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# Appendices for the Bachelor's degree programme(s) in Mathematics

## 2022-2023

# Appendix I Learning outcomes of the Bachelor's degree programme (Article 3.1.1)

As a consequence of the ongoing automation of society and the technological innovations that go along with this, the call of our society for mathematics is growing. Underneath virtually every form of automation lies a mathematical concept or model. In order to be able to respond to this development in society, it is important that mathematics is utilized in a proper and effective way. This requires that society has access to sufficiently many well qualified and highly trained mathematicians.

The Bachelor's degree programme in Mathematics aims to impart knowledge, skills, understanding and an academic attitude in the field of mathematics by means of a broadly based curriculum such that Bachelor's graduates are able to pursue an independent career as independent professionals and are also qualified for further training to become academic researchers in the field.

The Bachelor's graduate must be able to progress to the follow-on Master's degree programme in Mathematics. Graduates of the bachelor's degree programme in Mathematics should also be able to take the Master's degree programme in Applied Mathematics or in Education and Communication. In addition, Bachelor's graduates who have taken the 'Educatieve Minor' (teacher-training minor) gain a Grade Two teaching qualification in mathematics.

**Learning outcomes BSc Mathematics track General Mathematics**

The above aim has been translated into a set of learning outcomes which consists of generic learning outcomes complemented with specified learning outcomes with respect to both Knowledge and Skills.

**A. Generic learning outcomes – Knowledge**

Bachelor's graduates in Mathematics track General Mathematics

A1. have general knowledge of the foundations and principle branches of mathematics.

A2. have mastered the basic concepts of mathematics (see Appendix I for further specification) to a certain extent and are familiar with the interrelationships of these concepts within mathematics as well as with other disciplines (e.g., physics, logic, or philosophy).

A3. have in-depth knowledge of several current topics within mathematics.

A4. are familiar with the quantitative character of mathematics and have an understanding of the methods used in this field.

A5. have sufficient knowledge and understanding of mathematics to successfully complete a follow-up Master's degree programme in Mathematics.

A6. are aware of the societal, ethical and social aspects involved in the field of mathematics.

**B. Generic learning outcomes – Skills**

Bachelor's graduates in Mathematics track General Mathematics

B1 (Research) 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. See Appendix II for further specification.

B2 (Problem Solving) are able to identify, apply, and choose among several potentially appropriate mathematical methods, persist in the face of difficulty, emphasize the importance of clarity and precision, and present solutions that include appropriate justification for their reasoning. See Appendix II for further specification.

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

B4 (Collaborating) are able to collaborate intellectually and creatively in diverse contexts, while applying mathematical reasoning as well as emphasizing its importance.

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

B6 (Reflecting) 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) 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.

**Appendix I Specified basic knowledge related learning outcomes**

Bachelor's graduates in Mathematics track General Mathematics

1.1. have mastered the basic concepts and techniques of mathematics, in particular single and multivariable calculus, linear algebra, analysis, ordinary differential equations, probability theory, statistics and algebra.
1.2. have knowledge of more advanced subjects within the fields of algebra, geometry, analysis, numerical mathematics, dynamical systems, probability and statistics.
1.3. have specific knowledge of one of the fields of Pure Mathematics.
1.4. have gained knowledge of and experience in the 'heart' of mathematics, i.e., understand the basic rules of logic, appreciate the role of mathematical proof, proficiently construct logical arguments and rigorous proofs, formulate and solve abstract mathematical problems.
1.5. recognize connections between different branches of mathematics, understand the connections between theory and applications, and have knowledge of various applications of mathematics.
1.6. are able to use mathematical software packages in an effective way or, if necessary, modify programs themselves.

**Appendix II Degree programme-specific learning outcomes – Skills**

Bachelor's graduates in Mathematics track General Mathematics

***Research***

2.1 have an academic attitude, which means they are curious, critical, creative and dare to show initiative.

2.2 are able to formulate relatively simple mathematical questions and problems in an exact way and if necessary, adapt them to make them tractable.

2.3 are able to articulate assumptions, understand the importance of detailed definitions, and are able to think in an organized way, to apply exact logical arguments when solving problems, and to generalize and abstract.

2.4 are able to analyse and abstract simple problems that are outside the scope of their own study programme and to independently acquire new knowledge to this end.

***Problem solving***

2.5 are able, under supervision and from the perspective of their field of interest, to translate a problem into a relevant mathematical problem definition and to this end formulate and evaluate a solution based on source research.

