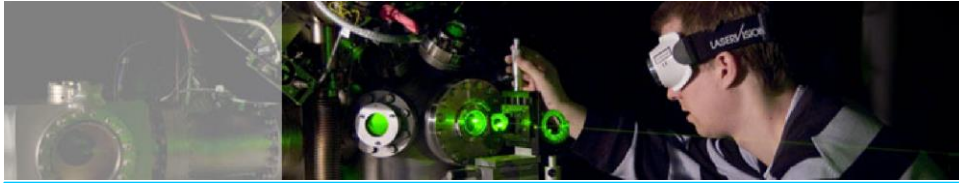




WESTFÄLISCHE  
WILHELMS-UNIVERSITÄT  
MÜNSTER

Department of  
Physics



# Course Program

## of the BSc in Physics

- Dekanat des Fachbereichs Physik -  
October 2021

## INTRODUCTION

The Westfälische Wilhelms-Universität in Münster is located in the cultural center of Westphalia in close vicinity to the Netherlands. The Treaty of Westphalia, signed in Münster in 1648, ended the Thirty Years' War. Münster's townhall therefore was awarded with the European Heritage Label. Nearly 60,000 students live in this beautiful town which 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, resulting in a lively atmosphere. The Department of Physics warmly welcomes foreign students. They are an important factor in creating an open and colorful academic and social life on campus.

We invite foreign students to participate in courses offered by members of the department. The Department of Physics consists of about 25 independent research groups that cover a broad range of specializations. All courses are open to full time, part time, and exchange students. Moreover, students studying other natural sciences, mathematics or medicine – both at the undergraduate and graduate level – are welcome to participate in them.

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 October and ending in mid-February, and a Summer Term beginning in 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. Usually, courses are given in a one or two hours time-slot. Most of them start "c.t." (Latin: cum tempore – with time), which means that they actually start at quarter past the hour. However, "s.t." (Latin: sine tempore – without time) indicates that a course will start punctual. For most of the regularly taught lectures times and rooms are given in the module descriptions below. There, the exact times are given. Note, however, that the times and rooms may be subject to change from one semester to the other and a check in the online course overview of the University for the current semester is recommended.

**Courses in the Bachelor's program are taught in German. It is therefore 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 the reports. Among the exercise classes belonging to the lectures in "Structure of Matter" and "Quantum Theory and Statistical Physics", there is always at least one given in English. Additionally, for exchange students the possibility to replace a written exam (in German) with an oral exam in English can be offered 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 and the Language Center (Sprachenzentrum).

We look forward to seeing you in Münster.

Tilman Kuhn

Dean of Studies of the Department of Physics

Münster, October 2021

## CONTACT

### Admissions Requirement and Studies

#### **Studierendensekretariat (Student Admissions Office)**

Schlossplatz 2, 48149 Münster, Germany

Admission and enrolment procedures for foreign and stateless applicants:

Monika Heitkötter Phone: +49 (0) 251 / 83-22234

Simone Olbrich Phone: +49 (0) 251 / 83-24772

Olaf Rehwinkel Phone: +49 (0) 251 / 83-22237

e-mail: [studierendensekretariat@uni-muenster.de](mailto:studierendensekretariat@uni-muenster.de)

<http://www.uni-muenster.de/studium/en/studierendensekretariat.html>

### International Office

Schlossplatz 3, 48149 Münster, Germany

e-mail: [international.office@uni-muenster.de](mailto:international.office@uni-muenster.de)

<http://www.uni-muenster.de/InternationalOffice/en/index.html>

### Advice for International Students

Verena Stenzel:

Phone: +49 (0) 251 / 83-22254

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Janna Rademacher:

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e-mail: [janna.rademacher@uni-muenster.de](mailto:janna.rademacher@uni-muenster.de)

<http://www.uni-muenster.de/studieninteressierte/en/index.shtml>

### Exchange Student Service (ESS)

Beate Pannewig-Vogt

Phone: +49 (0) 251 / 83-22113

e-mail: [admin.ess@uni-muenster.de](mailto:admin.ess@uni-muenster.de)

### Language Courses

#### **Sprachenzentrum (Language Center of the University of Münster)**

#### **Lehrgebiet Deutsch als Fremdsprache (German as a Foreign Language)**

Bahnhofstraße, 8-10

48143 Münster, Germany

Phone: +49 (0) 251/83-32108

e-mail: [ldafmail@uni-muenster.de](mailto:ldafmail@uni-muenster.de)

<https://www.uni-muenster.de/Sprachenzentrum/ldaf/>

## Accommodation

### **Studierendenwerk Münster (Student Welfare Organization)**

#### **- Wohnraumverwaltung**

Bismarckallee 5

48151 Münster, Germany

Tel.: +49 (0) 251 / 83-79553 (Monday to thursday: 8:45 – 15:00, Friday: 8:45 – 12:00)

e-mail: [wohnen@stw-muenster.de](mailto:wohnen@stw-muenster.de)

<https://www.stw-muenster.de/en/studentisches-wohnen-en/wohnanlagen/>

## Department of Physics

### **Dekanat des Fachbereichs Physik**

Wilhelm-Klemm-Straße 9

48149 Münster, Germany

Phone: +49 (0) 251 / 83-33646 or 33091

e-mail: [dekanphy@uni-muenster.de](mailto:dekanphy@uni-muenster.de)

<http://www.uni-muenster.de/Physik>

### **International Coordinator**

Prof. Dr. Alexander Kappes, Room 224 (2<sup>nd</sup> floor)

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e-mail: [alexander.kappes@uni-muenster.de](mailto:alexander.kappes@uni-muenster.de)

### **Study Coordinator**

Apl. Prof. Dr. Hartmut Bracht, Room 613b (6<sup>th</sup> floor)

Wilhelm-Klemm-Straße 10

48149 Münster, Germany

Phone: +49 (0) 251 / 83-39004

e-mail: [bracht@uni-muenster.de](mailto:bracht@uni-muenster.de)

### **Prüfungsamt der Math.-Nat. Fakultät (Examination Office)**

Münzstr. 10

48143 Münster, Germany

Andreas Arlt (responsible for the BSc in physics and geophysics)

Phone: +49 (0) 251 / 83-35007

e-mail: [andreas.arlt@uni-muenster.de](mailto:andreas.arlt@uni-muenster.de)

<https://www.uni-muenster.de/PAMathNat/>

# Descriptions of the Modules of the Degree Program

## **Physics (Bachelor of Science)**

**Department of Physics  
University of Münster**

## Recommended Study Organization

Semester	Modules			
1 (WS)	Physics I 14 CP		Fundamental Mathematics 16 CP	Interdisciplinary Studies* 18 CP
2 (SS)	Physics II 14 CP	Basic Laboratory Course 13 CP		
3 (WS)	Physics III 14 CP		Integration Theory 8 CP	
4 (SS)	Atomic and Quantum Physics 10 CP	Advanced Laboratory Course 12 CP	Computational Physics 10 CP	Measuring Technology and Signal Processing 8 CP
5 (WS)	Structure of Matter 14 CP		Bachelor Project 13 CP	Quantum Theory and Statistical Physics 16 CP
6 (SS)				

WS: Winter Semester    SS: Summer Semester

\* Choice from a list of interdisciplinary modules (see module descriptions) or personal composition of an interdisciplinary module which has a reasonable relation to the study of physics or will be suitable for the professional qualification (to be agreed on with the Dean of Studies).

