervisors of the modules M (Metaphysics and Epistemology) and A (Applied Philosophy) of the two-subjects-bachelor in philosophy
Components (course, duration, CP, term, time)	M1: Metaphysics (lecture, 2 h/w, 3 CP, 60 h self-study, SS) M2: Epistemology (lecture, 2h/w, 3 CP, 60 h self-study, WS) W1: Philosophy of Science (lecture/seminar, 2h/w, 3 CP, 60 h self-study) W2: Philosophy of Science (seminar, 2 h/w, 5 CP, 120 h self-study) Obligation to vote: M3: Metaphysics/ Epistemology (seminar, 2 h/w, 2 CP, 30 h self-study, no exam) M4: Metaphysics/ Epistemology (seminar, 2 h/w, 2 CP, 30 h self-study, no exam) W3: Philosophy of Science (seminar, 2 h/w, 2 CP, 30 h self-study, no exam) W4: Philosophy of Science (seminar, 2 h/w, 2 CP, 30 h self-study, no exam)
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	The lectures provide an introduction to metaphysics, epistemology and philosophy of science. In the seminars students have a focus on certain main points of these subjects. The students learn about theoretical and conceptual foundations of the subjects with emphasis on the philosophy of science. The students learn to deal with philosophical problems in a sound and analytical precise way. With the aid of this, a deepened understanding of the limits and capability of our cognition and of the foundations of science shall be reached.
Requirements to meet	Regular attendance of the lectures, regular and active participation in the four seminars/tutorials
Exam	M1, M2, W1: Written exam (3x45 minutes), oral exam (3x10 minutes) OR essay (3x 5-6 pages) (choice of examiner), does not count to overall grade W2: thesis, essay OR oral exam (15 pages/15 minutes) or written exam (90 minutes) Counts 12% to overall grade.
Prerequisites for attending	None

Module 22	**Spanish for Scientists (elective)**
Semester	1st to 3rd semester
Person in charge	Coordinator of the language centre, Ms. Solsona
Components (course, duration, CP, term)	**Level A1/B1:** Spanish without Prior Knowledge 1+2, level A1 (5 CP, 4 h/w, WS/SS elective) Spanish with Prior Knowledge1+2, level A2 (5 CP, 4 h/w, WS/SS mandatory) Español para avanzados 1+2, level B1, compact course in February (5 CP, 4h/w, mandatory) **Level B1/B2:** Technical Language: science, level B1/B2 (3 CP, 2 h/w, SS, mandatory) Voces y acentos, level B1/B2 (focus: listening comprehension) (3 CP, 2h/w, WS/SS, elective) Palabras y textos, level B1/B2 (focus: reading comprehension) (3 CP, 2h/w, WS/SS, elective) Mesa redonda, level B1/B2 (oral expression) (3 CP, 2h/w, WS/SS, elective) Taller de escritura, level B1/B2 (focus: written expression) (3 CP, 2h/w, WS/SS, elective) Learning of Technical Language in a Tandem (3 CP, 2 h/w, elective) Estudiar en España (3 CP, 2 h/w, SS, elective) **Level B2/C1:** Technical Language: science, level B2/C1 (3 CP, 2 h/w, SS, mandatory) Taller de redacción (focus: written expression) (3 CP, 2h/w, WS/SS, elective) Debatir en español (focus: oral expression / listening comprehension) (3 CP, 2h/w, WS/SS, elective) Tu turno: ejercicios para la presentación oral (focus: deepening of the competence of presentation) (3 CP, 2h/w, WS/SS, elective) Learning of Technical Language in a Tandem (3 CP, 2 h/w, elective) Diversidad hispana B2/C1 (Hispanic Cultural Studies) (3 CP, 2h/w, WS/SS, elective) Competencia Intercultural B2/C1 (Intercultural Competence) (3 CP, 2h/w, WS/SS, elective)
Credit points/ Work load	18 CP / 540 h
Learning targets	Ability to deal with study-oriented communication situation. The oral and written expressive powers are technical language-oriented. Graduation in this modules equals a faculty of language of at least B1.