2.6 are able to distinguish a coherent argument from a fallacious one, make vague ideas precise by formulating them in the mathematical language, recognize real-world problems that are amenable to mathematical analysis, and use fundamental mathematical concepts and methods to study these problems.

2.7 are able to approach mathematical problems on the basis of a certain logical system and with determination to find the right method of approach.

2.8 are aware of the importance of researching specific cases and examples and have the attitude and skills necessary to critically evaluate the solutions found, test them for correctness and interpret them.

2.9 are able, by abstracting and reasoning, to delve into the root of a problem and determine whether existing methods can be applied or new methods must be developed.

**Learning outcomes BSc Mathematics track Probability and Statistics**

This track differs in the following learning outcomes from the track General Mathematics

A2'. have mastered the basic concepts of mathematics, probability and statistics (see Appendix I' for further specification) to a certain extent and are familiar with the interrelationships of these concepts within mathematics as well as with other disciplines (e.g., econometrics, life sciences, physics).

B2' (Problem Solving, Modelling) are able to identify, apply, and choose among several potentially appropriate mathematical methods, present solutions that include appropriate justification for their reasoning, and 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. See Appendix II' for further specification.

B5' (Communicating) are able to communicate orally and in writing in academic and professional contexts, in English, and are able to interact with mathematicians as well with scientists who apply statistical methods. They are familiar with the relevant means of communication.

## Appendix I Specified basic knowledge related learning outcomes

Bachelor's graduates in Mathematics track Probability and Statistics

1.1. have mastered the basic concepts and techniques of mathematics, in particular single and multivariable calculus, linear algebra, analysis, ordinary differential equations, probability theory and statistics, and algebra.
1.2. have knowledge of more advanced subjects within the fields of algebra, geometry, analysis, numerical mathematics, dynamical systems, probability and statistics.
1.3. have specific knowledge of one of the fields of Pure Mathematics and Statistics.
1.4. have gained knowledge of and experience in precise (both mathematical and statistical) reasoning and mathematical proof.
1.5. recognize connections between different branches of mathematics, recognize the connections between theory and applications, and have knowledge of basic sciences at a level necessary to apply statistical or mathematical methods, and are aware of the wider multidisciplinary context of (life) science and engineering.
1.6. are able to use mathematical software packages in an effective way or, if necessary, modify programs themselves.

## Appendix II Degree programme-specific learning outcomes – Skills

Bachelor's graduates in Mathematics track Probability and Statistics

***Research***

2.1 have an academic attitude, which means they are curious, critical, creative and dare to show initiative.
2.2 are able to formulate relatively simple mathematical questions and problems in an exact way and if necessary, adapt them to make them tractable
2.3 are able to articulate assumptions, understand the importance of detailed definitions, and are able to think in an organized way, to apply exact logical arguments when solving problems, and to generalize and abstract.
2.4 are able to analyse and abstract simple problems that are outside the scope of their own study programme and to independently acquire new knowledge to this end.

***Problem solving, Modelling***

2.5 are able, under supervision and from the perspective of their field of interest, to translate a problem into a relevant mathematical problem definition and to this end formulate and evaluate a solution based on source research.
2.6 are able to make vague ideas precise by formulating them in the mathematical language, recognize real-world problems that are amenable to mathematical/statistical analysis, and are able to discuss the assumptions underlying their mathematical/statistical model, use mathematical/statistical concepts and methods to study these models.
2.7 are able to approach mathematical problems on the basis of a certain logical system and with determination to find the right method of approach and are aware of the limitations of the chosen method.
2.8 are aware of the importance of researching specific cases and examples and have the attitude and skills necessary to critically evaluate the solutions found, test them for correctness and interpret them.
2.9 are able, by modelling, abstracting and reasoning, to delve into the root of a problem and determine whether existing methods can be applied or new methods must be developed.

2.10 are able to conduct searches of literature, to critically use scientific databases and other sources of information, or to consult specialists to carry out statistical and mathematical analysis in order to study problems in (life) science and engineering.

# Appendix II Majors and Minors of the degree programme (Article 3.7.4)

The degree programme has the following two Tracks (165 ECTS):
- General Mathematics
- Probability and Statistics

The degree programme has the following choices in Minors (15 ECTS):
a. University-wide broadening minors
b. Faculty-wide deepening minors
c. Minor Mathematics (see Appendix IV)
d. Personal minor, based on an individual choice of course units to be approved by the Board of Examiners; the minor must be coherent and of sufficient level.

In addition, the programme offers the option of a Minor Abroad (30 ECTS) or an Education Minor (30 ECTS). Students who take a Minor Abroad or an Education Minor follow 150 ECTS from the track programme (instead of 165 ECTS); see Appendix IV for details.

