Universität Regensburg

DEPARTMENT OF PHYSICS
Examination Committee
Master of Physics

Regensburg, den 3. November 2015

Contents of Bachelor of Science in Physics at the University of Regensburg

The degree program for the Bachelor of Physics is composed of course modules and is completed by a Bachelor thesis. For a regular study curriculum the amount of credit points required is 180 ECTS points. The regular period to obtain the Bachelor of Science degree in physics is 6 semesters.
The first year of study is intended as an orientation phase. This phase allows the student to explore his/her abilities and strength. The program is organized such that a very broad spectrum of contents can be covered. Once the Bachelor exams are successfully completed the faculty of natural sciences awards the Bachelor of Science degree (B.Sc.) to the candidate.
The degree program for the Bachelor of Science has the following objectives:

- For students who intend to proceed with their studies and pursue a Masters degree in physics the Bachelor program provides a solid basic education which allows them to directly deal with topics of current research.
- For students who intend to conclude their academic education after obtaining the Bachelor degree the program offers a broad spectrum of non-physics subjects. These subjects allow combining the contents of the physics degree in an interdisciplinary fashion with the contents of other academic programs. Such a combination allows the students to gear their education perfectly towards their intended occupational field.

The main focus of the program is placed on physics however other subjects can be integrated. This flexibility allows the students to obtain an interdisciplinary profile to be attractive to various segments of the job market.
We anticipate that the majority of Bachelor alumni will not be confronted with physics problems in the long run during their professional experience. Nevertheless our alumni are sought-after in diverse segments of the job market. The reason for this is that analytical thinking and efficient problem solving strategies are essential components of the Bachelor of Physics program. Such capabilities are vital for many technical occupations as well as in executive positions.
To be accepted as a Bachelor student the general university admission rules apply.
The degree program for the Bachelor of Physics is arranged as follows:

- Mandatory subjects with a total amount of 127 ECTS points
- Elective courses with a total amount of 41 ECTS points
- The Bachelor thesis with a total amount of 12 ECTS points

Mandatory subjects

The mandatory studies are composed of the following modules

- Analysis for physics
- Mathematical methods and Linear Algebra
- Experimental physics A and B

- Theoretical physics I and II
- Structure of matter I: nuclear physics
- Structure of matter II: solid state physics
- Structure of matter III: nuclear and particle physics
- Lab courses A and B
- Advanced lab course I

Elective courses

The elective courses are grouped into three divisions

- Advanced Physics
  - Theoretical physics III: quantum mechanics II
  - Theoretical physics IV: quantum statistics
  - Advanced lab II

The modules in this area are indented to extend the physics understanding. Two of these modules are required for the subsequent admission into the Masters of Physics program.

- Supplementary Subjects
  - Chemistry
  - Biology
  - Mathematics
  - History of Science
  - Philosophy
  - Business administration
  - Business informatics
  - Political science
  - Bioinformatics

The supplementary subjects are as a general rule modules of bachelor programs that are offered by other departments of the University of Regensburg. The approval of such courses as supplementary subjects is based on agreements between different departments. The list of possible supplementary subjects is continuously extended and updated.

- Other Courses
  - Introduction to the Maple software package
  - Programming in C and C++
  - Scientific typesetting with LaTeX
  - Introduction to the Matlab software package
  - IT and Media
  - Seminar
  - Mathematical basics

These courses are intended to either extend existing knowledge in certain areas or to obtain multidisciplinary qualifications

For the elective courses the following minimum requirements apply:

- Either one Supplementary module and two advanced physics modules

– or two supplementary modules have to be successfully completed

Bachelor Thesis

A three-month experimental or theoretical study, conducted at the physics institute concluded by a thesis with a length of approximately 25 pages.

Example of a bachelor curriculum

Please note that the following list contains particular courses i. e. modules. The corresponding links contain a full description of the elements of the modules.

Semester	Course	Weekly hours	Hours (total)
B1	Experimental Physics I: Mechanics	4+2	
	Mathematics for Physicists I: Calculus I	4+2	
	Mathematics for Physicists II: Linear Algebra	4+2	
	Beginners Lab course A1	2.5	
	Supplemental studies	2	22.5
B2	Experimental Physics II: Electrodynamics	4+2	
	Theoretical Physics Ia: Classical Mechanics	4+2	
	Mathematics for Physicists III: Calculus II	4+2	
	Beginners Lab course A2	2.5	
	Supplemental studies	2	22.5
B3	Experimental Physics III: Waves and Quanta	4+2	
	Theoretical Physics Ib: Electrodynamics	4+2	
	Mathematics for Physicists VI: Calculus III	4+2	
	Lab course B	5	
	Supplemental studies	2	23
B4	Experimental Physics VI: Thermodynamics	4+2	
	Theoretical Physics II: Quantum Mechanics	4+2	
	Structure of Matter I: Atoms and Molecules	4+2	
	Miscellaneous	2	20
B5	Theoretical Physics III: Quantum Mechanics II	4+2	
	Structure of Matter II: Solid State Physics	4+2	

	Structure of Matter III: Nuclei and particles	4+2	
	Advanced Lab Course I	9	27
B6	Theoretical Physics VI: Quantum Statistics	4+2	
	Advanced Lab Course II	8	
	Supplementary Course	4	
	Bachelor thesis	6	24

The examination regulations also allow students to attend fewer physics courses and more supplementary courses. Also more emphasis on theoretical or experimental physics courses is possible. All underlined courses are required (mandatory courses).

