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Module	**Experimental Physics I**	**9 CP**

Module description	Experimental Physics I
Module code	**BP-01**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics, BSc Advanced Materials, BSc Chemistry; minor subject: Mathematics
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • have knowledge of the fundamental phenomena and principles of the sub-subject areas of mechanics and thermodynamics; • master the fundamental terminology and laws of conservation; • be able to describe the phenomena mathematically and develop solutions to simple problems; • have the ability to ascertain the principles of simple experiments from the relevant literature; • have knowledge of the fundamental measurement instruments; • be able to solve experimental exercises in a team; • be able to appropriately illustrate experimental results.
Module content	Base items, kinematics, Newtonian axioms, forces in nature, fictitious force, momentum, work and energy, angular momentum, statics and dynamics of rigid bodies, relativistic mechanics, mechanics of deformable materials, mechanical oscillations and waves, acoustics, kinetic gas theory, law of thermodynamics, real gas and phase transitions, forms of heat transfer, physical measurement technology.
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week) in small groups: calculation of examples related to topics covered in preceding lectures • Block laboratory following end of lectures: 10 experiments (20 hours)
Total workload in hours	270 hours — Credit points: 9 ECTS credits

Module composition/Workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	60			120
Tutorial	30	30			60
Laboratory	20	40		30	90
Total	110	130		30	270

Examination requirements	Written examination on lecture: 2/3 of tutorial problems must be solved successfully. Written examination on laboratory: all laboratory reports must be accepted and the final test completed.
Form(s) of examination and contribution to final mark	Form: Written examination on lecture (pass mark: 50%) Written examination on laboratory or final colloquium Contribution to final mark: Written examination on lecture: 50% Written examination on laboratory or final colloquium: 50%
Frequency, duration	Annually, winter semester; 1 semester
Intake capacity/Form of registration	150/online

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Module	**Introduction to Mathematical Methods in Physics**	**8 CP**
Module description	Introduction to Mathematical Methods in Physics	
Module code	**BP-02**	
Faculty/Subject/Department	Faculty 07/Physics	
Associated degree course(s)/Semester taken	BSc Physics, BSc Advanced Materials, lecture component in degree course L3	
Module coordinator	Cf. German Version	
Prerequisites	None	
Module guidance	Cf. German Version	
Learning outcomes	Students shall: • master the use of mathematical fundamentals – differentiation, integration and vector calculus; • learn the principal approaches of classical theoretical physics in combination with linear maps; • be able to solve classical 1/r problems such as the celestial mechanics of two solid bodies.	
Module content	• Mathematical fundamentals of theoretical physics: vectors, fields, Taylor series, differential operators, complex numbers, integrals, matrices and determinants, coordinate systems, differentiation and integration in different coordinate systems, simple linear differential equations. • Mechanics of a point mass: oscillations, motion in the nucleus potential, motion in a rotating coordinate system.	
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)	
Total workload in hours	240 hours	Credit points: 8 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	60			120
Tutorial	30		75	13	118
Total	90	60	75	13	238

Examination requirements	
Form(s) of examination and contribution to final mark	Form: 2 written examinations (pass mark: 50%): 80% 50% of tutorial and homework problems must be solved successfully: 20%
Frequency, duration	Annually, winter semester; 1 semester
Intake capacity/form of registration	120/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Mathematics for Physicists I**	**9 CP**

Module description	**Mathematics for Physicists I**
Module code	**BP-03**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • learn the basic concepts of analysis; • learn the basic concepts of linear algebra; • be able to undertake calculations with finite-dimensional matrices (inversion and diagonalisation) and master differentiation and integration with one variable.
Module content	Complex numbers, sequences and series, power series, convergence, continuity, differentiation and integration with one variable, integration techniques, linear equation systems, vector spaces, linear maps, matrix inversion, diagonalisation of linear maps, eigenvalues and eigenspaces, scalar products, determinants, matrix groups.
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)
Total workload in hours	270 hours — Credit points: 9 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	60			120
Tutorial	30		90	30	150
Total	90	60	90	30	270

Examination requirements	>50% of homework completed
Form(s) of examination and contribution to final mark	Form: 2 written examinations (pass mark: 50%): 100% Weighting according to lecturer
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	150/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Introduction to General, Inorganic and Organic Chemistry**	**6 CP**

Module description	**Introduction to General, Inorganic and Organic Chemistry**
Module code	**BP-04 A**
Faculty/Subject/Department	Faculty 08/Chemistry/all chemistry departments
Associated degree course(s)/Semester taken	BSc Chemistry, BSc Advanced Materials, BSc Food Science/1st semester
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • be familiar with the fundamental physical-chemical properties, matter states and bond forms as well as the fundamentals of thermodynamics, the principles of chemical equilibrium and of electrochemistry; • have knowledge of the periodic table and the interrelationships within the periodic system, the valence notation and chemical bonding models, the law of mass action, acid-base theories, redox reactions and simple inorganic-chemical bonds and their properties; • be familiar with the fundamentals of the organic-chemical nomenclature, forms of isomerism, organic-chemical matter groups and their properties, as well as with the most important classes of natural substances; • have knowledge of everyday chemical phenomena, be able to explain these and relate them to the topics covered in the lecture.
Module content	• **PC:** Structure of materials, aggregate states, separation of matter, the concept of the element, structure of atoms, isotopes, electron configurations, periodic system, definition of the mole, ideal gas law, energy and entropy, thermodynamic principles, fundamentals of kinetics, chemical bonds (metallic bonds, ionic bonds, covalent bonds). • **IC:** Valence formulae and mesomerism, chemistry of the main groups, properties of important bonds, simple chemical calculations, law of mass action, solubility product, acid-base analysis, pH-value, pKs-value, buffers, redox reactions, electrochemistry, electrolysis, galvanic elements, Nernst-equation. • **OC:** Hybridisation, bonds in organic chains, alkanes, constitutional isomers, nomenclature, conformational isomers, cycloalkanes, chair conformation, A-values, halogen alkanes, radicals, hyperconjugation, alekenes, configuration isomers (stereoisomers), electrophile addition, carbenium ions, alkynes, aromatics, Hückel laws, electrophile substitution, alcohols, redox reactions, enantiomers, CIP nomenclature, ethers, thiols, amines, carbonyl bonds, groups of matter and principle reactivity, aldehydes/ketones, reactions to imines, enamines and acetals, sugar and carbohydrates, Fischer projection, D/L nomenclature, Haworth projection, glycosidic bonds, optical rotation, carbonic acid derivatives, Sn2t, fats, amino acids, proteins.
Form(s) of instruction	Lecture
Total workload in hours	180 hours — Credit points: 6 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	60			120
	12	24		24	60
Total	72	84		24	180

Examination requirements	
Form(s) of examination and contribution to final mark	Written examination (2 hours): 100%
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	250/online
Language of instruction	German
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Foundations of Informatics I**	**6 CP**

Module description	**Foundations of Informatics I**
Module code	**BP-04 B**
Faculty/Subject/Department	Faculty 07/Computer Science/Department of Computer Science
Associated degree course(s)/Semester taken	BSc Physics, BSc Mathematics, L3 Computer Science, BSc Advanced Materials, BSc Food Science/1st semester
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • receive an overview of computer science; • know the fundamentals of the representation of information and of computer components; • be able to develop solutions for simple programming problems in a machine-orientated and a higher level programming language; • have a solid knowledge of the concepts of programming languages and programming techniques; • be able to analyse and classify elementary algorithms; • be able to design and construct elementary data structures; • be familiar with fundamental search and sorting algorithms.
Module content	Fundamentals of programming: • Overview of computer science • Presentation of information and data types • Computer components • Machine-orientated programming • Algorithm terminology • Control structures • Recursion • Dynamic variables Algorithms and data structures: • Analysis of algorithms • Construction of data types • Elementary data structures • Search algorithms • Sorting algorithms
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)
Total workload in hours	180 hours — Credit points: 6 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	30			90
Tutorial	28	42		20	90
Total	88	72		20	180