## Module Descriptions

<b>Physics I: Dynamics of Particles and Particle Systems</b> (1 <sup>st</sup> semester)	8
<b>Physics II: Thermodynamics, Electromagnetism and Theoretical Mechanics</b> (2 <sup>nd</sup> semester)	9
<b>Fundamental Mathematics</b> (1 <sup>st</sup> and 2 <sup>nd</sup> semester)	10
<b>Basic Laboratory Course</b> (2 <sup>nd</sup> , 3 <sup>rd</sup> and 4 <sup>th</sup> semester)	11
<b>Physics III: Waves, Quanta and Special Relativity</b> (3 <sup>rd</sup> semester)	12
<b>Integration Theory</b> (3 <sup>rd</sup> semester)	13
<b>Atomic and Quantum Physics</b> (4 <sup>th</sup> semester)	14
<b>Measuring Technology and Signal Processing</b> (4 <sup>th</sup> semester)	15
<b>Computational Physics</b> (4 <sup>th</sup> and 5 <sup>th</sup> semester)	16
<b>Structure of Matter</b> (5 <sup>th</sup> semester)	17
<b>Advanced Laboratory Course</b> (5 <sup>th</sup> and 6 <sup>th</sup> semester)	18
<b>Quantum Theory and Statistical Physics</b> (5 <sup>th</sup> and 6 <sup>th</sup> semester)	19
<b>Bachelor Project</b> (6 <sup>th</sup> semester)	20
<b><u>Choice in “Interdisciplinary Studies”</u></b>	
<b>Interdisciplinary Studies (general)</b>	21
<b>Chemistry</b>	
<b>Introduction to Chemistry</b>	22
<b>Inorganic and Organic Chemistry</b>	23
<b>German as a Foreign Language</b>	24
<b>Introduction to Business Administration</b>	25
<b>Introduction to Computer Science</b>	26
<b>Introduction to Economics</b>	27
<b>Principles of Geophysics</b>	28
<b>Mathematics</b>	29
<b>Philosophy for Physicists</b>	30
<b>Spanish for Scientists</b>	31
<b>Theoretical Basics of Psychology</b>	33

Note that the lecture rooms and times given in the following module descriptions may be subject to change. Please check with the online course overview of the University.

<b>Module 1</b>	<b>Physics I: Dynamics of Particles and Particle Systems</b>
Semester	1 <sup>st</sup> semester, WS
Person in charge	Dean of Studies
Components (course, duration, CP, term, time)	1a) Physics I: Dynamics of Particles and Particle Systems (lecture 6 h/w, 6 CP;WS) <i>Tue 10:15-11:45; Wed 8:15-9:45; Fri 10:15-11:45; IG1 HS1</i> 1b) Exercises to Physics I (4 h/w, 8 CP, WS) <i>Mon, Thu 8:30-10:00, various rooms; alternative dates possible</i>
Credit points/Work load	14 CP / 420 h (150 h in-class, 270 h self-studies)
Learning targets	Understanding of phenomena and physical processes in nature; mathematical representation and critical reflection of physical laws. Familiarization with the basic concepts of physics: experimentation, mathematical description, numerical modelling and visualization, here applied to mechanical processes. Knowledge of relevant 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; principle of relativity; accelerating and rotating reference frames; motion in central force fields. <u>Particle Systems</u> : center 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 the exercises to "Physics I".
Exam	3 hours written exam. The module with the best grade among the two modules "Physics I" and "Physics II" counts to the overall grade of the BSc. If this is to be applied to this module, it counts 10% of the overall grade.
Prerequisites for attending	None



<b>Module 2</b>	<b>Physics II: Thermodynamics, Electromagnetism and Theoretical Mechanics</b>
Semester	2 <sup>nd</sup> semester, SS
Person in charge	Dean of Studies
Components (course, duration, CP, term, time)	<p>1a) Physics II: Thermodynamics and Electromagnetism (lecture 6 h/w, 6 CP, SS) <i>Tue 10:15-11:45; Wed 8:15-9:45; Fri 10:15-11:45; IG1 HS1</i></p> <p>1b) Exercises to Physics II (2 h/w, 4 CP, SS) <i>Mon 8:30-10:00, various rooms; alternative dates possible</i></p> <p>2a) Theoretical Complements to Physics II (lecture 2 h/w, 2 CP, SS) <i>Thu 14:15-15:45; AP HS</i></p> <p>2b) Exercises to Theoretical Complements to Physics II (1 h/w, 2 CP, SS) <i>Thu 8:30-10:00, various rooms; alternative dates possible</i></p>
Credit points/Work load	14 CP / 420 h (165 h in-class, 255 h self-studies)
Learning targets	<p>Understanding of phenomena and physical processes in nature; mathematical representation and critical reflection of physical laws.</p> <p>Familiarization with the basic concepts of physics: experimentation, mathematical description, numerical modelling and visualization, here applied to thermodynamic and electromagnetic phenomena.</p> <p>Knowledge of relevant experimental devices and measurement techniques.</p> <p>Theoretical supplement: thorough knowledge of the fundamental principles of classical mechanics, familiarization with the methods of analytical mechanics and their application to physical problems, understanding the basics of linear and nonlinear dynamical systems.</p>
Contents	<p><u>Thermodynamics</u>: 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 magnetism; 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>: analytical mechanics and dynamical 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.</p>
Requirements to meet	Successful participation in the exercises to the lectures "Physics II" and "Theoretical Supplement to Physics II".
Exam	<p>4 hours written exam.</p> <p>The module with the best grade among the two modules "Physics I" and "Physics II" counts to the overall grade of the BSc. If this is to be applied to this module, it counts 10% of the overall grade.</p>
Prerequisites for attending	Recommended: Physics I.