The Minor Abroad has to satisfy the following two conditions:
- at least 15 ECTS of Mathematics (related) courses relevant to the student's track (at the discretion of the Board of Examiners)
- two coherent packages of 15 ECTS or one coherent package of 30 ECTS, both of sufficient level (at the discretion of the Board of Examiners)

To obtain a double Bachelor's degree in Mathematics and Physics a subspecialization of the Mathematics track General Mathematics can be combined with a subspecialization of the Physics track Particle Physics. The workload of this combination is 250 ETCS. Details can be found in App. III and IV.

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# Appendix III Course units in the propaedeutic phase

- **List of course units; Article 4.1.1**
- **Compulsory order of examinations; Article 9.3**

**Propaedeutic phase Bachelor's programme in Mathematics**
The propaedeutic phase of the Bachelor's degree programme in Mathematics with tracks in General Mathematics and Probability and Statistics comprises a compulsory joint programme of 60 ECTS:

| Course unit name | Course code | ECTS | Practical | Entry requirements |
|---|---|---|---|---|
| Calculus 1 | WBMA003-05 | 5 | PR | |
| Linear Algebra 1 | WBMA020-05 | 5 | PR | |
| Sets and Numbers | WBMA051-05 | 5 | | |
| Analysis | WBMA012-05 | 5 | | |
| Introduction to Graph Theory | WBMA052-05 | 5 | | |
| One out of:<br>- Introduction to Logic<br>- Mechanics and Relativity for Mathematicians | <br>WBAI013-05<br>WBMA060-05 | 5 | | |
| Calculus 2 | WBMA029-05 | 5 | | |
| Scientific Programming | WBMA053-05 | 5 | PR | |
| Linear Algebra 2 | WBMA035-05 | 5 | | |
| Linear Systems | WBMA043-05 | 5 | | |
| Probability Theory | WBMA046-05 | 5 | | |
| One out of:<br>- First-year Project Mathematics<br>- First-year Project Applied Mathematics | <br>WBMA041-05<br>WBMA040-05 | 5 | PR | |

**Propaedeutic Phase Double degree in Mathematics and Physics**
A student who desires to obtain both a Bachelor's degree in Mathematics and a Bachelor's degree in Physics has to be enrolled in both degree programmes. The learning outcomes of both programmes are met by combining a subspecialization of the Mathematics track General Mathematics with a subspecialization of the Physics track Particle Physics. The propaedeutic phase of this combination has a workload of 80 ECTS:

| **Course unit name** | **Course code** | **ECTS** | **Practical** | **Entry requirements** |
|---|---|---|---|---|
| Calculus 1 | WBMA003-05 | 5 | PR | |
| Linear Algebra 1 | WBMA020-05 | 5 | PR | |
| Physics Laboratory 1 | WBPH013-05 | 5 | PR | |
| Mechanics and Relativity | WBPH001-10 | 10 | | |
| Analysis | WBMA012-05 | 5 | | |
| One out of<br>– Sets and Numbers<br>– Introduction to Graph Theory | <br>WBMA051-05<br>WBMA052-05 | 5 | | |
| Physics of the Quantum Universe | WBPH028-05 | 5 | | |
| Electricity and Magnetism | WBPH033-10 | 10 | | |
| Calculus 2 | WBMA029-05 | 5 | | |
| One out of<br>– Scientific Programming<br>– Python for Physicists | <br>WBMA053-05<br>WBPH044-05 | 5 | PR | |
| Linear Algebra 2 | WBMA035-05 | 5 | | |
| Linear Systems | WBMA043-05 | 5 | | |
| Probability Theory | WBMA046-05 | 5 | | |
| One out of<br>– First-year Project Mathematics<br>– Physics Laboratory 2 | <br>WBMA041-05<br><br>WBPH050-05 | 5 | PR | |

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# Appendix IV Course units in the post-propaedeutic phase

- **List of course units; Article 7.1.1**
- **Compulsory order of examinations; Article 9.3**

**Post-propaedeutic phase Bachelor's programme in Mathematics**
The post-propaedeutic programme consists of common compulsory courses (70 ECTS), track specific compulsory courses (35 ECTS) and a minor (15 ECTS).