Examination requirements	
Form(s) of examination and contribution to final mark	Written examination: 85% >50% of homework completed: 15%
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	150/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Experimental Physics II**	**9 CP**

Module description	**Experimental Physics II**
Module code	**BP-05**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics, MSc Advanced Materials, MSc Chemistry
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • have knowledge of the fundamental phenomena and physical principles within the sub-areas of electricity and optics; • master the fundamental terms and conservation laws of physics, have the ability to develop experimental exercises from the literature, mathematically describe these and solve them within a team.
Module content	Electrostatics, electrical current, magnetostatics, induction, application fields of electromagnetism, electrical and magnetic properties of materials, Maxwell equations, electrical oscillations and waves, light as an electromagnetic wave, geometrical optics, wave optics, fundamentals of quantum and wave mechanics, simple examples of physical measurement technology.
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week) in small groups: calculation of examples related to topics covered in preceding lectures • Block laboratory following end of lectures: 10 experiments (20 hours)
Total workload in hours	270 hours — Credit points: 9 ECTS credits

Module composition/workload in hours

	A Course		B Final Colloquium	C Final module examination incl. preparation	Total
	a Contact hours	b Prepara-tion/revision			
Lecture	60	60			120
Tutorial	30	30			60
Laboratory	20	40	10	20	90
Total	110	130	10	20	270

Examination requirements	Written examination on lecture: 2/3 of tutorial problems must be solved successfully. Written examination on laboratory or final colloquium: all laboratory reports must be accepted.
Form(s) of examination and contribution to final mark	Written examination on lecture (pass mark: 50%); 50% Written examination on laboratory or final colloquium: 50%
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	150/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Theory of Advanced Mechanics**	**7 CP**

Module description	**Theory of Advanced Mechanics**
Module code	**BP-06**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics; minor subject: Mathematics
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	• Deepening of mathematical foundations and the methods of theoretical physics • Understanding of classical mechanics of different systems of point mass and rigid bodies • Introduction to the algebraic formulation of advanced mechanics with Poisson brackets • Understanding of cooperative phenomena
Module content	• Mathematical fundamentals of theoretical physics, calculus of variations, algebra of Poisson brackets, differentiation and integration in arbitrary coordinate systems • Dynamics of arbitrary systems of point masses, rotation and translation of rigid bodies, collective oscillations, principle of stationary action, Lagrangian and Hamiltonian dynamics, symmetries and conservation laws, general canonical transformations, dynamics in the context of Poisson brackets, fundamental Poisson brackets and dynamic invariants.
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)
Total workload in hours	210 hours — Credit points: 7 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	30			90
Tutorial	30		70	20	120
Total	90	30	70	20	210

Examination requirements	
Form(s) of examination and contribution to final mark	2 written examinations (pass mark: 50%): 80% 50% of homework problems successfully solved: 20%
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	100/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Mathematics for Physicists II**	**9 CP**
Module description	**Mathematics for Physicists II**	
Module code	**BP-07**	
Faculty/Subject/Department	Faculty 07/Mathematics	
Associated degree course(s)/Semester taken	BSc Physics, lecture component in degree course Mathematics	
Module coordinator	Cf. German Version	
Prerequisites	None	
Module guidance	Cf. German Version	
Learning outcomes	Students shall: • master differentiation and integration in multiple dimensions; • be able to apply Taylor series development in multiple dimensions; • understand the conclusions of integration theorems.	
Module content	Differentiation and integration in multiple dimensions, Taylor series development in multiple dimensions, extreme values under constraints, transformation, submanifolds and integration on submanifolds, Gauss integration theorem.	
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)	
Total workload in hours	270 hours	Credit points: 9 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	60			120
Tutorial	30		90	30	150
Total	90	60	90	30	270

Examination requirements	>50% of homework completed
Form(s) of examination and contribution to final mark	2 written examinations (pass mark: 50%): 100% Weighting according to lecturer
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	150/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Practical Introduction to General Chemistry**	**6 CP**

Module description	**Practical Introduction to General Chemistry**
Module code	**BP-08 A**
Faculty/Subject/Department	Faculty 08/Chemistry/all chemistry departments
Associated degree course(s)/Semester taken	BSc Chemistry, BSc Advanced Materials, BSc Food Science, BSc Physics/ 1st semester
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • understand how fundamental practical laboratory work is undertaken in terms of good laboratory practice; • be able to record their laboratory results in the form of laboratory notebooks and reports; • have a command of the fundamental quantitative and qualitative methods for the analysis of materials; • understand and can apply the fundamental separation techniques; • be able to plan, set up, undertake and analyse simple chemical and physical-chemical experiments.
Module content	• "Lab licence" (working safely in a laboratory) • Acids and bases, pH-value, chemical equilibrium, titrations • Redox reactions, galvanic elements, redox potentials • Equilibrium constants, solubility product • Complexation • Filtration, crystallisation, distillation, chromatography • Inorganic and organic detection reactions • Organic-chemical laboratory techniques • Simple organic-chemical experiments • Basic experiments related to energy of chemical reactions (exothermic, endothermic, exergonic, endergonic), to chemical equlibrium and to electrochemistry
Form(s) of instruction	• Laboratory • Seminar
Total workload in hours	180 hours — Credit points: 6 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Laboratory	56	56			112
Seminar	34	34			68
Total	90	90			180

Examination requirements	Regular attendance of laboratory and seminar.
Form(s) of examination and contribution to final mark	Form: Laboratory reports Mark: no mark will be given; the students pass the module if all reports are accepted for submission: 100%
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	250/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Foundations of Informatics II**	**6 CP**

Module description	**Foundations of Informatics II**
Module code	**BP-08 B**
Faculty/Subject/Department	Faculty 07/Computer Science/Department of Computer Science
Associated degree course(s)/Semester taken	BSc Physics, BSc Mathematics, L3 Computer Science, BSc Advanced Materials
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • master the use of the mathematical fundamentals of computer science; • master the principal mindset of theoretical computer science; • have basic knowledge of Boolean algebra; • have knowledge of the possibilities and limitations of switching functions and sequential circuits; • develop an understanding of formal calculation methods; • recognise the theoretical and practical limitations of algorithmic problem solving.
Module content	Combinatorial circuits, sequential circuits and automata: • Boolean algebra • Combinatorial circuits • Minimisation of switching functions • Sequential circuits, finite state machines • Reduction of finite state machines • Universal calculation model Computability • Turing machines • Algorithmic computability • Unsolvable problems • Recursive functions
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)
Total workload in hours	180 hours — Credit points: 6 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	30			90
Tutorial	28	42		20	90
Total	88	72		20	180

Examination requirements	
Form(s) of examination and contribution to final mark	Written examination: 85% >50% of homework completed: 15%
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	150/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Experimental Physics III: Physics of Atoms and Quanta**	**9 CP**

Module description	**Experimental Physics III: Physics of Atoms and Quanta**
Module code	**BP-09**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • be familiar with the experimental fundamentals of quantum mechanics; • be able to quantitatively reproduce the structure of hydrogen-like atoms; • master the fundamental structure as well as the excitation and deexcitation of atoms and molecules; • have the ability to develop experimental exercises based on the literature, mathematically describe these and solve them within a team.
Module content	• Hydrogen atom, fundamental experimental findings, excitation, emission of light, influence of external fields, theoretical approaches, many-electron systems, Pauli principle, x-ray spectra, molecule bonding, specific excitation possibilities in molecules • Measurement technology, applications (e.g. Laser)
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week) • Block laboratory following end of lectures: 12 experiments
Total workload in hours	270 hours — Credit points: 9 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation (and final colloquium)	Total
	a Contact hours	b Prepara-tion/revision			
Lecture	60	60			120
Tutorial	30	15			45
Laboratory	36	42		27	105
Total	126	117		27	270