<b>Module 3</b>	<b>Fundamental Mathematics</b>
Semester	1 <sup>st</sup> (WS) and 2 <sup>nd</sup> (SS) semester
Person in charge	Dean of Studies (Department of Mathematics)
Components (course, duration, CP, term, time)	<p>1a) Mathematics I for Physicists (lecture, 4 h/w, 4 CP, WS) <i>Mon 10:15-11:45; Thu 10:15-11:45; IG1 HS2</i></p> <p>1b) Exercises to Mathematics I for Physicists (2 h/w, 4 CP, WS) <i>Tue 8:30-10:00, various rooms, alternative dates possible</i></p> <p>2a) Mathematics II for Physicists (lecture, 4 h/w, 4 CP, SS) <i>Mon 10:15-11:45; Thu 10:15-11:45; AP HS</i></p> <p>2b) Exercises to Mathematics II for Physicists (2 h/w, 4 CP, SS) <i>Tue 8:30-10:00, various rooms, alternative dates possible</i></p>
Credit points/ Work load	16 CP / 480 h (180 h in-class, 300 h self-studies)
Learning targets	Understanding the basic concepts of analysis and linear algebra and ability to solve related problems.
Contents	<p><u>Basics</u>: Complete induction, mathematical nomenclature.</p> <p><u>Vector Spaces</u>: dimension, subspace, linear systems of equations.</p> <p>Convergence of series and progressions, real numbers, euclidean and normed vector spaces, complex numbers, exp and log, roots, powers, trigonometric functions, unitary vector spaces.</p> <p><u>Differentiable functions of one variable</u>: mean value theorem and applications, curves, differentiable functions of several 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, normed vector spaces, topology of metric spaces, interchange of limiting processes</p> <p><u>Linear Transformations</u>: dimension formula, matrix representation, determinants, volumes, vector product, eigenvalues, normal forms</p> <p><u>Differentiable Mappings</u>: inverse theorem, implicit functions, Lagrange multipliers</p>
Requirements to meet	<p>Successful participation in the exercises to the lectures “Mathematics I for Physicists” and “Mathematics II for Physicists”.</p> <p>2 – 3 hours written test on “Mathematics I for Physicists”.</p>
Exam	<p>2 – 3 hours written exam on the subjects of “Mathematics I for Physicists”.</p> <p>The grade of the module counts 5% to the overall grade of the BSc.</p>
Prerequisites for attending	None

<b>Module 4</b>	<b>Basic Laboratory Course</b>
Semester	2 <sup>nd</sup> (SS), 3 <sup>rd</sup> (WS) and 4 <sup>th</sup> (SS) semester
Person in charge	Prof. Dr. M. Donath
Components (course, duration, CP, term, time)	<p>1a) Introduction to Experimental Work (1 h/w, 0.5 CP, SS) <i>Thu: 12:15-13:00, IG1 HS1</i></p> <p>1b) Exercises to the Introduction to Experimental Work (2 h/w, 2.5 CP, SS) <i>Wed: 10:15-11:45, IG1 HS1</i></p> <p>2a) Laboratory Course in Mechanics and Electricity (3 h/w, 4.5 CP, WS) <i>Mon, Tue or Thu: 13:00-17:00, various laboratories</i></p> <p>2b) Laboratory Course in Optics, Thermal und Atomic Physics (4 h/w, 5.5 CP, SS) <i>Mon, Tue or Thu: 13:00-17:00, various laboratories</i></p>
Credit points/ Work load	13 CP / 390 h (150 h in-class, 240 h self-studies)
Learning targets	<p>Inductive understanding of phenomena and processes in nature; basic comprehension of experimental methods in classical mechanics, thermal physics, electromagnetism, optics and atomic physics.</p> <p>Practical experience in working with experimental setups; ability to interpret the measurements and to write a report.</p>
Contents	<p>Basics of experimental work, dealing with measurement uncertainties, use of calculation and text processing programs for the evaluation of experiments and written presentation of results. Selected experiments from the fields of mechanics, electricity, optics, thermodynamics and atomic physics.</p> <p>Evaluation and documentation of the experiments.</p>
Requirements to meet	Successful completion of all module components.
Exam	<p>2<sup>nd</sup> semester: writing a report on an experiment discussed in the exercises.</p> <p>3<sup>rd</sup> and 4<sup>th</sup> semester: preparation, execution and written documentation of all experiments will be evaluated. Based on the evaluation a grade is issued in each of the two semesters.</p> <p>The better of the two grades from the 3<sup>rd</sup> and 4<sup>th</sup> semester has a weighting of 90%, the worse a weighting of 10%.</p> <p>The grade of the module counts 4% to the overall grade of the BSc.</p>
Prerequisites for attending	Recommended: Physics I.

<b>Module 5</b>	<b>Physics III: Waves, Quanta and Special Relativity</b>
Semester	3 <sup>rd</sup> semester, WS
Person in charge	Dean of Studies
Components (course, duration, CP, term, time)	<p>1a) Physics III: Waves and Quanta (lecture 6 h/w, 6 CP, WS) <i>Mon 10:15-11:45; Wed 10:15-11:45; Thu 10:15-11:45; IG1 HS1</i></p> <p>1b) Exercises to Physics III (2 h/w, 4 CP, WS) <i>Tue 8:30-10:00, various rooms; alternative dates possible</i></p> <p>2a) Theoretical Complement to Physics III (lecture 2 h/w, 2 CP, WS) <i>Thu 14:15-15:45; IG1 HS2</i></p> <p>2b) Exercises to Theoretical Complement to Physics III (1 h/w, 2 CP, WS) <i>Fri 8:30-10:00, various rooms; alternative dates possible</i></p>
Credit points/ Work load	14 CP / 420 h (165 h in-class, 255 h self-studies)
Learning targets	<p>Understanding of phenomena and physical processes in nature; mathematical representation and critical reflection of physical laws.</p> <p>Familiarization with the basic concepts of physics: experimentation, mathematical description, numerical modelling and visualization, here applied to optical and quantum mechanical wave phenomena.</p> <p>Knowledge of relevant experimental devices and measurement techniques.</p> <p>Theoretical supplement: understanding of the basic principles of special relativity, application to relativistic problems in mechanics and electrodynamics.</p>
Contents	<p><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; Michelson-Morley experiment.</p> <p><u>Optics</u>: Interaction of light with matter; polarization 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.</p> <p><u>Quanta</u>: 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.</p> <p><u>Theoretical Supplement</u>: principles of special relativity, mathematical formulation, 4-vectors, covariant formulation of mechanics and electrodynamics.</p>
Requirements to meet	Successful participation in the exercises to the lectures "Physics III" and "Theoretical Supplement to Physics III".
Exam	<p>4 hours written exam.</p> <p>The grade of the module counts 10% to the overall grade of the BSc.</p>
Prerequisites for attending	Recommended: Physics I, Physics II.

<b>Module 6</b>	<b>Integration Theory</b>
Semester	3 <sup>rd</sup> semester, WS
Person in charge	Dean of Studies (Department of Mathematics)
Components (course, duration, CP, term, time)	1a) Mathematics III for Physicists (lecture, 4 h/w, 4 CP, WS) <i>Tue 18:15-19:45; M2 (Department of Mathematics, Einsteinstr. 64)</i> <i>Fri 10:15-11:45; AP HS</i> 1b) Exercises to Mathematics III for Physicists (2 h/w, 4 CP, WS) <i>Wed 8:30-10:00, various rooms, alternative dates possible</i>
Credit points/ Work load	8 CP / 240 h (90 h in-class, 150 h self-studies)
Learning targets	Understanding the basic concepts of integration theory and ability to solve related problems.
Contents	<u>Ordinary Differential Equations</u> : Picard-Lindelöf theorem, linear differential equations, examples. <u>Measure and Integration theory</u> : transformation rule, the Lebesgue integral, convergence theorems, theorem of Fubini, Integral theorems of Stokes, Gauß and Green in two and three dimensions. <u>Complex Analysis</u> : Cauchy integral theorem, power series, residue theorem, <u>Fourier series</u> : convergence in the mean. <u>Hilbert space</u> : $L^2$ and Fourier transformation.
Requirements to meet	Successful participation in the exercises to the lecture “Mathematics for Physicist III”.
Exam	2 – 3 hours written exam on the subjects of “Mathematics for Physicists III”. The grade of the module counts 5% to the overall grade of the BSc.
Prerequisites for attending	Recommended: Fundamental Mathematics.