**Common compulsory courses**

| Course unit name | Course code | ECTS | Practical | Entry requirements |
|---|---|---|---|---|
| Group Theory | WBMA005-05 | 5 | | |
| Metric and Topological Spaces | WBMA036-05 | 5 | | |
| Statistics | WBMA009-05 | 5 | | |
| Complex Analysis | WBMA018-05 | 5 | | |
| Multivariable Analysis | WBMA022-05 | 5 | | |
| Geometry | WBMA034-05 | 5 | | |
| Functional Analysis | WBMA033-05 | 5 | | |
| Numerical Mathematics 1 | WBMA045-05 | 5 | PR | |
| Partial Differential Equations | WBMA008-05 | 5 | | |
| Mathematics & Society: Ethical and Professional Aspects | WBMA049-05 | 5 | | |
| Preparation Bachelor's Project | WBMA056-05 | 5 | | |
| Bachelor's Project Mathematics | WBMA902-15 | 15 | PR | Passed 150 ECTS of the Bachelor's programme in Mathematics, including Preparation Bachelor's Project |

**Track specific compulsory courses General Mathematics**

| Course unit name | Course code | ECTS | Practical | Entry requirements |
|---|---|---|---|---|
| Dynamical Systems | WBMA031-05 | 5 | | - |
| One out of:<br>- Project Security and Coding<br>- Project Chaos Theory | <br>WBMA026-05<br>WBMA025-05 | 5 | PR | <br>-<br>- |
| Algebraic Structures | WBMA039-05 | 5 | | - |
| Two out of:<br>- Analysis on Manifolds<br>- Advanced Algebraic Structures<br>- Philosophy of Science<br>- Introduction to Science and Education (Dutch) | <br>WBMA013-05<br>WBMA011-05<br>FI180WET<br>WBEC002-05 | 15 | | <br>-<br>-<br>-<br>- |

| | | | | |
|---|---|---|---|---|
| - Discrete Mathematics<br>- Stochastic Processes | WBMA019-05<br>WBMA048-05 | | | |
| Elective (see optional course units below) | | 5 | | |
| Elective (see optional course units below) | | 5 | | |

**Track specific compulsory courses Probability and Statistics**

| Course unit name | Course code | ECTS | Practical | Entry requirements |
|---|---|---|---|---|
| Discrete Mathematics | WBMA019-05 | 5 | | - |
| Probability and Measure | WBMA024-05 | 5 | | - |
| Stochastic Processes | WBMA048-05 | 5 | | - |
| Project Statistical Reasoning | WBMA038-05 | 5 | PR | - |
| Statistical Modelling | WBMA028-05 | 5 | PR | - |
| Elective (see optional course units below) | | 5 | | - |
| Elective (see optional course units below) | | 5 | | - |

The degree programme has the following choices in minors (15 ECTS):

a. University-wide broadening minors
b. Faculty-wide deepening minors
c. Minor Mathematics
d. Personal minor, based on an individual choice of course units to be approved by the Board of Examiners

The Minor Mathematics consists of 3 course units:

**Minor Mathematics**

| Course unit name | Course code | ECTS | Practical | Entry requirements |
|---|---|---|---|---|
| Three out of:<br>- Elementary Number Theory<br>- Percolation Theory<br>- Algebraic Topology<br>- Introduction to Optimization | WBMA057-05<br>WBMA056-05<br>WBMA058-05<br>WBMA054-05 | 15 | | |

In addition, the programme offers the option of a Minor Abroad (30 ECTS) or an Education Minor (30 ECTS). Students who take a Minor Abroad or an Education Minor do not have to take the following courses from the degree programme (15 ECTS):

| Track General Mathematics | Track Probability and Statistics |
|---|---|
| Two out of:<br>- Analysis on Manifolds<br>- Advanced Algebraic Structures<br>- Philosophy of Science<br>- Introduction to Science and Education (Dutch)<br>- Discrete Mathematics<br>- Stochastic Processes<br>One Elective | Two Electives<br>One out of:<br>- Statistical Modelling<br>- Stochastic Processes |

**Elective course units General Mathematics & Probability and Statistics**
Elective course units can be chosen from the post-propaedeutic track specific courses General Mathematics, the post-propaedeutic track specific courses Probability and Statistics, the compulsory Applied Mathematics courses and the Minor Mathematics as long as they are not otherwise part of the student's programme.