Table of contents:

- Self adjunct and Hermitean endomorphisms
- Orthogonal and unitary endomorphisms
- Major axis transformations

Mathematics for physicists III: Calculus II

- Curves in n-dimensional space
- Differentiable mappings in n dimensions
- Vector fields and potentials
- Taylor expansion in multiple variables
- Minima and maxima with side conditions
- Theorems about inverse functions and implicit functions
- Manifolds
- Integrals in n-dimensional space
- Transformation equations
- Polar and cylindrical coordinates
- Conventional differential equations
- Linear differential equations
- Differential expressions
- Integral theorems in n dimensions (theorems of Gauss, Greene and Stokes)
- Theorem of divergence and rotation

Mathematics for physicists IV: Calculus III

- Analytical functions
- Curve integrals
- Cauchy's theorem
- Application of residual theorem
- Flux and systems of 1st order
- Linear Differential equations
- Boundary- and eigenvalue problems
- Equations from separation-ansatzes
- Differential equations in the complex plane
- Legendre's equation
- Spherical harmonics

Experimental Physics I: Classical mechanics (4hrs course, 2 hrs problem solving class, home study)

- Basic concepts of motion
- Newton's Laws
- Conservation of energy and momentum
- Rotational motion
- Oscillations
- Nonlinear mechanics and chaos
- Mechanical waves
- Solid matter

- Liquids

Experimental Physics II: Electrodynamics (4hrs course, 2 hrs problem solving class, home study)

- Basic electrostatics
- Applications of electrostatics
- Insulators in electric fields
- Electrical currents
- Magnetostatics
- Magnetic Induction
- Alternating currents
- Magnetic materials
- Electromagnetic waves

Experimental Physics III: Waves and Quanta (4hrs course, 2 hrs problem solving class, home study)

- Introduction: Light and electromagnetic waves
- Geometrical optics, beam optics
- Wave optics
- Polarization
- Wave equations and boundary conditions
- Wave/particle dualism

Experimental Physics IV: Thermodynamics (4hrs course, 2 hrs problem solving class, home study)

- Introduction: Energy transfer in systems
- Thermal systems
- Ideal gas
- Thermodynamic potentials
- Composed systems and equilibrium
- Flow of liquids and gases
- Real systems, phase transitions
- Statistical mechanics in spin ½ systems
- Fermi- and Bose systems
- Ideal Fermi gas: Sommerfeld model of free electrons
- Ideal Bose gas: phonons and photons

Beginners lab course A1: Mechanics (5hrs lab course biweekly, home study)

- Linear motion
- Elastic and inelastic scattering
- Rotary motion
- Moment of inertia and angular momentum
- Linear pendulum
- Non-linear pendulum

Beginners lab course A2: Electrodynamics (5hrs lab course biweekly, home study)

- I-V characteristics, Wheatstone bridge
- Oscilloscope and RC circuits
- Damped oscillation of RLC circuit
- AC behavior of RC and RL circuits
- RLC circuit and resonance properties

Lab course B: Experimental measurements, precision and error analysis (5hrs lab course biweekly, home study)

- Electronic properties (conductivity, magnetism, charge of electron, Hall effect)
- Electronic components (rectifiers, transformers, op-amps, single and coupled oscillators, solar cells, fuel cells, lock-in amplifiers, counters)
- Optics components (Fabry-Perot interferometer, polarizer, grating, slit)
- Optical phenomena (interference, polarization, diffraction, Kerr-microscopy, spectroscopy, filtering)

Advanced Lab course: Independent experimental measurements, use of modern equipment, precision and error analysis and lab report (9 hrs lab course biweekly, home study)

Theoretical Physics Ia: Classical mechanics

- Mechanics of point particles
- Concepts, Lagrange formalism
- Applications: One particle problems
- Applications: Many particle problems
- Special relativity
- Rigid body dynamics
- Hamiltonian mechanics
- Nonlinear Dynamics

Theoretical Physics Ib: Electrodynamics

- Introduction, Maxwell equations, notion of a field
- Mathematical tools
- Electrostatics
- Magnetostatics
- Time dependent electromagnetic fields
- Lorentz invariance of the Maxwell equations, relativistic effects
- Elements of optics and of electrodynamics in matter

Theoretical Physics II: Quantum mechanics

- Waves and particles, historical and experimental foundations
- From wave to quantum mechanics
- Elementary problems
- Central force problem and angular momentum
- Abstract formalism: vectors and operators in Hilbert space
- Angular momentum and spin
- Approximate methods

Theoretical Physics III: Quantum mechanics II

- Time dependent processes
- Few- and many-electron systems, atoms and molecules
- Basics of scattering theory
- Relativistic quantum mechanics
- Basics of field theory

Theoretical Physics IV: Quantum statistics

- Statistical ensembles
- Isolated systems
- Systems in contact with: heat bath, heat and particle reservoir
- Systems with interactions
- Thermostatics
- Equilibrium
- Thermodynamical calculus
- Phase transitions

Structure of Matter I: Atoms and molecules

- Wave-particle dualism
- Probability and probability amplitudes
- Simple quantum systems
- Time dependence of probability amplitudes
- Atoms
- Molecules

Structure of Matter II: Solid state physics

- Crystal structure and defects
- Lattice dynamics
- Electrons in a periodic potential
- Electronic transport in metals
- Phonons in metals
- Electrons in magnetic fields
- Semiconductors
- Optical properties of semiconductors
- Magnetism

Structure of Matter III: Nuclei and particles

- Properties of nuclei
- Models of nuclei
- Origin of chemical elements
- Scattering
- Energy absorption
- Applications of nuclear physics
- Experiments of particle physics

- Theoretical description of interactions
- Composition of matter from quarks and leptons
- Weak interaction
- Standard model of particle physics
- Limits of the standard model