<b>Module 7</b>	<b>Atomic and Quantum Physics</b>
Semester	4 <sup>th</sup> semester, SS
Person in charge	Dean of Studies
Components (course, duration, CP, term)	1a) Atomic and Quantum Physics (lecture, 6 h/w, 6 CP, SS) <i>Mon 10:15-11:45; Wed 10:15-11:45; Thu 10:15-11:45; IG1 HS2</i> 1b) Exercises to Atomic and Quantum Physics (2 h/w, 4 CP, SS) <i>Tue 8:30-10:00, various rooms; alternative dates possible</i>
Credit points/ Work load	10 CP / 300 h (120 h in-class, 180 h self-studies)
Learning targets	Basic understanding of quantum mechanics and atomic physics; Ability to mathematically solve problems in quantum mechanics and atomic physics; Advanced knowledge of the quantum nature of matter.
Contents	<u>Introduction to Quantum Mechanics</u> : (corresponding to 4 h/w) 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); indistinguishability (Bosons and Fermions) <u>Atomic and Molecular Physics</u> : (corresponding to 2 h/w) atomic nature of matter; Stern-Gerlach experiment; experimental methods in 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 to “Atomic and Quantum Physics”.
Exam	3 hours written exam. The grade of the module counts 7% to the overall grade of the BSc.
Prerequisites for attending	Recommended: Physics I, Physics II, Physics III.

<b>Module 8</b>	<b>Measuring Technology and Signal Processing</b>
Semester	4 <sup>th</sup> semester, SS
Person in charge	Prof. Dr. Fallnich, Prof. Dr. Demokritov
Components (course, duration, CP, term, time)	1a) Fundamentals of Signal Processing (lecture, 4 h/w, 4 CP, SS) <i>Tue 10:15-11:45, Fri: 10:15-11:45; AP HS</i> 1b) Exercises to Fundamentals of Signal Processing (2 h/w, 4 CP, SS) <i>Thu: 8:30-10:00, various rooms, alternative dates possible</i>
Credit points/ Work load	8 CP / 240 h (90 h in-class, 150 h self-studies)
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 the interplay between physics and 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; physical basis of information technology, life science, energy production and environmental studies.
Requirements to meet	Successful participation in the exercises.
Exam	30 – 45 minutes oral exam. The grade of the module counts 6% to the overall grade of the BSc.
Prerequisites for attending	None

<b>Module 9</b>	<b>Computational Physics</b>
Semester	4 <sup>th</sup> (SS) and 5 <sup>th</sup> (WS) semester
Person in charge	Dean of Studies
Components (course, duration, term, time)	<p>1) Introduction to Scientific Programming (elective, lecture 1 h/w, 1.5 CP, exercises 2 h/w, 3.5 CP, SS) <i>Lecture: Thu: 14:15-15:45; IG1 HS2; Exercises: different times</i></p> <p>2) Numerical Solution of Physical Problems (elective, lecture 1 h/w, 1.5 CP, exercises 2 h/w, 3.5 CP, WS) <i>Lecture: Tue: 14:15-15:45; IG1 HS2; Exercises: different times</i></p> <p>3) Computer-Based Experiments (elective, experimental exercises, 5 LP, WS or SS)</p> <p>4) Project on Simulation of Physical Problems (elective, 5 LP, WS or SS)</p> <p>5) Course offered by the ZIV (Center for IT-Infrastructure) equivalent to 5 CP (elective, WS or SS). The course has to be related to the study of physics (to be agreed on with the person in charge of this module)</p> <p>Two courses must be selected. It is mandatory to select at least one of the courses "Introduction to Scientific Programming" and "Numerical Solution of Physical Problems".</p>
Credit points/Work load	10 CP / 300 h
Learning targets	<p>Introduction to Scientific Programming: use of computers to solve physical problems, algorithmic formulation of problems, understanding the possibilities and limits of numerical simulations.</p> <p>Numerical Solution of Physical Problems: learning of basic algorithms to solve problems in different parts of physics.</p> <p>Computer based Experimentation: Use of computers to control experiments and to obtain and handle measured data.</p>
Contents	<p><u>Introduction to Scientific Programming</u>: Introduction to operating systems and programming languages, transformation of physical problems to algorithmic form, number representations, numerical solutions of physical problems, analysis of convergence, numerical differentiation and integration.</p> <p><u>Numerical Solution of Physical Problems</u>: Systems of linear equations, eigenvalue problems, Fast-Fourier transformation, ordinary and partial differential equations, integral equations, Monte-Carlo methods.</p> <p><u>Computer Based Experimentation</u>: 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).</p> <p><u>Project on Simulation of Physical Problems</u>: Theory and modelling of complex systems, scientific programming, interdisciplinary cooperation in small groups.</p>
Requirements to meet	<p>Successful participation in the exercises to "Introduction to scientific programming" or "Numerical Solution of Physical Problems".</p> <p>Successful participation in the exercises or practical course to the second chosen elective part.</p>
Exam	<p>2 hours written exam on "Introduction to scientific programming" or "Numerical Solution of Physical Problems".</p> <p>The grade of the module counts 4% to the overall grade of the BSc.</p>
Prerequisites for attending	Recommended: Physics I, Physics II, Physics III.