| Course unit name | Course code | ECTS | Practical | Entry requirements |
|---|---|---|---|---|
| Project Systems Theory | WBMA027-05 | 5 | PR | - |
| Differential Equation in Science and Engineering | WBMA061-05 | 5 | | - |
| Project Mathematical Modelling | WBMA055-05 | 5 | PR | - |
| Mathematical Modelling | WBMA007-05 | 5 | | - |
| Computational Methods of Science | WBMA004-05 | 5 | PR | - |
| Advanced Systems Theory | WBMA001-05 | 5 | | - |
| Numerical Mathematics 2 | WBMA023-05 | 5 | PR | - |
| Discrete Mathematics | WBMA019-05 | 5 | | - |
| Probability and Measure | WBMA024-05 | 5 | | - |
| Stochastic Processes | WBMA048-05 | 5 | | - |
| Project Statistical Reasoning | WBMA038-05 | 5 | PR | - |
| Statistical Modelling | WBMA028-05 | 5 | | - |
| Dynamical Systems | WBMA031-05 | 5 | | |
| Algebraic Structures | WBMA039-05 | 5 | | |
| Project Security and Coding | WBMA026-05 | 5 | PR | - |
| Project Chaos Theory | WBMA025-05 | 5 | PR | - |
| Analysis on Manifolds | WBMA013-05 | 5 | | - |
| Advanced Algebraic Structures | WBMA011-05 | 5 | | - |
| Philosophy of Science | FI180WET | 5 | | - |
| Introduction to Science and Education (Dutch) | WBEC002-05 | 5 | | - |
| Elementary Number Theory | WBMA057-05 | 5 | | |
| Percolation Theory | WBMA059-05 | 5 | | |
| Algebraic Topology | WBMA058-05 | 5 | | |
| Introduction to Optimization | WBMA054-05 | 5 | | |

**Elective course units General Mathematics**

In addition, in the track General Mathematics the elective course units can be chosen from:

| Course unit name | Course code | ECTS | | Entry requirements |
|---|---|---|---|---|
| One out of:<br>- Imperative Programming<br>- C++ fundamentals | <br>WBCS003-05<br>WBCS033-05 | 5 | PR | <br>-<br>- |
| Programming in C++ | WBCS034-05 | 5 | PR | - |
| Advanced Logic | WBAI017-05 | 5 | | - |
| Symmetry in Physics | WBPH047-05 | 5 | | - |
| Quantum Physics 1 | WBPH014-05 | 5 | | - |

**Elective course units Probability and Statistics**
In addition, in the track Probability and Statistics the elective course units can be chosen from:

| Course unit name | Course code | ECTS | Practical | Entry requirements |
|---|---|---|---|---|
| One out of:<br>- Imperative Programming<br>- C++ fundamentals | <br>WBCS003-05<br>WBCS033-05 | 5 | PR | <br>-<br>- |
| Programming in C++ | WBCS034-05 | 5 | PR | |
| Dynamic Econometrics | EBB813A05 | 5 | | - |
| Game Theory | EBB872A05 | 5 | | - |
| Risk Insurance | EBB863A05 | 5 | | - |
| Statistical Signal Processing | WBAS009-05 | 5 | | - |
| One out of:<br>- Introduction to Actuarial Sciences<br>- Introduction to Econometrics | <br>EBB827A05<br><br>EBB828A05 | 5 | | - |

**Post-propaedeutic phase double Bachelor's degree in Mathematics and Physics**

A student who desires to obtain a Bachelor's degree in Mathematics as well as a Bachelor's degree in Physics can combine a subspecialization of the Mathematics track General Mathematics with a subspecialization of the Physics track Particle Physics. The post-propaedeutic phase of this combination has a workload of 170 ECTS:

| **Course unit name** | **Course code** | **ECTS** | **Practical** | **Entry requirements** |
|---|---|---|---|---|
| Group Theory | WBMA005-05 | 5 | | |
| Metric and Topological Spaces | WBMA036-05 | 5 | | |
| Statistics | WBMA009-05 | 5 | | |
| Complex Analysis | WBMA018-05 | 5 | | |
| Multivariable Analysis | WBMA022-05 | 5 | | |
| Geometry | WBMA034-05 | 5 | | |
| Functional Analysis | WBMA033-05 | 5 | | |
| Numerical Mathematics 1 | WBMA045-05 | 5 | PR | |
| Partial Differential Equations | WBMA008-05 | 5 | | |
| Dynamical Systems | WBMA031-05 | 5 | | |
| Project Chaos Theory | WBMA026-05 | 5 | PR | |
| Algebraic Structures | WBMA039-05 | 5 | | |
| Two out of:<br>- Analysis on Manifolds<br>- Advanced Algebraic Structures<br>- Philosophy of Science<br>- Introduction to Science and Education (Dutch)<br>- Discrete Mathematics<br>- Stochastic Processes | <br>WBMA013-05<br>WBMA011-05<br><br>FI180WET<br>WBEC002-05<br><br>WBMA019-05<br>WBMA048-05 | 10 | | |
| Thermal Physics | WBPH002-10 | 10 | | |
| Computational Methods in Science and Technology | WBPH005-05 | 5 | PR | |
| Quantum Physics 1 | WBPH014-05 | 5 | | |
| Waves and Optics | WBPH032-05 | 5 | | |
| Structure of Matter | WBPH034-10 | 10 | | |
| Electronics and Signal Processing | WBPH038-05 | 5 | | |
| Physics Laboratory 3 | WBPH051-05 | 5 | PR | |
| Quantum Physics 2 | WBPH052-05 | 5 | | |
| One out of:<br>- Atoms & Molecules<br>- Subatomic Physics | <br>WBPH003-05<br>WBPH031-05 | 5 | | |
| One out of:<br>- Advanced Mechanics<br>- Physics Laboratory 4 | <br>WBPH017-05<br>WBPH026-05 | 5 | <br><br>PR | |
| One out of:<br>– Astroparticle Physics<br>– Cosmology | <br>WBPH036-05<br>WBAS001-05 | 5 | | |
| One out of:<br><br>WBPH040-05 | | 5 | <br>PR | |