Examination requirements	50% of homework completed, all laboratory reports accepted.
Form(s) of examination and contribution to final mark	Written examination (pass mark: 50%): 50% Written examination or final colloquium: 50%
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	150/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Theory of Electrodynamics**				**7 CP**
Module description	**Theory of Electrodynamics**				
Module code	**BP-10**				
Faculty/Subject/Department	Faculty 07/Physics				
Associated degree course(s)/Semester taken	BSc Physics				
Module coordinator	Cf. German Version				
Prerequisites	None				
Module guidance	Cf. German Version				
Learning outcomes	• Deepening of mathematical foundations in the context of vector fields • Understanding of classical electrodynamics • Preparation for the interpretation of classical fields with photons • Introduction to the covariance of the Maxwell equations and their gauge degrees of freedom • Fourier analysis and modern information technology • Understanding of field propagation within a medium • Polarisation of media and the boundary conditions at interfaces				
Module content	• 1. Mathematical principles of theoretical physics; volume, surface and line integrals, Gauss' theorem, Stokes' theorem, construction of Lorentz invariant quantities; divergences of a four-vector and sustained charge. • 2. Statics and dynamics of charged point mass and continuous charge distribution; divergence and rotation of vector fields; Maxwell equations; electromagnetic fields in vacuum, propagation of waves in a medium; polarisation of media; ferro-, para- and diamagnetism; behaviour of electromagnetic fields at interfaces; complex diffraction index; covariance of Maxwell equations.				
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)				
Total workload in hours	210 hours			Credit points: 7 ECTS credits	

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Prepara-tion/revision			
Lecture	60	30			90
Tutorial	30	70		20	120
Total	90	100		20	210

Examination requirements	
Form(s) of examination and contribution to final mark	2 written examinations (pass mark: 50%): 80% 50% of homework tasks successfully solved: 20%
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	100/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Mathematics for Physicists III**	**9 CP**

Module description	**Mathematics for Physicists III**
Module code	**BP-11**
Faculty/Subject/Department	Faculty 07/Mathematics
Associated degree course(s)/Semester taken	BSc Physics, lecture component in degree course Mathematics
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • know different forms of differential equations and their solutions; • learn basic concepts of function theory; • master integrals in the complex plane; • be able to apply power series and Laurent series developments.
Module content	Ordinary differential equations, solvability conditions and solution methods, linear systems, linear differential equations of higher order, initial and boundary value problems, holomorphic functions, integration in the complex plane, Cauchy integral representation, Laurent series, analyticity, Cauchy's integral theorem, residue theorem with different applications for integration on the real axis, principal values.
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)
Total workload in hours	270 hours — Credit points: 9 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	60			120
Tutorial	30		90	30	150
Total	90	60	90	30	270

Examination requirements	>50% of homework completed
Form(s) of examination and contribution to final mark	Form: 2 written examinations (pass mark: 50%): 100% Weighting according to lecturer
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	150/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Physical Chemistry I – Thermodynamics and Electrochemistry**	**7 CP**

Module description	**Physical Chemistry I – Thermodynamics and Electrochemistry**
Module code	**BP-12 A**
Faculty/Subject/Department	Faculty 08/Chemistry/Physical Chemistry
Associated degree course(s)/Semester taken	BSc Chemistry, BSc Advanced Materials, BSc Food Science, BSc Physics
Module coordinator	Cf. German Version
Prerequisites	General Chemistry or Mathematics
Module guidance	Cf. German Version
Learning outcomes	Students shall: • master the fundamental laws in the fields of chemical thermodynamics, electrochemistry and of chemical kinetics; • be familiar with the physical-chemical approaches to these important fields within chemistry and be able to apply these to neighbouring disciplines.
Module content	1) Introduction to thermodynamics: ideal and real gases, thermal and caloric equations of state, 1st law, thermochemistry, Carnot process, entropy, Joule-Thomson effect, partial molar quantity, fundamental equations of thermodynamics, chemical potential, chemical equilibrium, phase balances, miscible phase thermodynamics (phase diagram). 2) Electrochemistry: fundamental terms, ionic migration, weak and strong electrolytes, fixed electrolytes, reversible cell potential (EMF), electrical dipole layer, electrochemical potential, electrode potential, half cells, half-cell potential, Stockholm convention, diffusion potential, different types of galvanic cells: chemical cells, concentration cells (e.g. lambda probe). 3) Basic concepts of chemical kinetics: Arrhenius equation, reaction of nth order, dynamic equilibrium, quasi steady-state.
Form(s) of instruction	• Lecture • Tutorials
Total workload in hours	210 hours — Credit points: 7 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	20	10		90
Tutorial	30	50	10	30	120
Total	90	80	20	20	210

Examination requirements	50% of tutorial problems successfully solved.
Form(s) of examination and contribution to final mark	Written examination: 100%
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	90/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Practical Introduction to Operating Systems and Computer Networks – Undergraduate Seminar**	**6 CP**

Module description	**Practical Introduction to Operating Systems and Computer Networks – Undergraduate Seminar**
Module code	**BP-12 B**
Faculty/Subject/Department	Faculty 07/Computer Science/Department of Computer Science
Associated degree course(s)/Semester taken	BSc Physics, BSc Mathematics, L3 Computer Science
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • master the use of UNIX operating system commands; • acquire basic knowledge of operating system concepts; • acquire experience in the area of shell programming; • be familiar with the concept of the internet; • gain the competence to assess security-related aspects of computer usage; • be introduced to the current and classical literature of computer science; • present a specific topic coherently and be able to discuss this topic in front of a group.
Module content	• Introduction to the UNIX operating system • Processes, file systems • Resource management • Fundamentals of computer communication • Shell programming • Security aspects • Internet structure and services • Selected topics in introductory computer science literature
Form(s) of instruction	• Lecture (2 hours/week) • Tutorial (2 hours/week) • Seminar (2 hours/week)
Total workload in hours	180 hours — Credit points: 6 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	30	15			45
Tutorial	28		42	20	90
Seminar	30			15	45
Total	88	15	42	35	180

Examination requirements	50% of tutorial and homework problems successfully solved.
Form(s) of examination and contribution to final mark	Written examination: 50% Seminar presentation: 50%
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	15/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Numerical Mathematics for Physicists I+II**	**16 CP**

Module description	**Numerical Mathematics for Physicists I+II**
Module code	**BP-12 C**
Faculty/Subject/Department	Faculty 07/Mathematics/AG Numerical Mathematics and Scientific Arithmetic
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	Mathematics for Physics Students 1 and 2
Module guidance	Cf. German Version
Learning outcomes	• Understanding the principles of numerical mathematics and applied analysis • Ability to analyse convergence criteria and the stability of current methods • Competence in computer-aided problem-solving • Development, implementation, and assessment of methods
Module content	Gaussian elimination with and without pivoting; rounding errors; iterative methods for linear equation systems (Jacobi/Gauss-Seidel); polynomial interpolation; solvability; Lagrange forms, Newtonian representation; divided differences; spline spaces, B-splines, interpolation, finding of zero points; bisection; Secant and Newtonian methods; elementary quadrature rules, composite quadrature formulae; Gaussian quadrature; Banach's fixed-point theorem, solutions to ordinary differential equations.
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)
Total workload in hours	480 hours over 2 semesters — Credit points: 16 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	120	120			240
Tutorial	60		150	30	240
Total	180	120	150	30	480

Examination requirements	Students' performance in the tutorials is continuously monitored and reported.
Form(s) of examination and contribution to final mark	Written examination (Numerical Mathematics I, pass mark: 50%): 50% 50% of homework problems successfully solved (Numerical Mathematics I +II): 50%
Frequency, duration	Winter semester; 2 semesters
Intake capacity/form of registration	150/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Experimental Physics IV: Solid State Physics**	**6 CP**