<b>Module 10</b>	<b>Structure of Matter</b>
Semester	5 <sup>th</sup> semester, WS
Person in charge	Dean of Studies
Components (course, duration, CP, term, time)	<p>1a) Condensed Matter Physics (lecture, 4 h/w, 4 CP, WS) <i>Wed 10:15-11:45, Fri 8:30-10:00; IG1 HS2</i></p> <p>1b) Exercises to Condensed Matter Physics (1 h/w, 2 CP, WS) <i>Wed 8:30-10:00 biweekly, various rooms, alternative dates possible</i></p> <p>2a) Nuclear and Particle Physics (lecture, 3 h/w, 3 CP, WS) <i>Wed 12:15-13:00, Thu 10:15-11:45; AP HS</i></p> <p>2b) Exercises to Nuclear and Particle Physics (1 h/w, 2 CP, WS) <i>Wed 8:30-10:00 biweekly, various rooms, alternative dates possible</i></p> <p>3) Astrophysics and Cosmology (lecture 1 h/w, 1 CP, WS) <i>Thu 12:15-13:00; IG1 HS2</i></p> <p>4) Seminar on the Structure of Matter (2 h/w, 2 CP, WS or SS) <i>(choice among various seminars at different times and places)</i></p>
Credit points/ Work load	14 CP / 420 h (180 h in-class, 240 h self-studies)
Learning targets	<p>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 concepts like symmetry,</p> <p>Seminar: ability to become acquainted with a physical topic and to present it orally.</p>
Contents	<p><u>Physics of Condensed Matter</u>: 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.</p> <p><u>Nuclear and Particle Physics</u>: 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, fundamental interactions.</p> <p><u>Astrophysics and Cosmology</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.</p>
Requirements to meet	<p>Successful participation in the exercises to “Physics of Condensed Matter”.</p> <p>Successful participation in the exercises to “Nuclear and Particle Physics”.</p> <p>Successful participation (including talk/presentation) in the seminar.</p>
Exam	<p>30 – 45 minutes oral exam.</p> <p>The grade of the module counts 10% to the overall grade of the BSc.</p>
Prerequisites for attending	Recommended: Physics I, Physics II, Physics III, Atomic and Quantum Physics.

<b>Module 11</b>	<b>Advanced Laboratory Course</b>
Semester	5 <sup>th</sup> (WS) and 6 <sup>th</sup> (SS) semester
Person in charge	Dean of Studies
Components (course, duration, CP, term, time)	<p>1) Advanced Laboratory Course in the Institute of Applied Physics (3 CP, WS, SS)</p> <p>2) Advanced Laboratory Course in the Institute of Nuclear Physics (3 CP, WS, SS)</p> <p>3) Advanced Laboratory Course in the Institute of Materials Physics (3 CP, WS, SS)</p> <p>4) Advanced Laboratory Course in the Physical Institute (3 CP, WS, SS) <i>Mon 9:00-17:00, various laboratories</i></p>
Credit points/ Work load	12 CP/360 h (120 h in-class, 240 h self-studies)
Learning targets	<p>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.</p> <p>Basic knowledge of electronics, optoelectronics, controlling, and information technologies.</p> <p>Advanced knowledge of nuclear and particle physics, nuclear-physical devices and measuring methods.</p> <p>Advanced knowledge of functional materials, devices and measuring methods in materials physics.</p> <p>Advanced knowledge of atomic and solid state physics, devices and measuring methods of atomic and solid state physics.</p>
Contents	<p>Selected experiments to learn about measuring techniques and experimental and theoretical aspects of different sections of physics.</p> <p>Ability to experiment with complex measurement techniques and computer based data acquisition and to evaluate the results.</p>
Requirements to meet	Successful completion including lab report of all required experiments
Exam	<p>Preparation, execution and written reports of all experiments will be evaluated. Based on the evaluation a final grade is issued in each of the four parts of the module. The average of the individual grades of the parts yields the overall grade for the module.</p> <p>The grade of the module counts 9% to the overall grade of the BSc.</p>
Prerequisites for attending	<p>Required: Physics I, Physics II and Basic Laboratory Course</p> <p>Recommended: Physics III, Atomic and Quantum Physics, Measuring technology and signal processing.</p>

<b>Module 12</b>	<b>Quantum Theory and Statistical Physics</b>
Semester	5 <sup>th</sup> (WS) and 6 <sup>th</sup> (SS) semester
Person in charge	Dean of Studies
Components (course, duration, CP, term, time)	<p>1a) Quantum Theory (lecture, 4 h/w, 4 CP, WS) <i>Tue 10:15-11:45; Fri 10:15-11:45; IG1, HS2</i></p> <p>1b) Exercises to Quantum Theory (2 h/w, 4 CP, WS) <i>Thu 14:15-15:45, various rooms; alternative dates possible</i></p> <p>2a) Statistical Physics (lecture, 4 h/w, 4 CP, SS) <i>Tue 10:15-11:45; Fri 10:15-11:45; IG1, HS2</i></p> <p>2b) Exercises to Statistical Physics (2 h/w, 4 CP, SS) <i>Thu 14:15-15:45, various rooms; alternative dates possible</i></p>
Credit points/ Work load	16 CP / 480 h (180 h in-class, 300 h self-studies)
Learning targets	<p>Advanced understanding of quantum theory and statistical physics to describe systems on the basis of their fundamental microscopic properties.</p> <p>Advanced knowledge of the mathematical structure of quantum theory and the statistical approach to many-particle systems.</p> <p>Ability to find mathematical solutions to problems in quantum theory and statistical physics.</p>
Contents	<p><u>Quantum Theory</u>: mathematical framework of quantum theory; symmetries and conservation laws; postulates and measurement process; addition of angular momenta 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 quantization; quantized radiation field and spontaneous emission; EPR paradox, hidden variables and Bell's inequality.</p> <p><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.</p>
Requirements to meet	<p>Successful participation in the exercises to "Quantum Theory".</p> <p>Successful participation in the exercises to "Statistical Physics".</p> <p>3 hours written test on the subject of "Quantum Theory".</p>
Exam	<p>30 – 45 minutes oral exam.</p> <p>The grade of the module counts 10% to the overall grade of the BSc.</p>
Prerequisites for attending	Recommended: Physics I, Physics II, Physics III, Basic Laboratory Course, Atomic and Quantum Physics.

<b>Module 13</b>	<b>Bachelor Project</b>
Semester	6 <sup>th</sup> semester, SS
Person in charge	Supervisor of Bachelor's thesis
Components (course, duration, CP, term)	1) Bachelor's Thesis Independent work on the subject of the bachelor's thesis (11 CP). Preparation and presentation of the results in a final talk (2 CP).
Credit points/ Work load	13 CP / 390 h (in-class and self-studies)
Learning targets	The student demonstrates the ability to deal with a current problem of experimental or theoretical physics using scientific methods within the given timeline, to perform thorough literature research on the given topic and to present the results appropriately in written and oral form.
Contents	A research topic suggested by an authorized supervisor of the Department of Physics is dealt with. Upon agreement with an authorized supervisor, the thesis project can be also done as an internship in industry.
Requirements to meet	Preparation of the thesis and final talk on the subject of the thesis (duration 30 minutes). The thesis is evaluated and graded by the supervisor and a co-supervisor. The two examiners of the thesis have to participate in the oral presentation.
Exam	The module grade is the grade of the bachelor's thesis. The grade of the module counts 10% to the overall grade of the BSc.
Prerequisites for attending	To start working for the Bachelor's thesis the successful completion of 90 CP is required.