| | | | | |
|---|---|---|---|---|
| - Experimental Particle Physics<br>- Relativistic Quantum Mechanics | WBPH045-05 | | | |
| Symmetry in Physics | WBPH047-05 | 5 | | |
| One out of<br>– Mathematics & Society: Ethical and Professional Aspects<br>– Physics, Astronomy & Society: Ethical and Professional Aspects | WBMA049-05<br>WBPH053-05 | 5 | | |
| Bachelor Research Project (double BSc Physics+Maths) | WBPH901-20 | 20 | PR | Passed courses of the Bachelor programme in Mathematics or the Bachelor programme in Physics having a total workload of at least 200 ECTS |

The curriculum for the double Bachelor's degree in Mathemativs and Physics can be split into the following two distinct programmes of 180 ECTS each:

**Mathematics** track General Mathematics subspecialization Mathematics and Physics

| **Course unit name** | **Course code** | **ECTS** | **Practical** | **Entry requirements** |
|---|---|---|---|---|
| Calculus 1 | WBMA003-05 | 5 | PR | |
| Linear Algebra 1 | WBMA020-05 | 5 | PR | |
| Mechanics and Relativity | WBPH001-10 | 10 | | |
| Analysis | WBMA012-05 | 5 | | |
| One out of<br>– Sets and Numbers<br>– Introduction to Graph Theory | WBMA051-05<br>WBMA052-05 | 5 | | |
| Calculus 2 | WBMA029-05 | 5 | | |
| One out of<br>– Scientific Programming<br>– Python for Physicists | WBMA053-05<br>WBPH044-05 | 5 | PR | |
| Linear Algebra 2 | WBMA035-05 | 5 | | |
| Linear Systems | WBMA043-05 | 5 | | |
| Probability Theory | WBMA046-05 | 5 | | |
| One out of<br>– First-year Project Mathematics<br>– Physics Laboratory 2 | WBMA041-05<br>WBPH050-05 | 5 | PR | |
| Group Theory | WBMA005-05 | 5 | | |
| Metric and Topological Spaces | WBMA036-05 | 5 | | |
| Statistics | WBMA009-05 | 5 | | |

| | | | | |
|---|---|---|---|---|
| Complex Analysis | WBMA018-05 | 5 | | |
| Multivariable Analysis | WBMA022-05 | 5 | | |
| Geometry | WBMA034-05 | 5 | | |
| Functional Analysis | WBMA033-05 | 5 | | |
| Numerical Mathematics 1 | WBMA045-05 | 5 | PR | |
| Partial Differential Equations | WBMA008-05 | 5 | | |
| Dynamical Systems | WBMA031-05 | 5 | | |
| Project Chaos Theory | WBMA026-05 | 5 | PR | |
| Algebraic Structures | WBMA039-05 | 5 | | |
| Minor, 15 ECTS of out<br>– Thermal Physics<br>– Waves and Optics<br>– Structure of Matter<br>– Electronics and Signal Processing<br>– Quantum Physics 2<br>– Physics Laboratory 3<br>– Subatomic Physics<br>– Advanced Mechanics<br>– Physics Laboratory 4<br>– Experimental Particle Physics<br>– Relativistic Quantum Mechanics | <br>WBPH002-10<br>WBPH032-05<br>WBPH034-10<br>WBPH038-05<br><br>WBPH052-05<br>WBPH051-05<br>WBPH031-05<br>WBPH017-05<br>WBPH026-05<br>WBPH040-05<br><br>WBPH045-05 | 15 | | |
| Two out of:<br>- Analysis on Manifolds<br>- Advanced Algebraic Structures<br>- Philosophy of Science<br>- Introduction to Science and Education (Dutch)<br>- Discrete Mathematics<br>- Stochastic Processes | <br>WBMA013-05<br>WBMA011-05<br><br>FI180WET<br>WBEC002-05<br><br>WBMA019-05<br>WBMA048-05 | 10 | | |
| Quantum Physics 1 | WBPH014-05 | 5 | | |
| Symmetry in Physics | WBPH047-05 | 5 | | |
| One out of<br>– Mathematics & Society: Ethical and Professional Aspects<br>– Physics, Astronomy & Society: Ethical and Professional Aspects | <br>WBMA049-05<br><br><br>WBPH053-05 | 5 | | |
| Bachelor Research Project (double BSc Physics+Maths) | WBPH901-20 | 20 | PR | Passed courses of the Bachelor programme in Mathematics or the Bachelor programme in Physics having a total workload of |