Module description	**Experimental Physics IV: Solid State Physics**
Module code	**BP-13**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • be familiar with the concepts of solid state physics; • master typical calculation methods for properties of solids; • have experience in the calculation of characteristic quantities through practical examples.
Module content	Crystal structures, diffractometry with x-rays, neutrons, electrons, bond types, phonons, elastic properties, sound propagation, phononic density of state, Boltzmann statistics, heat capacity, Debye-Waller factor, thermal expansion, Boltzmann transport equation, free electron gas, electronic density of state, Fermi statistics, metal/semi-conductor/insulator, hole concept, Boltzmann transport equation for electrons, measurement of relaxation times, Fermi sphere, de Haas van Alphen effect, cyclotron resonance, electrical transport, ferroelectricity, diamagnetism and paramagnetism, ferromagnetism, semi-conductors, doping, conductivity, Schottky contact, pn-junction characteristic, transistors.
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)
Total workload in hours	180 hours — Credit points: 6 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	50			110
Tutorial	30	30		10	70
Total	90	80		10	180

Examination requirements	At least 50% of tutorial problems successfully solved.
Form(s) of examination and contribution to final mark	Tutorial problems: 25% Written or oral examination: 75%
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	100/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Data Acquisition and Processing**	**7 CP**

Module description	**Data Acquisition and Processing**
Module code	**BP-14**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics, BSc Advanced Materials/4th semester
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • have fundamental knowledge of analogue and digital measurement technology; • master the measurement chain (with sensor equipment) from signal acquisition and signal processing to data visualisation; • master the use of computer hardware and software for specific measurement technology functions; • learn the use of important databases for materials research and be able to use the data exchange in network systems in the context of new problem types.
Module content	Fundamental measurement technology: • Analogous measurement technology (measurement bridges, measurement amplifiers) • Fundamentals of sensor technology with different physical mechanisms • Basic circuitry of measurement and control technology for the determination of different physical properties (transmitters, measurement of frequency and impulse width, closed loops) • Methods for reduction of noise (filter and correlation methods, lock-in measurement technology) • Set-up of measurement technology (AD/DA converter, interfaces, data conversion and storage systems) Measurement technology for materials research: • e.g. impedance spectroscopy • High resolution scanning probe microscopy methods for the characterisation of materials (e.g. atomic force microscopy for surface analysis, use of image processing with digital filter techniques) Information Technology • Programming of a measurement problem (control of equipment) and data acquisition in an experiment using software (e.g. Labview) • Data analysis, visualisation and modelling (e.g. Origin/Mathematica/Maple) • Data exchange and acquisition (databases, internet)
Form(s) of instruction	• Lecture • Laboratory
Total workload in hours	210 hours — Credit points: 7 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	30	30			60
Laboratory	60	72		18	150
Total	90	102		18	210

Examination requirements	All tests passed and laboratory reports accepted for submission.
Form(s) of examination and contribution to final mark	Final written or oral examination: 40% Laboratory reports: 60%
Frequency, duration	Summer semester
Intake capacity/form of registration	100/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Theory of Quantum Mechanics**	**8 CP**
Module description	**Theory of Quantum Mechanics**	
Module code	**BP-15**	
Faculty/Subject/Department	Faculty 07/Physics	
Associated degree course(s)/Semester taken	BSc Physics	
Module coordinator	Cf. German Version	
Prerequisites	Advanced Mechanics Theory	
Module guidance	Cf. German Version	
Learning outcomes	Deepening of the mathematical foundation in linear algebra and differential equations, familiarisation with the interrelationship between observables and operators for single particle units; understanding of the solutions of the single particle Schrödinger equation for simple problems; understanding of the uncertainty principle, quantisation of the energy level of harmonic oscillators and the hydrogen atom, simple scattering problems.	
Module content	1. Mathematical fundamentals of theoretical physics; commutator algebra: eigenvalues and eigen functions; partial differential equations; orthogonal function sets. 2. Historical development of quantum mechanics; free Schrödinger equation and free particles; Schrödinger equation with single particle potentials; quantisation of harmonic oscillators; quantisation of angular momentum; energy levels of the hydrogen atom; electron spin; time-independent perturbation theory; Zeeman and Stark effect, simple stationary scattering problems, Born's approximation and partial wave segmentation.	
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)	
Total workload in hours	240 hours	Credit points: 8 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	45			105
Tutorial	30		90	15	135
Total	90	45	90	15	240

Examination requirements	
Form(s) of examination and contribution to final mark	Written examination(s) (pass mark: 50%): 80% 50% of tutorial and homework problems successfully solved: 20%
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	100/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Laboratory Exercises in Physical Chemistry**	**5 CP**

Module description	**Laboratory Exercises in Physical Chemistry**
Module code	**BP-16A**
Faculty/Subject/Department	Faculty 08/Chemistry/all chemistry departments
Associated degree course(s)/Semester taken	BSc Chemistry, BSc Advanced Materials, BSc Food Science, BSc Physics
Module coordinator	Cf. German Version
Prerequisites	Practical Introduction to General Chemistry
Module guidance	Cf. German Version
Learning outcomes	Students shall: • be familiar with the fundamental physical-chemical properties, states of matter and bond forms as well as the fundamentals of thermodynamics, the principles of chemical equilibrium and of electrochemistry; • have knowledge of the periodic table and the interrelationships within the periodic system, the valence notation and chemical bonding models, the law of mass action, acid-base theories, redox reactions and simple inorganic-chemical bonds and their properties; • be familiar with the fundamentals of the organic-chemical nomenclature, forms of isomerism, organic-chemical groups of matter and their properties, as well as the most important classes of natural substances; • have knowledge of everyday chemical phenomena and be able to explain these and relate them to topics covered in the lecture.
Module content	1) Experiments on phenomenological thermodynamics: ideal and real gases, calorimetry, first law of thermodynamics, thermochemistry, Joule-Thompson effect, partial molar quantity, chemical equilibrium. 2) Experiments on electrochemistry: conductivity of strong and weak electrolytes, Ostwald's law of dilution, ionic migration, current-voltage curves, electrochemical cells, reversible cell potential (EMF) and its temperature dependency, concentration chains. 3) Experiments on chemical kinetics: reactions of the 1st and 2nd order, temperature dependency of reaction speeds.
Form(s) of instruction	• Laboratory (12 experiments, each 5 hours) • Seminar (2 hours/seminar/5 seminars, accompanying the lab)
Total workload in hours	150 hours — Credit points: 5 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Laboratory	60	50	10		120
Seminar	10	15	5		30
Total	70	65	15		150

Examination requirements	Regular attendance of seminar and laboratory
Form(s) of examination and contribution to final mark	Form: Laboratory reports Mark: no mark will be given; the students pass the module if all reports are accepted for submission.
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	60/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Foundations of Informatics III**	**6 CP**

Module description	**Foundations of Informatics III**
Module code	**BP-16 B**
Faculty/Subject/Department	Faculty 07/Computer Science/Department of Computer Science
Associated degree course(s)/Semester taken	BSc Physics, BSc Mathematics, L3 Computer Science
Module coordinator	Cf. German Version
Prerequisites	Successful completion of Fundamentals of Computer Science 1 and 2
Module guidance	Cf. German Version
Learning outcomes	Students shall: • have learnt about the important aspects of selected core areas of computer science; • understand and recognise interdisciplinary concepts; • have knowledge of different paradigms and their application areas; • have deepened their knowledge from the modules Fundamentals of Computer Science I and II.
Module content	Fundamental topics from core areas of computer science, including: algorithms and data structures, parallel processing, computer languages, compiler construction, operating systems, computer networks, coding theory, complexity.
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)
Total workload in hours	180 hours — Credit points: 6 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	30			90
Tutorial	28	42		20	90
Total	88	72		20	180