<b>Module 14</b>	<b>Interdisciplinary Studies</b> (elective module, general description)
Semester	1 <sup>st</sup> to 3 <sup>rd</sup> semester
Person in charge	Chosen by the student, to be agreed on with the Dean of Studies.
Components (course, duration, CP, term)	Upon agreement with a person in charge for the module (chosen by the student) and the Dean of Studies of the Department of Physics. At least 10 CP must be achieved in courses from a Department other than the Department of Physics. With the exception of English there is also the possibility to intensively learn a foreign language as a subject of the module. The components, study and exam achievements have to be specified in a module description, which has to be signed by the person in charge for the module and the Dean of Studies of the Department of Physics.
Credit points/ Work load	18 CP / 540 h
Conditions	To be agreed on with the person in charge.
Learning targets	To be agreed on with the person in charge.
Contents	To be agreed on with the person in charge.
Study/Exam achievements	To be agreed on with the person in charge. At least one study achievements must be completed. At least one exam. If two or more exams are passed, the grade of the module will be given by the average of each part's grade. The grade of the module counts 10% to the overall grade of the BSc.
Prerequisites for attending	None

<b>Module 15a</b>	<b>Interdisciplinary Studies: Introduction to Chemistry</b> (elective module)
Semester	1 <sup>st</sup> (WS) semester
Person in charge	Prof. Dr. Strassert
Components (course, duration, CP, term)	1) Introduction to Chemistry (lecture, 4 h/w, 4 CP, WS) 2) Introduction to Chemistry (Theoretical Exercises, 2 h/w, 2 CP, WS) 3) Introduction to Chemistry (Laboratory course, 5 h/w, 4 CP, in the lecture-free period)
Credit points/ Work load	10 CP / 300 h (165 h in-class, 135 h self-study)
Learning targets	Fundamental terminology 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 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 chemistry laboratories, knowledge and competences to obtain chemical data and information. Ability to work autonomously on related chemical problems.
Contents	<u>Lecture and Exercises:</u> Basics in inorganic and organic chemistry. Inorganic Chemistry: atomic structure, chemical bonds (covalent, metallic and ionic bonds), thermal equilibrium, acids and bases, redox reactions, characteristics of selective elements. Organic Chemistry: structure of organic compounds, fundamental types of organic reactions (substitution, addition, elimination). <u>Laboratory Course:</u> Basic rules of working in a chemistry lab, different classes of substances and types of reactions, qualitative analysis (detection reactions).
Requirements to meet	Regular and active participation in exercises and laboratory, Written test on "Chemistry for Scientists"
Exam	90 minutes written exam. The module grade contributes with the weight 10/18 to the grade of the Interdisciplinary Studies. The grade of the Interdisciplinary Studies counts 10% to the overall grade of the BSc.

<b>Module 15b</b>	<b>Interdisciplinary Studies: Inorganic and Organic Chemistry</b> (elective module)
Semester	2 <sup>nd</sup> (SS) semester
Person in charge	Changing according to the responsibility for the lectures
Components (course, duration, term)	1) Main Group Chemistry (lecture 3 h/w, 3.5 CP, SS) 2) Main Group Chemistry (seminar 1 h/w, 1 CP, SS) 3) Organic Chemistry I (lecture 3 h/w, 2.5 CP, SS) 4) Organic Chemistry I (exercises 1 h/w, 1 CP, SS)
Credit points/ Work load	8 CP / 240h (135 h in-class, 105 h self-studies)
Learning targets	<u>Main Group Chemistry</u> : On the basis of "Introduction to Chemistry", the students get an advanced overview of the chemistry of the elements, i.e. discussion of binding characteristics, relationships within the periodic table, with an emphasis on technologically relevant processes. <u>Organic Chemistry I</u> : The students will be able to classify the types of organic chemical substances. They are familiar with the physical properties of organic chemical substances and know the typical reactions of the most important representatives of organic chemical substances. They identify functional groups, name them, describe them verbally and in formula language and can derive the resulting reactivity.
Contents	<u>Main Group Chemistry</u> : structural chemistry of the main group elements, fundamentals of chemistry of metals, typical reactions and detection reactions, technically important procedures. <u>Organic Chemistry I</u> : (Lewis dot) Formula notation, characteristics, physical properties, nomenclature, reactivity, basic reaction types, functional binding models, and hybridization. Material characteristics are clarified using selected demonstration experiments. Brief introductions to the apparatus methods of organic chemistry are given.
Requirements to meet	Successful participation in the exercises.
Exam	90 minutes written exam. The module grade contributes with the weight 8/18 to the grade of the Interdisciplinary Studies. The grade of the Interdisciplinary Studies counts 10% to the overall grade of the BSc.
Prerequisites for attending	Successful completion of the module Introduction to Chemistry.

<b>Module 16</b>	<b>Interdisciplinary Studies: German as a Foreign Language</b> (elective module)
Semester	1 <sup>st</sup> to 3 <sup>rd</sup> semester
Person in charge	Coordinator "German as a Foreign Language" of the language center
Components (language level, course, duration)	<p>Mandatory courses:</p> <p>1) Level B2 – Intermediate level 2: German Conversation and Listening Comprehension (4 h/w, 6 CP)</p> <p>2) Level C1 – Advanced level: German Conversation and Listening Comprehension (4 h/w, 6 CP)</p> <p>Elective courses (Two courses must be taken):</p> <p>3) Level B2 – Intermediate level 2 or level C1 – advanced level: German for Specific Purposes: Natural Science, Medicine and Pharmacy (Emphasis: Writing Skills) (2 h/w, 3 CP)</p> <p>4) Level B2 – Intermediate level 2 or level C1 – advanced level: German for Specific Purposes: Natural Science, Medicine and Pharmacy (Emphasis: Reading Skills) (2 h/w, 3 CP)</p> <p>5) Level B2 – Intermediate level 2: Listening Comprehension Self- study Module (2 h/w, 3 CP)</p> <p>6) Level B2 – Intermediate level 2: Communicative Grammar (2 h/w, 3 CP)</p>
Credit points/ Work load	18 CP / 540 h
Learning targets	Ability to deal with study-oriented communication situations. The oral and written skills include a science and technically oriented language. The successful completion of this modules corresponds to a language level of at least B2.
Contents	Depending on the individual composition of the module.
Requirements to meet	Regular attendance in the courses, because language competence is transferred through mutual communication. Successful completion of homework.
Exam	<p>There will be an examination in each of the courses. Examinations can take place in form of an oral or written exam, in form of a homework or an oral presentation. The two mandatory courses have a weighting of 1/3 each and the two elective courses have a weighting of 1/6 each.</p> <p>The grade of the module counts 10% to the overall grade of the BSc.</p>
Prerequisites for attending	Only for foreign student with a language competence in German of level DSH-1 (C-Test, at least 46 points). If this level is not reached at the entrance test, the students have to take part in preparatory language courses.



