Appendices Bachelor's degree programme Physics

Appendix I Learning outcomes of the degree programme (Article 1.3)

A. Generic learning outcomes – Knowledge

A1. Bachelor's graduates have general knowledge of the foundations and history of mathematics, natural sciences and technology, in particular those of their own discipline.

A2. Bachelor's graduates have mastered the basic concepts of their own discipline (see Appendix 1 for further specification) to a certain extent and are familiar with the interrelationships of these concepts within their own discipline as well as with other disciplines.

A3. Bachelor's graduates have in-depth knowledge of several current topics within their own discipline.

A4. Bachelor's graduates are familiar with the quantitative character of the fields of mathematics and natural sciences and have an understanding of the methods used in these fields, and particularly within their own discipline, including computer-aided methods.

A5. Bachelor's graduates have sufficient knowledge and understanding of mathematics and natural sciences to successfully complete a follow-up Master's degree programme in their own discipline.

A6. Bachelor's graduates are aware of the societal, ethical and social aspects involved in the fields of mathematics and natural sciences.

B. Generic learning outcomes – Skills

B1 (Research) Bachelor's graduates are able to draw up a research question, design, plan and conduct research and report on it independently with a certain degree of supervision. Bachelor's graduates are able to evaluate the value and limitations of their research and assess its applicability outside their own field.

B2 (Designing and Modeling) Bachelor's graduates are able to translate a problem, in particular a design problem, into a plan of approach and – taking into account the requirements of the client and/or technical preconditions – find a solution.

B3 (Gathering information) Bachelor's graduates are able to gather relevant information using modern means of communication and to critically interpret this information.

B4 (Collaborating) Bachelor's graduates are able to collaborate in teams (including multidisciplinary teams) on technical-scientific problems.

B5 (Communicating) Bachelor's graduates are able to communicate orally and in writing in academic and professional contexts, with both colleagues and others. They are familiar with the relevant means of communication.

B6 (Reflecting) Bachelor's graduates are able to assess their own actions and those of others in a natural sciences context, bearing in mind the social/societal and ethical aspects.

B7 (Learning skills) Bachelor's graduates are able to apply learning skills that enable them to pursue a follow-up degree and acquire knowledge in new fields with a high level of autonomy.

B8 Additional subject-specific skills are listed in Appendix 2.

Appendix 1 Degree programme-specific learning outcomes – Basic Knowledge

The Bachelor's graduate in Physics has:

1.1. Knowledge of the most important subjects in the field of
- a) Classical Mechanics / Mechanics
- b) Electromagnetism
- c) Quantum Physics
- d) Thermodynamics
- e) Statistical Physics
- f) Wave phenomena, Oscillations and Optics
- g) Materials: structure and interactions
- h) Calculus and Linear Algebra

1.2. Knowledge of topics in at least one of the following research fields
- a) Theoretical Physics
- b) Particle Physics
- c) Nano Physics
- d) Energy and Environment
- e) Life and Health

1.3. Achieved in the Minor, a deeper knowledge of subjects within their own discipline or a broad general knowledge of a different discipline.

Appendix 2 Degree programme-specific learning outcomes – Skills

The Bachelor's graduate in Physics is able to:

2.1. estimate the orders of magnitude of various physical processes,
2.2. use specific software, such as a programming language or a (symbolical) software package,
2.3. setup and carry out an experiment, while taking into account the safety and environmental issues,
2.4. analyze experimental data in a proper and ethical manner, including an error analysis.

Appendix II Follow-on Master's degree programmes (Article 1.5)

The Bachelor's degree programme will grant unconditional admission to the following Master's degree programmes at the University of Groningen:

- Physics
- Education and Communication in Mathematics and Natural Sciences
- Energy and Environmental Sciences

Appendix III Majors and Minors in the degree programme (Article 2.1.2)

1) The total programme consists of a core part and an elective part that consists of a Major and a Minor, and which is chosen from the following three tracks:
   - Physics of Energy and Environment
   - Physics of Life and Health
   - Experimental and Theoretical Physics
2) The Physics of Energy and Environment track includes the Minor Physics of Energy and Environment. The Physics of Life and Health track includes the Minor Physics of Life and Health.
   The Minor for the Experimental and Theoretical Physics track may be chosen from the collection of university and faculty Minors.

Appendix IV Course units in the propaedeutic phase

- **List of course units; Article 3.1.1**
- **Course units with one or more practicals; Article 3.2**
- **Form of examinations; Article 7.4**

Course unit	ECTS	Assessment method	Practical
Calculus 1	5	Written exam, test	x
Physics Laboratory 1	5	Written exam, practical assessment (preparation, experimental skills, lab journal, reports, discussion of results)	x
Choice: ▪ Kaleidoscope Modern Physics ▪ Molecules: Structure, Reactivity, and Function ▪ Introduction to Mathematics	5	 ▪ Written exam ▪ Written exam, practical assessment, discussion of results ▪ Written exam	x
Thermodynamics	5	Written exam	
Mechanics and Relativity 1	5	Written exam	
Linear Algebra 1	5	Written exam, practical assessment	x
Mechanics and Relativity 2	5	Written exam, practical assessment	x
Calculus 2	5	Written exam	
Choice: ▪ Introduction Astronomy ▪ Physics of Modern Technology ▪ Introduction to Physics Bachelor Tracks ▪ Introduction NExT ▪ Introduction to Energy and Environment ▪ Physics of Life	5	 ▪ Homework, mid-exam, written exam, report, mandatory attendance Introduction Research ▪ Written exam, presentation, essay, mandatory attendance Introduction Research ▪ Written exam, presentation, mandatory attendance Introduction Research ▪ Written exam, mandatory attendance Introduction Research ▪ Written exam, mandatory attendance Introduction Research ▪ Oral exam, mandatory attendance Introduction Research	
Calculus 3	5	Written exam	
Electricity and Magnetism I	5	Written exam, practical assessment	x
Physics Laboratory 2	5	Practical assessment (presentation schedule, presentation of results, report, poster presentation)	x