Examination requirements	
Form(s) of examination and contribution to final mark	Written examination: 85% >50% of homework completed: 15%
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	150/Tutorial/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Experimental Physics V: Nuclear and Hadron Physics**				**6 CP**
Module description	**Experimental Physics V: Nuclear and Hadron Physics**				
Module code	**BP-17**				
Faculty/Subject/Department	Faculty 07/Physics				
Associated degree course(s)/Semester taken	BSc Physics				
Module coordinator	Cf. German Version				
Prerequisites	None				
Module guidance	Cf. German Version				
Learning outcomes	Students shall • have knowledge of the fundamental phenomena and principles of nuclear, particle and astrophysics; • be aware of the applications of nuclear and particle physics.				
Module content	Nuclear properties, nuclear decay, nuclear models, nuclear reactions, applications of nuclear energy, radioactivity, radiation protection, accelerators and detectors, scattering experiments, fundamental particles and interactions, element synthesis and energy production in stars.				
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)				
Total workload in hours	180 hours			Credit points: 6 ECTS credits	
Module composition/workload in hours		A Course		B Autonomous work	C Final module examination incl. preparation	Total
		a Contact hours	b Prepara-tion/revision			
	Lecture	60	50			110
	Tutorial	30	30		10	70
	Total	90	80		10	180
Examination requirements	50% of tutorial problem sets successfully solved.				
Form(s) of examination and contribution to final mark	Written examination (pass mark: 50%): 75% Tutorial problem sets: 25%				
Frequency, duration	Winter semester; 1 semester				
Intake capacity/form of registration	100/online				
Language of instruction	* See separate list for current semester (StudIP)				
Date/Literature	* See separate list for current semester (StudIP)				

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Module	**Advanced Laboratory Exercises**	**14 CP**

Module description	**Advanced Laboratory Exercises**
Module code	**BP-18**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/ Semester taken	MSc Physics
Module coordinator	Cf. German Version
Prerequisites	Experimental Physics I - III
Module guidance	Cf. German Version
Learning outcomes	Students shall have the ability to: • use the literature to familiarise themselves with a given experimental task; • theoretically and experimentally plan and undertake an advanced project within a team; • discuss the planning and undertaking of the project; • summarise the task, theory, and results in a coherent report.
Module content	Part A Group 1 • Fourier analysis and string oscillations • Determination of e/m according to Busch • Stefan-Boltzmann law Group 2 • Gamma spectroscopy • Photolithography • X-ray diffraction Group 3 • Band spectrum of iodine • Hall effect • Zeeman effect • Optical pumps on rubidium • Raman effect Group 4 • X-ray reflectometry • Scanning tunnel microscopy • I-U characteristic curves of semi-conductors and solar cells Seven experiments are to be completed within Part A, with at least one experiment each group. Part B 1. Solid state physics • Electron spin resonance • Photoluminescence on semi-conductor quantum coatings • Quantum Hall effect • Thermoelectrics • Electrochemical semi-conductor technology • Organic thin films • Mass spectrometry and trace analysis 2. Nuclear and particle physics • Muon disintegration • COMPTON scattering • Alpha radiation • Environmental radiation • Absorption and back scattering of electrons and photons Two experiments from each group in Section B must be completed.
Form(s) of instruction	Laboratory (110 hours); Seminar (11 hours)
Total workload in hours	420 hours — Credit points: 14 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final colloquium incl. preparation	Total
	a Contact hours	b Prepara-tion/revision			
Laboratory	110	275			385
Seminar	11			24	35
Total	121	275		24	420

Examination requirements	11 verified lab reports from Part A and Part B.
Form(s) of examination and contribution to final mark	Laboratory experiments: 75% Final colloquium: 25%
Frequency, duration	Winter semester; 2 semesters
Intake capacity/ registration	60/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Theory of Thermodynamics**	**8 CP**

Module description	**Theory of Thermodynamics**
Module code	**BP-19**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	• Understanding of the classification of physical systems • Intuitive interpretation of the concepts entropy, temperature, chemical potential and pressure as well as statistical balance • Assigned Lagrange parameters for temperature, chemical potential and pressures • Introduction to the Maxwell relations • Phase diagrams of materials • Fixing of kinetic and chemical equilibrium in the context of the Boltzmann approximation • Phase transitions and critical phenomena
Module content	1. Mathematical fundamentals: probability theory and central limit theorem 2. Characterisation of physical systems; the concept of entropy; extensive and intensive properties; cycle processes and the law of thermodynamics; thermodynamic potential; Maxwell relations; fluctuation and dissipation; susceptibility, phase equilibrium and phase diagrams; phase transitions and critical phenomena; ideal Fermi and Bose gases; Boltzmann equation.
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)
Total workload in hours	240 hours — Credit points: 8 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	45			105
Tutorial	30	90		15	135
Total	90	135		15	240

Examination requirements	
Form(s) of examination and contribution to final mark	2 written examinations (pass mark: 50%): 80% 50% of tutorial and homework problems successfully solved: 20%
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	100/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Optimisation for Physicists I**	**8 CP**

Module description	**Optimisation for Physicists I**
Module code	**BP-20 A**
Faculty/Subject/Department	Faculty 07/Mathematics/AG Numerical Mathematics and Scientific Arithmetic
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	Numerical Mathematics I and II for Physics Students
Module guidance	Cf. German Version
Learning outcomes	Understanding the design and application of optimisation methods and their mathematical analysis.
Module content	Linear optimisation, simplex method, transport problems; non-linear optimisation: 1) Without constraints, quasi-Newton algorithms, DFP and BFGS methods 2) With linear constraints, Kuhn-Tucker conditions and algorithms, trust-region methods 3) With non-linear constraints, penalty algorithms
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)
Total workload in hours	240 hours — Credit points: 8 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	60			120
Tutorial	30		90		120
Total	90	60	90		240

Examination requirements	
Form(s) of examination and contribution to final mark	50% of problem sets successfully solved: 100%
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	150/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Comprehensive Interrelations in Experimental Physics**	**5 CP**
Module description	**Comprehensive Interrelations in Experimental Physics**	
Module code	**BP-21**	
Faculty/Subject/Department	Faculty 07/Physics	
Associated degree course(s)/Semester taken	BSc Physics	
Module coordinator	Cf. German Version	
Prerequisites	Experimental Physics I - V	
Module guidance	Cf. German Version	
Learning outcomes	Students shall: • have an overview of the fields of experimental physics; • be able to recognise the interrelations between the different fields of experimental physics.	
Module content	Content of the modules Experimental Physics I, II, III, IV, and V, i.e. classical physics, atomic and quantum physics, solid state physics, sub-atomic physics.	
Form(s) of instruction	Meeting with the examining instructor, independent study, revision of summarised module content, learning within a team.	
Total workload in hours	150 hours	Credit points: 5 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work (independent study; study for exams; also in teams)	C Final module examination incl. preparation	Total
	a Contact hours	b Prepara-tion/revision			
Total	4		145	1	150

Examination requirements	
Form(s) of examination and contribution to final mark	Oral examination: 100%
Frequency, duration	Summer semester or winter semester
Intake capacity/form of registration	60/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Comprehensive Interrelations in Theoretical Physics**	**5 CP**

Module description	**Comprehensive Interrelations in Theoretical Physics**
Module code	**BP-22**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	Theoretical Physics 2 to 5
Module guidance	Cf. German Version
Learning outcomes	Students shall: • have an overview of the theoretical physics contents in various fields; • be able to demonstrate the interrelations between the different fields of theoretical physics; • develop and understand complex interrelations in theoretical physics in the context of team work.
Module content	Contents of the modules Advanced Mechanics Theory, Electrodynamics Theory, Quantum Mechanics Theory, Thermodynamics Theory
Form(s) of instruction	Meeting with the examining instructor, independent study in small groups, revision of summarised module content,, learning within a team.
Total workload in hours	150 hours — Credit points: 5 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work (independent study, exam preparation in small groups)	C Final module examination incl. preparation	Total
	a Contact hours	b Prepara-tion/revision			
Total	4		145	1	150