| | | | | |
|---|---|---|---|---|
| | | | | at least 200 ECTS |

**Physics** track Particle Physics subspecialization Mathematics and Physics

| **Course unit name** | **Course code** | **ECTS** | ***Practical*** | **Entry requirements** |
|---|---|---|---|---|
| Calculus 1 | WBMA003-05 | 5 | PR | |
| Linear Algebra 1 | WBMA020-05 | 5 | PR | |
| Physics Laboratory 1 | WBPH013-05 | 5 | PR | |
| Mechanics and Relativity | WBPH001-10 | 10 | | |
| Physics of the Quantum Universe | WBPH028-05 | 5 | | |
| Electricity and Magnetism | WBPH033-10 | 10 | | |
| Calculus 2 | WBMA029-05 | 5 | | |
| One out of<br>– Scientific Programming<br>– Python for Physicists | <br>WBMA053-05<br>WBPH044-05 | 5 | PR | |
| One out of<br>– First-year Project Mathematics<br>– Physics Laboratory 2 | <br>WBMA041-05<br>WBPH050-05 | 5 | PR | |
| Thermal Physics | WBPH002-10 | 10 | | |
| Computational Methods in Science and Technology | WBPH005-05 | 5 | PR | |
| Quantum Physics 1 | WBPH014-05 | 5 | | |
| Complex Analysis | WBMA018-05 | 5 | | |
| Waves and Optics | WBPH032-05 | 5 | | |
| Structure of Matter | WBPH034-10 | 10 | | |
| Electronics and Signal Processing | WBPH038-05 | 5 | | |
| Physics Laboratory 3 | WBPH051-05 | 5 | PR | |
| Quantum Physics 2 | WBPH052-05 | 5 | | |
| One out of<br>– Mathematics & Society: Ethical and Professional Aspects<br>– Physics, Astronomy & Society: Ethical and Professional Aspects | <br>WBMA049-05<br>WBPH053-05 | 5 | | |
| Minor, 15 ECTS out of<br>– Group Theory<br>– Metric and Topologic Spaces<br>– Statistics<br>– Multivariable Analysis<br>– Partial Differential Equations<br>– Dynamical Systems<br>– Geometry | <br>WBMA005-05<br>WBMA036-05<br>WBMA009-05<br>WBMA022-05<br>WBMA008-05<br>WBMA031-05<br>WBMA034-05 | 15 | | |

| | | | | |
|---|---|---|---|---|
| – Functional Analysis<br>– Numerical Mathematics 1<br>– Algebraic Structures<br>– Analysis on Manifolds<br>– Advanced Algebraic Structures | WBMA033-05<br>WBMA045-05<br>WBMA039-05<br>WBMA013-05<br>WBMA011-05 | | | |
| Project Chaos Theory | WBMA026-05 | 5 | PR | |
| One out of:<br>- Atoms & Molecules<br>- Subatomic Physics | <br>WBPH003-05<br>WBPH031-05 | 5 | | |
| One out of:<br>- Advanced Mechanics<br>- Physics Laboratory 4 | <br>WBPH017-05<br>WBPH026-05 | 5 | PR | |
| One out of:<br>– Astroparticle Physics<br>– Cosmology | <br>WBPH036-05<br>WBAS001-05 | 5 | | |
| One out of:<br>- Experimental Particle Physics<br>- Relativistic Quantum Mechanics | <br>WBPH040-05<br><br>WBPH045-05 | 5 | PR | |
| Symmetry in Physics | WBPH047-05 | 5 | | |
| Bachelor Research Project (double BSc Physics+Maths) | WBPH901-20 | 20 | PR | Passed courses of the Bachelor programme in Mathematics or the Bachelor programme in Physics having a total workload of at least 200 ECTS |

# Appendix V Admission to the post-propaedeutic phase (Article 6.1.1)

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

a. Students who have been issued a positive study advice from the degree programme in question.
b. Students who have been issued a positive study advice from one of the degree programmes: Applied Mathematics.