<b>Module 17</b>	<b>Interdisciplinary Studies: Introduction to Business Administration</b> (elective module)
Semester	1 <sup>st</sup> to 3 <sup>rd</sup> semester
Person in charge	Prof. Dr. A. Pfingsten, Prof. Dr. W. Kajüter
Components (course, duration)	1) Introduction to Business Administration (lecture, 2 h/w, 2 CP) 2) Finance (lecture, 2 h/w, 2.5 CP) 3) Investment (lecture, 2 h/w, 2.5 CP) 4) Tutorial on Business Administration I (2 h/w, 2 CP) 5) Accounting and Annual Financial Statements (lecture, 2 h/w, 3 CP) 6) Foundations of Corporate Accounting (lecture 3 h/w, 4 CP) 7) Tutorial on Foundations of Corporate Accounting (exercises, 2 h/w, 2 CP)
Credit points/ Work load	18 CP / 540 h (225 h in-class, 315 h self-studies)
Learning targets	Understanding and application of fundamental economic terms, assigning problems to proper context, development of simple means of problem solving, solving problems in investment and finance.
Contents	<u>Business Administration I (components 1 – 4):</u> Overview of basic subjects and methods of business administration as well as of functional divisions of companies; special focus on investment and finance decisions including finance mathematical tools. <u>Business Administration II (components 5 – 7):</u> Basics in accounting.
Exam	2 hours written exam on the subjects of “Introduction to Business Administration”, “Financing” and “Investment”. (Weighting: 50%) 1.5 hours electronic exam on the subjects of “Accounting and Annual Financial Statements”. (Weighting: 16.67%) 2 hours written exam on the subjects of “Foundations of Corporate Accounting”. (Weighting: 33.33%) The grade of the module counts 10% to the overall grade of the BSc.

<b>Module 18</b>	<b>Interdisciplinary Studies: Introduction to Computer Science</b> (elective module)
Semester	1 <sup>st</sup> and 2 <sup>nd</sup> semester or later (beginning WS)
Person in charge	Prof. Dr. Markus Müller-Olm, Prof. Dr. Jan Vahrenhold
Components (course, duration, CP, term, time)	1) Introduction to Computer Science (lecture, 4 h/w, 5 CP, WS) 2) Exercises to Introduction to Computer Science (2 h/w, 4 CP, WS) 3) Algorithms and Data Structures (lecture, 4 h/w, 5 CP, SS) 4) Exercises to Algorithms and Data Structures (2 h/w, 4 CP, SS)
Credit points/ Work load	18 CP / 540 h (180 h in-class, 360 h self-studies)
Learning targets	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 methods.
Requirements to meet	Successful participation in the Exercises to Introduction to Computer Science and Exercises to Algorithms and Data Structures.
Exam	2 hours written exam in Introduction to Computer Science. 2 hours written exam in Algorithms and Data Structures. Each of the two exams counts 50% to the overall grade of the module. The grade of the module counts 10% to the overall grade of the BSc.
Prerequisites for attending	None

<b>Module 19</b>	<b>Interdisciplinary Studies: Introduction to Economics</b> (elective module)
Semester	1 <sup>st</sup> to 3 <sup>rd</sup> semester
Person in charge	Prof. Dr. Kempa / Prof. Dr. Bohl / Prof. Dr. Löschel
Components (course, duration, CP, term)	1) Microeconomics (lecture, 4 h/w, 6 CP) 2) Exercises in Microeconomics (exercises, 2 h/w, 3 CP) 3) Macroeconomics (lecture, 4 h/w, 6 CP) 4) Tutorial on Macroeconomics (exercises, 2 h/w, 3 CP)
Credit points/ Work load	18 CP / 540 h (180 h in-class, 360 h self-studies)
Learning targets	Basic concepts of economics; understanding and applying essential theories and models; assessing states, trends and economic interventions. Independently solving problems in economics.
Contents	<u>Microeconomics</u> : 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 hand (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 course by providing problem sets that are solved by the students. <u>Macroeconomics</u> : The fundamental macroeconomic concepts for a national economy are described and explained. The basis is the national account system. This is followed by a theoretical and an 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	2 hour written exam in "Microeconomics". 2 hour written exam in "Macroeconomics". Each of the two exams counts 50% to the overall grade of the module. The grade of the module counts 10% to the overall grade of the BSc.

<b>Module 20</b>	<b>Interdisciplinary Studies: Principles of Geophysics</b> (elective module)
Semester	1 <sup>st</sup> to 3 <sup>rd</sup> semester
Person in charge	Prof. Dr. Michael Becken
Components (course, duration, term)	1a) Introduction to General Geophysics (lecture, 2 h/w, 2 CP, WS) 1b) Introduction to General Geophysics (Practical) (1 h/w, 2 CPWS) 2) The Earth (lecture, 4 h/w, 2 CP, SS), 3) Introduction to Applied Geophysics (integrated course, 3 h/w, 4 CP, SS) 4a) Introduction to Geophysical Data Processing (lecture, 2h/w, 2 CP, WS) 4b) Introduction to Geophysical Data Processing (practical) (1 h/w, 2CP,WS) 5a) Applied Geophysics I (lecture, 2 h/w, 2 CP, WS) 5b) Applied Geophysics I (Practical) (1 h/w, 2 CP, WS)
Credit points/ Work load	18 CP / 540 h (240 h in-class, 300 h self-study)
Learning targets	Overview of the geophysical approach and the most important methods including simple practical demonstrations and exercises. First steps in data analysis.
Contents	Important components of the system Earth, development, present properties, and relevant 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. Successful participation in four geophysical terrain surveys.
Exam	2 hours written exam in "Introduction to General Geophysics". 2 hours written exam in "Introduction to Geophysical Data Processing". 1.5 hours written exam in "Applied Geophysics I". Each exam has a weighting of 1/3. The grade of the module counts 10% to the overall grade of the BSc.
Prerequisites for attending	None

<b>Module 21</b>	<b>Interdisciplinary Studies: Mathematics</b> (elective module)
Semester	1 <sup>st</sup> to 3 <sup>rd</sup> semester
Person in charge	Dean of Studies and a teaching person of choice
Components (course, duration, CP, term, time)	<p>Upon agreement with the person in charge for the module (chosen by the student) and the Dean of Studies of the Department of Physics courses from the “Bachelor of Science in Mathematics” have to be chosen. These have to have a meaningful connection to the studies in physics.</p> <p>The courses “Analysis I”, “Analysis II” and “Linear Algebra I” as well as the accompanying exercises cannot be part of this module.</p> <p>If the module “Basics of Analysis” and the lecture “Linear Algebra I” as well as the “Exercises to 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 “Fundamental Mathematics” (module 3) and “Integration Theory” (module 5). In this case the lecture “Linear Algebra II” and the “Exercises to Linear Algebra II” of the department of mathematics have to be part of the module 21, “Mathematics”.</p>
Credit points/ Work load	18 CP / 540 h
Learning targets	The students get a deep insight in subjects of mathematics, 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	To be agreed on with the person in charge.
Exam	<p>To be agreed on with the person in charge.</p> <p>If two or more exams are passed, the grade of the module will be given by the average of each part's grade weighted according to the respective CPs.</p> <p>The grade of the module counts 10% to the overall grade of the BSc..</p>
Prerequisites for attending	None