Examination requirements	
Form(s) of examination and contribution to final mark	Oral examination: 100%
Frequency, duration	Summer semester or winter semester
Intake capacity/form of registration	60/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Many-Particle Physics**				**6 CP**
Module description	**Many-Particle Physics**				
Module code	**BP-23A**				
Faculty/Subject/Department	Faculty 07/Physics				
Associated degree course(s)/Semester taken	BSc Physics				
Module coordinator	Cf. German Version				
Prerequisites	Electrodynamics Theory and Quantum Mechanics Theory				
Module guidance	Cf. German Version				
Learning outcomes	• Introduction to the simple processes of multi-particle physics • Understanding the shell model of atoms and atomic nuclei • Examination and simple calculations of collective excitations • Interpretation of quantum mechanics in semi-classical limits • Understanding the fundamentals of kinetic theory and chemical reactions • Phase transitions and critical phenomena				
Module content	1. Effective single particle approximations of multi-particle physics; Hartree-Fock Theory; Thomas-Fermi Theory; shell model of atoms and atomic nuclei; collective oscillations and rotations. 2. Semi-classical limits of quantum theory of time-dependent systems; phase-space representations; Vlasov equation and simple solution methods, kinetic theory of gases; chemical reactions and “detailed equilibrium”; phase transitions and critical phenomena.				
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (1 hour/week)				
Total workload in hours	180 hours			Credit points: 6 ECTS credits	
Module composition/workload in hours		A Course		B Autonomous work	C Final module examination incl. preparation	Total
		a Contact hours	b Prepara-tion/revision			
	Lecture	60	45			105
	Tutorial	15	45		15	75
	Total	75	90		15	180
Examination requirements						
Form(s) of examination and contribution to final mark	2 written examinations (pass mark: 50%): 80% 50% of homework and tutorial problems successfully solved: 20%					
Frequency, duration	Summer semester; 1 semester					
Intake capacity/form of registration	90/online					
Language of instruction	* See separate list for current semester (StudIP)					
Date/Literature	* See separate list for current semester (StudIP)					

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Module	**Learning by Teaching**				**2 CP**
Module description	**Learning by Teaching**				
Module code	**BP-23B**				
Faculty/Subject/Department	Faculty 07/Physics				
Associated degree course(s)/Semester taken	BSc Physics				
Module coordinator	Cf. German Version				
Prerequisites	Successful completion of all modules in the first 5 semesters				
Module guidance	Cf. German Version				
Learning outcomes	Students shall develop a teaching project and be able to: • supervise younger students from the first four semesters in tutorials and laboratories under the guidance of the responsible tutor; • explain physical interrelationships; • practically apply and evaluate teaching methods; • apply and appraise methods of self-evaluation.				
Module content	• Supervision of students from the first four semesters in tutorials or laboratories • Teaching of fundamental knowledge of physics (autonomous revision and consolidation of content) • Teaching methods • Monitoring achievement, evaluation through questionnaires, analysis				
Form(s) of instruction	• Teaching projects (20 hours)				
Total workload in hours	60 hours			Credit points: 2 ECTS credits	
Module composition/workload in hours		A Course		B Autonomous work (design of a questionnaire)	C Final module examination incl. preparation (Evaluation and written report)	Total
		a Contact hours	b Preparation/revision			
	Total	20	20	10	10	60
Examination requirements						
Form(s) of examination and contribution to final mark	Assessment of the written report: 100%					
Frequency, duration	Summer semester; 1 semester					
Intake capacity/form of registration	50/online					
Language of instruction	German					
Date/Literature	* See separate list for current semester (StudIP)					

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Module	**Mathematics for Physicists IV**	**9 CP**

Module description	**Mathematics for Physicists IV**
Module code	**BP-23C**
Faculty/Subject/Department	Faculty 07/Mathematics
Associated degree course(s)/Semester taken	BSc Physics, lecture component in degree course Mathematics
Module coordinator	Cf. German Version
Prerequisites	Mathematics for Physics Students I and II
Module guidance	Cf. German Version
Learning outcomes	Students shall: • learn general concepts of integration; • be able to apply Fourier representations; • gain knowledge of partial differential equations and their solutions; • be able to use Banach and Hilbert spaces and linear maps of infinite-dimensional spaces.
Module content	Lebesgue integral, Fourier series, Fourier transformations, partial differential equations, Banach and Hilbert spaces, linear maps of infinite-dimensional spaces, self-adjoint maps.
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)
Total workload in hours	270 hours — Credit points: 9 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	45			105
Tutorial	30		105	30	165
Total	90	45	105	30	270

Examination requirements	>50% of homework completed
Form(s) of examination and contribution to final mark	Form: 2 written examinations (pass mark: 50%): 100% Weighting according to lecturer
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	50/online
Language of instruction	* See separate list from current semester (StudIP)
Date/Literature	* See separate list from current semester (StudIP)

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Module	**Nuclear Physics Techniques in Medical and Technical Applications**	**8 CP**

Module description	**Nuclear Physics Techniques in Medical and Technical Applications**
Module code	**BP-23D**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • have knowledge of the fundamental phenomena and principles of nuclear physics; • be familiar with the elementary interactions of particles and photons in materials; • have foundational knowledge of detector principles and fundamental measurement systems; • have the ability to derive the fundamentals of measurement technology and application examples from the literature; • be able to analyse and illustrate measurement data.
Module content	Interactions of charged and neutral particles in materials, absorption of low-energy and high-energy photons, detector systems for the measurement of location, time and energy of particles and photons, coincidence techniques, principles of gas, semi-conductor and scintillation detectors, readout electronics and data acquisition systems, fundamentals of x-ray diagnosis, tomography, scintigraphy, radiation therapy, element analysis in technology and the environment.
Form(s) of instruction	• Lecture (2 hours/week) • Laboratory (84 hours) in small groups: Set-up and implementation of different detector systems, including readout electronics and data acquisition, measurements and tests with radioactive and cosmic rays, data analysis, simulation of the functional principle of individual detector systems.
Total workload in hours	240 hours — Credit points: 8 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Colloquium and final colloquium	Total
	a Contact hours	b Preparation/revision			
Lecture	30	30			60
Laboratory	84	84		12	180
Total	114	114		12	240

Examination requirements	All laboratory reports submitted must be accepted.
Form(s) of examination and contribution to final mark	Laboratory reports: 50% Colloquia: 25% Final colloquium: 25%
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	12/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Approximation Theory for Physicists**	**8 CP**

Module description	**Approximation Theory for Physicists**
Module code	**BP-23E**
Faculty/Subject/Department	Faculty 07/Mathematics/AG Numerical Mathematics and Scientific Arithmetic
Associated degree course(s)/Semester taken	BSc Physics, lecture component in degree course Mathematics
Module coordinator	Cf. German Version
Prerequisites	Numerical Mathematics I and II for Physics Students
Module guidance	Cf. German Version
Learning outcomes	Ability to use and analyse approximation methods as well as their mathematical analysis with respect to convergence, existence, and uniqueness.
Module content	Fundamentals of approximation theory; polynomial approximation; minimax-approximations, spline-approximations, approximations with rational functions; approximation orders (Jackson theorems); multi-dimensional approximations; approximations with translation invariant spaces.
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)
Total workload in hours	240 hours — Credit points: 8 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	60			120
Tutorial	30		90		120
Total	90	60	90		240

Examination requirements	
Form(s) of examination and contribution to final mark	50% of homework tasks successfully solved: 100%
Frequency, duration	Winter semester, irregular; 1 semester
Intake capacity/form of registration	150/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Study Project**					**8 CP**
Module description	**Study Project**					
Module code	**BP-23F**					
Faculty/Subject/Department	Faculty 07/Physics					
Associated degree course(s)/Semester taken	BSc Physics					
Module coordinator	Cf. German Version					
Prerequisites	None					
Module guidance	Cf. German Version					
Learning outcomes	Students shall complete a project and thereby: • gain experience in the methods within one specific discipline and deepen their knowledge and skills in this discipline through team work; • broaden their skills in reviewing literature and in scientific discussion; • deepen their skills in the use of multimedia presentation techniques, including for teaching purposes.					
Module content	• Literature review • Implementing a project plan • Discussion and presentation of results • Draft a report					
Form(s) of instruction	Participation in a current research and development project for a duration of 5 weeks in an external institution (industry or research centre or in a research group in the Physics Department.					
Total workload in hours	240 hours			Credit points: 8 ECTS credits		
Module composition/workload in hours		A Course		B Autonomous work	C Final module examination incl. preparation	Total
		a Contact hours	b Preparation/revision			
	Internship		40	158	42	240
Examination requirements						
Form(s) of examination and contribution to final mark	Report: 40% Presentation: 60%					
Frequency, duration	Summer semester; 1 semester					
Intake capacity/form of registration	60/online					
Language of instruction	* See separate list for current semester (StudIP)					
Date/Literature	* See separate list for current semester (StudIP)					