# Appendix VI Contact hours propaedeutic and post-propaedeutic phase (Article 3.6)

| **Degree programme year 1** | |
|---|---|
| **Structure contact hours** | **Contact hours per year** |
| Lectures | 335 |
| Tutorial | 290 |
| Practical | 25 |
| Computer practical | 40 |
| Study support/Mentor groups | 70 |
| Supervision during an internship | - |
| Examinations | 80 |
| Misc. contact hours (symposia) | 20 |

| **Degree programme post-propaedeutic** | |
|---|---|
| **Structure contact hours** | **Contact hours per year** |
| Lectures | 620 |
| Tutorial | 450 |
| Practical | 40 |
| Computer practical | 48 |
| Study support/Mentor groups | - |
| Supervision during an internship | - |
| Examinations | 240 |
| Misc. contact hours (symposia) | 30 |

# Appendix VII Additional Requirements Open Degree Programmes (Art. 7.3)

Students wishing to pursue an open degree programme may file a request with the Board of Examiners. An Open Degree Programme must always be approved in advance by the Board of Examiners. The Board of Examiners will evaluate whether the proposed curriculum meets the learning outcomes of the degree programme and can determine further conditions in their rules and regulations.

The Open Degree Programme in Mathematics must include the common compulsory courses of the post-propaedeutic programme and at least 25 ECTS is to be taken from track-specific compulsory courses (see App. IV for details).

# Appendix VIII Transitional provisions (article 12.1)

Since the TER for this academic year is applicable to all students registered in the Bachelor's degree programme in Mathematics, regardless of the starting date of students, transitional arrangements are in place.

The propaedeutic phase of the 2022/23 curriculum has three new compulsory course units. The course Sets and Integers replaces Kaleidoscope Mathematics. The course Scientific Programming replaces Computer-Aided Problem Solving. Students from the cohort 2021/22 and earlier may take Kaleidoscope Mathematics instead of Sets and Integers and Computer-Aided Problem Solving instead of Scientific Programming provided they have passed the (discontinued) replacement courses before September 1, 2022. The course Mechanics and Relativity 1 is no longer part of the programme. Students from the cohort 2021/22 and earlier who have passed Mechanics and Relativity 1 before September 1, 2022 may replace Introduction to Graph Theory with Mechanics and Relativity 1. In summary:

**For cohort 2021-2022 and earlier**

| **Old Course** | **New Course** |
|---|---|
| Kaleidoscope Mathematics | Sets and Numbers |
| Mechanics and Relativity 1 | Introduction to Graph Theory |
| Mechanics and Relativity 2 | Mechanics and Relativity for Mathematicians |
| Computer-Aided Problem Solving | Scientific Programming |

In the post-propaedeutic phase, the following substitutions are allowed (provided the (discontinued) replacement course is passed before September 1, 2022):

**For cohort 2021-2022 and earlier**

| **Old Course** | **New Course** |
|---|---|
| Fluid Dynamics | Differential Equations in Science and Engineering |
| Bachelor's Workgroup Mathematics | Preparation Bachelor's Project |
| Calculus of Variation and Optimal Control | Introduction to Optimization |
| Project Modelling | Project Mathematical Modelling |

In the track Probability and Statistics, the compulsory course Stochastic Models and choice between Introduction to Actuarial Sciences and Introduction to Econometrics have been replaced by two compulsory courses, Multivariable Analysis and Geometry. In addition, the compulsory course Asymptotic Statistics is discontinued. Instead, an extra elective is added to the track Probability and Statistics. The following replacement rule applies:

**For cohort 2021-2022 and earlier**

| Old Courses | New Courses |
|---|---|
| Stochastic Models<br>One out of<br>– Introduction to Actuarial Sciences<br>– Introduction to Econometrics | Multivariable Analysis<br>Geometry |
| Asymptotic Statistics | Elective (see App IV for optional courses in Probability and Statistics) |

See also the transitional arrangements in the appendices TER of previous years.
For information on transitional arrangements for courses offered by other degree programmes, see also the Teaching and Examination Regulations of the corresponding programme.