<b>Module 22</b>	<b>Interdisciplinary Studies: Philosophy for Physicists</b> (elective module)
Semester	1 <sup>st</sup> - 3 <sup>rd</sup> semester
Person in charge	Supervisors of the modules M (Metaphysics and Epistemology) and A (Applied Philosophy) of the Bachelor's program in philosophy
Components (course, duration, CP, term, time)	<p>1) Metaphysics (lecture, 2 h/w, 2 CP, SS)  2) Epistemology (lecture, 2 h/w, 2 CP, WS)  3) Philosophy of Science (lecture/seminar, 2 h/w, 2 CP)  4) Seminar on Philosophy of Science (2 h/w, 8 CP)</p> <p><u>Choice of two of the following seminars:</u></p> <p>5) Seminar on Metaphysics/ Epistemology (2 h/w, 2 CP, no exam)  6) Seminar on Metaphysics/ Epistemology (2 h/w, 2 CP, no exam)  7) Philosophy of Science (2 h/w, 2 CP, no exam)  8) Philosophy of Science (2 h/w, 2 CP, no exam)</p>
Credit points/ Work load	18 CP / 540 h (180 h in-class, 360 h self-studies)
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 analyse 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 analytically 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	Written test of 45 minutes OR 10 minutes oral exam OR essay of 5-6 pages in each of the three components 1 – 3. The type will be determined by the examiner. Successful participation in the two seminars (components 5 – 8).
Exam	Thesis, essay (15 pages) OR oral exam (30 minutes) related to the seminar on Philosophy of Science (component 4). The type of the exam will be determined by the examiner. The grade of the module counts 10% to the overall grade of the BSc.
Prerequisites for attending	None

<b>Module 23</b>	<b>Interdisciplinary Studies: Spanish for Scientists</b> (elective module)
Semester	1 <sup>st</sup> to 3 <sup>rd</sup> semester
Person in charge	Coordinator of the language center
Components (course, duration, CP, term)	<p>1) Spanish for Natural Sciences Technical and Scientific Language: from level B1 (2 h/w, 3 CP, SS, mandatory)</p> <p>Depending on the prior knowledge choice of courses among the following list with a total of 15 CP.</p> <p><b>Level A1/B1:</b></p> <p>2) Spanish for Absolute Beginners, level A1 (4 h/w, 5 CP, WS/SS)</p> <p>3) Intermediate Spanish, level A2 (4 h/w, 5 CP, WS/SS)</p> <p>4) Advanced Spanish /Español para avanzados), level B1, compact course in February (4 h/w, 5 CP)</p> <p><b>Level B1/B2:</b></p> <p>5) Spanish Listening Skills (Voces y acentos) (2 h/w, 3 CP, WS/SS)</p> <p>6) Words and Texts (Palabras y textos)(2 h/w, 3 CP, WS/SS)</p> <p>7) Spanish Discussion Skills (Mesa redonda)(2 h/w, 3 CP, WS/SS)</p> <p>8) Spanish Writing Workshop (2 h/w, 3 CP, WS/SS)</p> <p>9) Language Learning in Tandem (2 h/w, 3 CP)</p> <p>10) Language Learning and Project Work in Tandem (4 h/w, 5 CP)</p> <p>11) Studying in Spain and Latin America - Preparatory Course for Exchange Students (2 h/w, 3 CP, SS)</p> <p><b>Level B2/C1:</b></p> <p>12) Spanish Academic Writing (2 h/w, 3 CP, WS/SS)</p> <p>13) Debating in Spanish (Debatir en español)(2 h/w, 3 CP, WS/SS)</p> <p>14) Spanish Presentation Skills (Ejercicios para la presentación oral) (2 h/w, 3 CP, WS/SS)</p> <p>15) Language Learning in Tandem (2 h/w, 3 CP)</p> <p>16) Language Learning and Project Work in Tandem (4 h/w, 5 CP)</p> <p>17) Hispanic Cultural Studies(Diversidad hispanica)(2 h/w, 3 CP, WS/SS)</p> <p>18) Intercultural Competence (Competencia Intercultural)(2 h/w, 3 CP, WS/SS)</p>
Credit points/ Work load	18 CP / 540 h
Learning targets	Ability to deal with study-oriented communication situations. The oral and written skills include a science and technically oriented language. The successful completion of this modules corresponds to a language level of at least B1.
Contents	<ol style="list-style-type: none"> <li>1. Conversations and discussions on social and basic study-related topics.</li> <li>2. Reading of everyday-life texts and basic science-related texts with help of reading strategies.</li> <li>3. Reading of everyday-life texts and advanced science-related texts.</li> <li>4. Reading and discussion of authentic science-related texts from different areas of sciences. Treatment of intercultural, specialized topics.</li> <li>5. Learning of technical language in a tandem with the aim to create a</li> </ol>

	<p>project (suitable for the subject).</p> <ol style="list-style-type: none"> <li>6. Course for Spanish conversation, level B2.</li> <li>7. Economic topics of the Spanish culture area.</li> <li>8. Training for oral and written use of language.</li> </ol>
Exam	<p>Different types of exam depending on the course.</p> <p>The grade of the module counts 10% to the overall grade of the BSc.</p>
Prerequisites for attending	<p>Sufficient grade in the entry-level test.</p>



<b>Module 24</b>	<b>Interdisciplinary Studies: Theoretical Basics of Psychology</b> (elective module)
Semester	1 <sup>st</sup> to 3 <sup>rd</sup> semester
Person in charge	Dr. C. Dirksmeier
Components (course, duration, CP, term, time)	<p>1) Biological Psychology (lecture, 2 h/w, 6 CP, WS)</p> <p>2) General Psychology and Cognitive Science I (lecture, 2 h/w, 4 CP, SS)</p> <p>3) General Psychology and Cognitive Science II (lecture, 2 h/w, 4 CP, WS)</p> <p>Choice of one lecture from the following parts of psychology:</p> <p>4) Differential and Personality Psychology (lecture 2 h/w, 4 CP, WS or SS)</p> <p>5) Developmental Psychology (lecture 2 h/w, 4 CP, WS or SS)</p> <p>6) Social Psychology (lecture 2 h/w, 4 CP, WS or SS)</p>
Credit points/ Work load	18 CP / 540 h
Learning targets	<p>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.</p> <p>Furthermore they obtain basic knowledge of methodical and theoretical concepts in one of the following parts: differential psychology, development psychology or social psychology.</p>
Contents	<p>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 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.</p> <p>Contents of the lectures general psychology and cognitive neuroscience are the psychological structures and processes which establish 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.</p> <p>The elective parts refer to the basics, functions, concepts and research methods of differential psychology, development psychology and social psychology.</p>
Exam	<p>90 minutes written exam or 30 minutes oral exam on each of the three lectures 1.-3.</p> <p>The exam on 1. counts 40%, those on 2. and 3. count 30% each to the final grade of the module.</p> <p>The grade of the module counts 10% to the overall grade of the BSc.</p>
Prerequisites for attending	After consultation with the person in charge for this module.