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Module	**Methods and Applications of Atomic and Nuclear Physics**	**5/3 CP**

Module description	**Methods and Applications of Atomic and Nuclear Physics**
Module code	**BP-23G**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • have knowledge of the fundamental principles of the generation of electron, ion and photon beams; • know the elementary interactions of particles and photons in materials; • have fundamental knowledge of detector principles and key measurement instruments; • have the ability to identify application areas from the literature and to present these coherently in the context of a seminar.
Module content	Generation of high-energy radiation, electron and ion beams, particle sources, high voltage technology, accelerator principles, interactions of radiation with materials, detection of radiation, principles of gas, semi-conductor and scintillation detectors, matter characterisation, applications in medical diagnostics and therapy, problems of nuclear energy, applications in atomic and nuclear physics.
Form(s) of instruction	• Lecture (2 hours/week) • Seminar (1 hour/week)
Total workload in hours	150 hours or 90 hours (without seminar presentation) — Credit points: 5 or 3 (without seminar presentation) ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	30	15		15	60
Seminar	21	15	34	20	90
Total	51	30	34	35	150

Examination requirements	
Form(s) of examination and contribution to final mark	Seminar presentation with a mark of at least “sufficient”: 40%/0% Oral or written final examination: 60%/100%
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	40/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**English for Young Physicists**	**2 CP**

Module description	**English for Young Physicists**
Module code	**BP-23H**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • learn to present a topic from the field of physics in English; • learn to lead a scientific discussion in English; • learn vocabulary and grammar necessary for a scientific research stay in an English-speaking country.
Module content	Academic vocabulary in English, training of grammar, correct application of conditional sentences, prepositions, adverbs, rhetoric: training of rephrasing.
Form(s) of instruction	• Seminar (2 hours/week)
Total workload in hours	60 hours — Credit points: 2 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation(English vocabulary research: 5 hours; lecture in English with 20 slides or written research work in English of 4 pages with 300 words per page)	Total
	a Contact hours	b Preparation/revision			
Seminar	30	15		15	60
Total	30	15		15	60

Examination requirements	
Form(s) of examination and contribution to final mark	Final written assignment: 75% Homework: 25%
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	50/online
Language of instruction	90% English/10% German
Date	By arrangement
Literature	* See separate list for current semester (StudIP)

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Module	**Introductory Seminar on Experimental Nuclear and Particle Physics**	**3 CP**

Module description	**Introductory Seminar on Experimental Nuclear and Particle Physics**
Module code	**BP-23I**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • be familiarised with current topics in nuclear and particle physics through the preparation of a presentation based on original literature; • practise convincing presentation style and the use of contemporary presentation media.
Module content	Structure of nucleons, meson production, quark structure of hadrons, particle physics, CP violation, neutrino physics, heavy ion reactions, accelerators, generation of radioactive beams, structure of exotic nuclei, nuclear astrophysics, mass spectrometry.
Form(s) of instruction	• Seminar (2 hours/week)
Total workload in hours	90 hours — Credit points: 3 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Seminar	36	15	24	15	90
Total	36	15	24	15	90

Examination requirements	
Form(s) of examination and contribution to final mark	Successful preparation and delivery of a presentation: 100%
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	30/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Introductory Seminar on Theoretical Nuclear and Hadron Physics**	**3 CP**

Module description	**Introductory Seminar on Theoretical Nuclear and Hadron Physics**
Module code	**BP-23J**
Faculty/Subject/Department	Faculty 07/Physics/Department of Theoretical Physics
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall: • be familiarised with current topics of theoretical nuclear, hadronic, astro and particle physics through the preparation of a presentation based on original literature; • practise a convincing presentation style and the use of contemporary presentation media.
Module content	Structure of nucleons, quark model of hadrons, fundamental symmetries of QCD, meson production, quark, neutrino physics, heavy ion reactions, scattering theory, nuclear structure and reaction theory, nuclear astrophysics.
Form(s) of instruction	• Seminar (2 hours/week)
Total workload in hours	90 hours — Credit points: 3 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Seminar	36	15	24	15	90
Total	36	15	24	15	90

Examination requirements	
Form(s) of examination and contribution to final mark	Successful preparation and delivery of a presentation: 100%
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	10/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Elementary Differential Geometry**	**9 CP**
Module description	**Elementary Differential Geometry**	
Module code	**BP-23K**	
Faculty/Subject/Department	Faculty 07/Mathematics/Department of Mathematics	
Associated degree course(s)/Semester taken	BSc Physics, MSc Physics	
Module coordinator	Cf. German Version	
Prerequisites	Mathematics for Physics Students I and II or equivalent knowledge	
Module guidance	Cf. German Version	
Learning outcomes	Students shall be familiar with curves and surfaces in a space as well as with their inner geometry.	
Module content	• Curves and surfaces • Riemannian metrics • Curvature concepts • Gaussian theorem (Theorema egregium)	
Form(s) of instruction	• Lecture (4 hours/week) • Tutorial (2 hours/week)	
Total workload in hours	270 hours	Credit points: 9 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	60			120
Tutorial	30	90		30	150
Total	90	150		30	270

Examination requirements	Successful and regular attendance of tutorials.
Form(s) of examination and contribution to final mark	1 written or oral examination: 100%
Frequency, duration	Irregular, approximately every 4th semester; 1 semester
Intake capacity/form of registration	200/online
Language of instruction	German or English
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Renewable Energy Sources and Photo-Electricity**	**6 CP**

Module description	**Renewable Energy Sources and Photo-Electricity**
Module code	**BP-23L**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	Experimental Physics IV
Module guidance	Cf. German Version
Learning outcomes	Students shall: • be familiarised with the fundamentals of renewable energy sources and their application potential; • learn about the physics of simple semi-conductor components, such as the Schottky contact and p/n diodes, the principles of which form the basis of modern photovoltaic module technology; • be familiarised with the societal indicators as well as the economic conditions that set the framework for the implementation of these technologies.
Module content	Energy-wealth relations; conventional energy sources, biomass, geothermic energy, wind and water, thermal solar energy converters, nuclear energy, photovoltaics.
Form(s) of instruction	• Lecture (2 hours/week) • Seminar (2 hours/week)
Total workload in hours	180 hours — Credit points: 6 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation (student lecture)	Total
	a Contact hours	b Preparation/revision			
Total	60	60		60	180

Examination requirements	
Form(s) of examination and contribution to final mark	Oral examination: 60% Presentation: 40%
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	30/online
Language of instruction	* See separate list for current semester (StudIP)
Date/Literature	* See separate list for current semester (StudIP)

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Module	**Computational Exercises in Quantum Mechanics**				**2 CP**
Module description	**Computational Exercises in Quantum Mechanics**				
Module code	**BP-23M**				
Faculty/Subject/Department	Faculty 07/Physics				
Associated degree course(s)/Semester taken	BSc Physics				
Module coordinator	Cf. German Version				
Prerequisites	To be taken concurrently with the lecture in Quantum Mechanics				
Module guidance	Cf. German Version				
Learning outcomes	Students shall: • master quantum mechanics methods; • be able to autonomously solve quantum mechanics problems with the aid of computer programmes.				
Module content	The module consists of a series of quantum mechanics problems to be solved either analytically or numerically. The theoretical concepts learnt in the lecture component of Quantum Mechanics Theory (BP-15) will be practically applied. Assignments shall give students practice in autonomously solving quantum mechanics problems. The following topics will be covered in particular: • Potential wells • Wave packets • Hydrogen atom • Kronig-Penney model • Spin dynamics				
Form(s) of instruction	• Computer tutorials (2 hours/week)				
Total workload in hours	60 hours			Credit points: 2 ECTS credits	
Module composition/workload in hours		A Course		B Autonomous work	C Final module examination incl. preparation	Total
		a Contact hours	b Preparation/revision			
	Computer tutorials	28	17.5		14.5	60
Examination requirements						
Form(s) of examination and contribution to final mark	1 written examination (3 hours): 100% or 1 oral examination (0.5 hours): 100%					
Frequency, duration	Summer semester; 1 semester					
Intake capacity/form of registration	20/online					
Language of instruction	* See separate list for current semester (StudIP)					
Date/Literature	* See separate list for current semester (StudIP)					