Appendix V Course units in the post-propaedeutic phase

- **List of course units; Article 6.1**
- **Course units with one or more practicals; Article 6.2**
- **Compulsory order of examinations; Article 7.2**
- **Form of examinations; Article 7.4**

Course unit	ECTS	Assessment method	Practical	Prerequisites
Introduction to Programming and Numerical Methods	5	Written exam, practical assessment	x	
Electricity and Magnetism II	5	Written exam		
Quantum Physics 1	5	Written exam		
Waves and optics	5	Written exam, practical assessment	x	
Statistical Physics	5	Written exam		
Electronics and signal processing	5	Written exam, practical assessment	x	
Structure of Matter 1	5	Written exam		
Science and Society	5	Written exam, performance, essay, presentation, mandatory attendance		
Structure of Matter 2	5	Written exam		
Physics Laboratory 3	5	Practical assessment (preparation, experimental skills, lab journal, report, discussion of results)	x	
Track ▪ Physics of Energy and Environment ▪ Physics of Life and Health ▪ Experimental and Theoretical Physics	55	See individual tables		
Bachelor Research Project	15	Performance, presentation, report	x	Passed 150 ECTS of the Bachelor's degree programme

Physics of Energy and Environment

Course unit	ECTS	Assessment method	Practical
Geo-energy	5	Written exam	
Climate System and Atmosphere	5	Written exam	
Physics Laboratory 4	5	Practical assessment (preparation, experimental skills, lab journal, report, discussion of results)	x
Thermodynamics of Energy Systems	5	Written exam	
Nuclear energy	5	Written exam, essay	
Energy from Gas	5	Report	
Solar Cells	5	Written exam, presentation, report	
Principles of Measurement Systems	5	Written exam, homework assignments	
Physics of Fluids	5	Written exam	
Energy and Society	5	Written exam, assignments, report	
Applied Spectroscopy	5	Written exam	

Physics of Life and Health

Course unit	ECTS	Assessment method	Practical
Molecular Biophysics	5	Written exam	
Structural Biology	5	Written exam	x
Physics Laboratory 4	5	Practical assessment (preparation, experimental skills, lab journal, report, discussion of results)	x
Molecular Dynamics	5	Report, presentation, (research) assignment	x
Ionizing Radiation in Medicine	5	Written exam, presentation, participation excursion	
Imaging Techniques in Radiology	5	Written exam, case studies	x
Nanophysics and Nanotechnology	5	Written exam	
Principles of Measurement Systems	5	Written exam, homework assignments	
Physics of Fluids	5	Written exam	
Biochemistry	5	Written exam	x
Cellular Chemistry	5	Written exam	x

Experimental and Theoretical Physics

Course unit	ECTS	Assessment method	Practical
Choice: ▪ Complex Analysis ▪ Molecular Biophysics	5	 ▪ Written exam ▪ Written exam	
Quantum Physics 2	5	Written exam	
Minor	30	Depending on courses	
Choice: ▪ Astroparticle Physics ▪ Device Physics ▪ Symmetry in Physics ▪ Relativistic Quantum Mechanics ▪ Nano-probing and Nano-fabrication ▪ Materials Design: Theoretical Methods ▪ Fundamentals of Particle Physics	15	 ▪ Written exam ▪ Written exam, case studies ▪ Written exam ▪ Written exam, assignments ▪ Written exam ▪ Written exam, computer practical assessment, report ▪ Written exam	 x

Minor Experimental and Theoretical Physics 'Science for Scientists'

The Minor comprises 30 ECTS and is a coherent and deepening package of course units

Course unit	ECTS	Assessment method	Practical
Physics Laboratory 4	5	Practical assessment (preparation, experimental skills, lab journal, report, discussion of results)	x
Cosmology	5	Written exam, homework assignments	
Nuclear Energy	5	Written exam, essay	
Ionizing Radiation in Medicine	5	Written exam, presentation, participation excursion	
Solid State Physics 1	5	Written exam	
Atoms and Molecules	5	Written exam	
Subatomic Physics	5	Written exam	
Modern Developments Nanophysics	5	Presentation, active participation presentation sessions	
Chaos Theory	5	Essay	

Experimental Techniques Particle Physics	5	Written exam	
Nanophysics and Nanotechnology	5	Written exam	
Advanced Mechanics	5	Written exam, numerical homework assignments	
Principles of Measurement Systems	5	Written exam, homework assignments	
Electives, courses from Bachelor's programmes Chemistry, Chemical Engineering, (Applied) Physics, Astronomy, (Applied) Mathematics, Industrial Engineering and Management, which are to be individually approved by the Exam Committee.	0-30	See the programme-specific appendices IV and V of the Teaching and Examination Regulation.	See the programme-specific appendices IV and V of the Teaching and Examination Regulation.

Appendix VIII Admission to the post-propaedeutic phase

The following candidates will be admitted to the post-propaedeutic phase:

- Holders of a propaedeutic certificate of the degree programmes in Physics or Applied Physics