Contents	1. Conversations and discussions about social and basic study-relevant topics. 2. Treatment of everyday life-texts and basic specialized texts with help of reading strategies 3. Treatment of everyday life-texts and advanced specialized texts 4. Treatment of authentic specialized texts from different areas of sciences. Treatment of intercultural, specialized topics. 5. Learning of technical language in a tandem with the aim to create a project (suitable for the subject) 6. Course for Spanish conversation, level B2 7. Economic topics of the Spanish culture area 8. Training for oral and written use of language
Exam	Written examination Counts 12% to overall grade
Prerequisites for attending	Sufficient grade in the entry-level test

Module 23	**Theoretical Basics of Psychology (elective)**
Semester	1st to 3rdsemester
Person in charge	Dr. C. Dirksmeier
Components (course, duration, CP, term, time)	1. Biological Psychology (lecture, 2 h/w, 6 CP, WS) *Wed: 8:30-10:00, Fl 39* 2. General psychology and cognitive neuroscience I (lecture, 2 h/w, 4 CP, SS), *Tue: 10:15-11:45, Fl 39* 3. General psychology and cognitive neuroscience II (lecture, 2 h/w, 4 CP, WS), *Thu: 4:15-5:45, Fl 39* 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)
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, general psychology and cognitive neuroscience 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 biospychology is dedicated to basics of general neurophysiology, physiology of senses and behaviour relevant structures of the nerve system. Building up on this, the following lecture is dedicated to electrophysiologic and image-guided methods of biopsychology and the biological basics of different integrative functions of the nerve system are imparted. Contents of the lectures general psychology and cognitive neuroscience are the psychological structures and processes whichestablish 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. The selective modules refer to the basics, functions, concepts and research methods of differential psychology, development psychology and social psychology.
Exam	Participation in lecture/seminar to 4. A written exam (90 min) or oral exam (30 min) chosen by the examiner to lectures 1. - 3. The module grade is given by the weighted average of the three parts. The module grade counts 12% to the overall grade.
Prerequisites for attending	After consultation with the person in charge for this module.

Module 24	**Mathematics (elective)**
Semester	1st to 3rdsemester
Person in charge	Dean of studies and a teaching person of choice
Components (course, duration, CP, term, time)	In agreement with the person in charge for the module and the dean of the faculty of physics courses from “Bachelor of Science Mathematics” have to be chosen. These have to have a meaningful connection to the studies in physics. The courses “Analysis I”, “Analysis II” and “Linear Algebra I” as well as the accompanying exercises cannot be part of this module. If the module “Basics of Analysis” and the lecture “Linear Algebra I” as well as the “Exercises for Linear Algebra I” and the written examination for “Linear Algebra I” are already completed at the department of mathematics, it is possible to use them to replace the modules “Basics of Mathematics” (module 3) and “Integration Theory” (module 5). In this case the lecture “Linear Algebra II” and the “Exercises for Linear Algebra II” of the department of mathematics have to be part of the module 24, “Mathematics”.
Credit points/ Work load	18 CP / 540 h
Learning targets	The students get a deep insight in subjects of mathematics, which are linked to the theoretical description of physical systems. They are able to apply the learned mathematical concepts, methods and connections to the solution of theoretical problems.
Contents	After consulting the person in charge
Exam	After consulting the person in charge If two or more exams are passed, the module grade will be given by the weighted average of each part's grade. Counts 12% to overall grade.
Prerequisites for attending	None

Module 25	**Interdisciplinary Studies (elective)**
Semester	1st to 3rd 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. At least 10 CP must be achieved in an area of study different from physics. With the exception of English there is also the possibility to intensively learn a foreign language as a subject of the module. 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)
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 12% to overall grade.
Prerequisites for attending	None