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Module	**Fundamentals of Micro- and Nanostructuring**	**6 CP**

Module description	**Fundamentals of Micro- and Nanostructuring**
Module code	**BP-23N**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics
Module coordinator	Cf. German Version
Prerequisites	• Working knowledge of English • Physically fit to work in a cleanroom environment
Module guidance	Cf. German Version
Learning outcomes	Students shall: • be familiar with the fundamental methods and materials of micro-structuring and nano-structuring (planar technology); • have an understanding of the necessary infrastructural technology (cleanroom technology); • have the ability to analyse micro-technical and (top-down-) nano-technical design drafts for devices with regard to their feasibility from a manufacturing point of view; • be able to draw up concepts of simple process flows and generate the required CAD data.
Module content	• Photolithography, electron beam lithography • Structural transfer, wet and dry etching • CAD: file formats, tools • Measurement and characterisation methods of micro-technology, microscopy • Cleanroom technology and conduct within a cleanroom • Selected applications of micro-technology and nano-technology
Form(s) of instruction	• Lecture (2 hours/week) • Tutorials in the form of laboratories in small groups or as individual tutorials (2 hours/week) • Seminar (2 hours/week)
Total workload in hours	180 hours — Credit points: 6 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	30	60	30		120
Lab work in a cleanroom lab, incl. preparation of data or seminar paper			60		60
	30	60	90		180

Examination requirements	
Form(s) of examination and contribution to final mark	Progress monitoring (quiz format) and homework: 50% and Production of a micro- or nano-structure and documentation thereof: 50% or Seminar presentation: 50%
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	20/online
Language of instruction	German or English (if student demand is sufficient)
Date	* See separate list for current semester (StudIP) Lecture: Fridays 2pm to 4pm Laboratory dates: according to individual arrangement
Literature	None; material will be placed on Stud.IP

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Module	**Biological and Nanoelectronical Systems**	**6 CP**

Module description	**Biological and Nanoelectronical Systems**
Module code	**BP-23P**
Faculty/Subject/Department	Faculty 07/Physics
Associated degree course(s)/Semester taken	BSc Physics, BSc Advanced Materials
Module coordinator	Cf. German Version
Prerequisites	None
Module guidance	Cf. German Version
Learning outcomes	Students shall be taught the following: • Fundamental properties of semi-conductor electrolyte interfaces; progression of charge carrier concentration and electric potential vertically to these interfaces; • Interaction between charge carriers in semi-conductors and the charge distribution at the semi-conductor/electrolyte interface; • Coupling concepts of bio-organic functional systems with semi-conductor devices and the associated analysis; • Technical challenges in the realisation of integrated “lab-on-chip” systems; • Fundamentals of electronic coupling of living cells with field effect transistors; • Electrical properties of ion channels in cell membranes; • Advantages of the detection of (bio-)chemical signals by the use of semi-conductor nano-structures; • Influence of surface charges in semi-conductor nano-structures on chemical surface reactions; • Feasibility of electrical and optical detection of chemical reactions at the surface.
Module content	<u>Fundamentals of field effect transistors in electrolytes</u> • Semi-conductor/electrolyte interface • Ion sensitivity of semi-conductor surfaces • Ion sensitivity of field effect transistors <u>Applications of field effect transistors in electrolytes</u> • Bio-functionalisation of semi-conductors • Analytical methods • BioFETSs; enzyme modified FETs, Immuno-FETs <u>Cell-transistor hybrid systems</u> • Lipid membrane structures and electrical properties • Electronic modelling of cell-transistor hybrid systems <u>Lab-on-Chip Systems</u> • Fundamentals of micro-fluidics and nano-fluidics • Electrophoresis, electroosmosis <u>Chemical and biochemical nano-sensors</u> • Self-assembled growth of semi-conductor nano-structures • Electronic and optical properties • Application of nano-structures in chemical sensor technology
Form(s) of instruction	• Lecture (2 hours/week) • Seminar (1.3 hours/week)
Total workload in hours	180 hours — Credit points: 6 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	30	45			75
Seminar	20	20	35	30	105
	50	65	35	30	180

Examination requirements	
Form(s) of examination and contribution to final mark	Oral examination (30 minutes): 50% Seminar presentation: 50%
Frequency, duration	Winter semester; 1 semester
Intake capacity/form of registration	20/online
Language of instruction	* See separate list for current semester (StudIP)
Date	* See separate list for current semester (StudIP)
Literature	* See separate list for current semester (StudIP)

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Module	**Experimental Physics VI: Particle Physics**	**6 CP**
Module description	**Experimental Physics VI: Particle Physics**	
Module code	**BP-23Q**	
Faculty/Subject/Department	Faculty 07/Physics	
Associated degree course(s)/Semester taken	BSc Physics	
Module coordinator	Cf. German Version	
Prerequisites	None	
Module guidance	Cf. German Version	
Learning outcomes	Students shall understand the modern fundamentals and methods of experimental hadronic, nuclear and particle physics.	
Module content	Properties and systematics of fundamental particles and hadrons, strong and weak interactions, standard model of particle physics, modern accelerator equipment and experiments, physics with heavy ions, astrophysical aspects of hadronic, nuclear and particle physics, origin of the universe.	
Form(s) of instruction	• Lecture (4 hours/week) • Seminar (2 hours/week)	
Total workload in hours	180 hours	Credit points: 6 ECTS credits

Module composition/workload in hours

	A Course		B Autonomous work	C Final module examination incl. preparation	Total
	a Contact hours	b Preparation/revision			
Lecture	60	45			105
Tutorial	30		30	15	75
Total	90	45	30	15	180

Examination requirements	
Form(s) of examination and contribution to final mark	Written examination (pass mark: 50%): 75%; 50% of tutorial problems successfully solved: 25%
Frequency, duration	Summer semester; 1 semester
Intake capacity/form of registration	100/online
Language of instruction	* See separate list for current semester (StudIP)
Date	* See separate list for current semester (StudIP)
Literature	* See separate list for current semester (StudIP)

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Module	**Bachelor's Thesis**	**12 CP**
Module description	**Bachelor's Thesis**	
Module code	**BP-24**	
Faculty/Subject/Department	Faculty 07/Physics	
Associated degree course(s)/Semester taken	BSc Physics	
Module coordinator	Cf. German Version	
Prerequisites	None	
Module guidance	Cf. German Version	
Learning outcomes	Students should have the skills to apply scientific methods to solve a concrete scientific problem, present their findings in a scientific paper, and defend their findings.	
Module content	• Drafting of a work plan • Familiarisation with relevant literature • Developing the measurement and analysis methods, or theoretical solution methods, implementation and evaluation or numerical calculations, discussion and diagram of results • Writing of dissertation and of a poster presentation	
Form(s) of instruction	9 weeks, full-time	
Total workload in hours	360 hours	Credit points: 12 ECTS credits
Prerequisites for examination		
Form(s) of examination and contribution to final mark	Dissertation: 100% and poster presentation	
Frequency, duration	Summer semester; 1 semester	
Intake capacity/form of registration	90/online	
Language of instruction	* See separate list for current semester (StudIP)	
Date	* See separate list for current semester (StudIP)	
Literature	* See separate list for current semester (StudIP)	