university of groningen

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

## 2024-2025

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

**Objectives of BSc Applied Mathematics**

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 (applied) mathematicians.

The Bachelor's degree programme in Applied Mathematics aims to impart knowledge, skills, understanding and an academic attitude in the field of applied 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 Applied Mathematics. Graduates of the Bachelor's degree programme in Applied Mathematics should also be able to take the Master's degree programme in Mathematics or in Education and Communication.

**Learning outcomes BSc Applied 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 Applied Mathematics:

A1. have general knowledge of the foundations and principal branches of (applied) mathematics.

A2. have mastered the basic concepts of applied mathematics (see Appendix I for further specification) to a certain extent and are familiar with the interrelationships of these concepts within mathematics and applied mathematics as well as with other disciplines (e.g. in science and engineering).

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

A4. are familiar with the quantitative character of applied mathematics and have an understanding of the mathematical methods used in various areas of application, particularly including computer-aided methods.

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

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

**B. Generic learning outcomes – Skills**

Bachelor's graduates in Applied 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 and to evaluate the value and limitations of their research and assess its applicability outside their own field. See Appendix II for further specification.

B2 (Designing and Modelling) are able to translate a problem, in particular a design problem, into a plan of approach and – taking into account requirements and/or technical preconditions – find a solution.

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 in teams on technical-scientific problems, are able to work on (interdisciplinary) projects, taking responsibility for their (mathematical) contributions.

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 as scientists and engineers. 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 and engineering 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 Applied 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 applied analysis, numerical mathematics, dynamical systems and systems theory.
1.3. have knowledge of more advanced topics in the fields of Computational Mathematics, and Systems and Control.
1.4. have gained knowledge of and experience in the 'heart' of mathematics, i.e., the truth and value of exact mathematical proof.
1.5. have knowledge of basic sciences at a level necessary to apply mathematical methods, and are aware of the wider multidisciplinary context of science and engineering
1.6. are able to use mathematical software packages in an effective way or, if necessary, modify programs themselves.

**Appendix II Specified skills related learning outcomes**

Bachelor's graduates in Applied 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) problems in the mathematical language, pose relevant mathematical questions and address them in an exact way, and if necessary, adapt the problem to make it mathematically 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 model, analyse and abstract simple problems that are outside the scope of their own study programme and to independently acquire new knowledge to this end.

***Designing and 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 formulate concrete problems from application areas as mathematical problems, and are able to discuss the assumptions underlying their mathematical model.

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 abstracting and modelling, 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 numerical simulations and mathematical analysis in order to study problems in science and engineering.

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

The degree programme has the following Major:

- Applied Mathematics (165 ECTS)

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

- University-wide broadening minors
- Faculty-wide deepening minors
- Minor Mathematics (see the TER of the degree programme Mathematics)
- 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 major programme instead of 165 ECTS; see Appendix IV for details.

The Minor Abroad has to satisfy the following conditions:

- At least 15 ECTS of Applied Mathematics (related) courses (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)

# Appendix III Course units in the first year

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

The first year of the Bachelor's degree programme in Applied Mathematics comprises a compulsory programme of 60 ECTS.

**Compulsory programme, year 1**

| Course unit name | Course code | ECTS | Practical | Entry requirements |
|---|---|---|---|---|
| Calculus 1 | WBMA003-05 | 5 | | |
| Linear Algebra 1 | WBMA020-05 | 5 | | |
| Sets and Numbers | WBMA051-05 | 5 | | |
| Analysis | WBMA012-05 | 5 | | |
| Introduction to Graph Theory | WBMA052-05 | 5 | | |
| Calculus 2 | WBMA029-05 | 5 | | |
| Scientific Programming | WBMA053-05 | 5 | PR | |
| Linear Algebra 2 | WBMA035-05 | 5 | | |
| Mechanics and Relativity for Mathematicians | WBMA060-05 | 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><br>WBMA040-05 | 5 | PR | |

# Appendix IV Course units in the second and third year

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

The second and third year of the programme consist of a major (105 ECTS) and a minor (15 ECTS).

**Compulsory major courses**

| Course unit name | Course code | ECTS | Practical | Entry requirements |
|---|---|---|---|---|
| Metric and Topological Spaces | WBMA036-05 | 5 | | |
| Statistics | WBMA009-05 | 5 | | |
| Introduction to Optimization | WBMA054-05 | 5 | | |
| Complex Analysis | WBMA018-05 | 5 | | |
| Multivariable Analysis | WBMA022-05 | 5 | | |
| Differential Equations in Science and Engineering | WBMA061-05 | 5 | PR | |
| Functional Analysis | WBMA033-05 | 5 | | |
| Numerical Mathematics 1 | WBMA045-05 | 5 | PR | |
| Partial Differential Equations | WBMA008-05 | 5 | | |
| Mathematical Modelling | WBMA007-05 | 5 | | |
| Computational Methods of Science | WBMA004-05 | 5 | PR | |
| Two out of:<br>- Project Mathematical Modelling<br>- Project Systems Theory<br>- Project Statistical Reasoning (25/26) | <br>WBMA055-05<br><br>WBMA027-05<br>WBMA038-05 | 10 | PR | |
| Two out of:<br>- Numerical Mathematics 2<br>- Advanced Systems Theory<br>- Statistical Modelling | <br>WBMA023-05<br>WBMA001-05<br>WBMA028-05 | 10 | <br>PR<br><br>PR | |
| Mathematics & Society: Ethical and Professional Aspects | WBMA049-05 | 5 | | |
| Elective (see optional course units below) | | 5 | | |
| Preparation Bachelor's Project | WBMA056-05 | 5 | | |
| Bachelor's Project Applied Mathematics | WBMA901-15 | 15 | PR | Passed 150 ECTS of the Degree programme in Applied Mathematics, including Preparation Bachelor's Project. Approval of the study |

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| | | | | programme by the BOE, approval of Career Portfolio and enrolment Bachelor's Project Applied Mathematics in Progress. |

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

- University-wide broadening minors
- Faculty-wide deepening minors
- Minor Mathematics (see the TER of the Bachelor's programme Mathematics), provided that the courses are not already part of the student's programme
- Personal minor, based on an individual choice of course units to be approved by the Board of Examiners

In addition, the programme offers the option of a Minor Abroad (30 ECTS), the contents of which must be approved by the Board of Examiners, 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 Applied Mathematics (15 ECTS):

| **Course unit name** |
|---|
| One elective (see optional course units below)<br>Two out of:<br>- Numerical Mathematics 2<br>- Advanced Systems Theory<br>- Statistical Modelling |

**Elective courses from Applied Mathematics**
Elective course units can be chosen from the second and third year courses of the Bachelor's programme in Applied Mathematics as long as they are not otherwise part of the student's programme.

| **Course unit name** | **Course code** | **ECTS** | **Practical** | **Entry requirements** |
|---|---|---|---|---|
| Numerical Mathematics 2 | WBMA023-05 | 5 | PR | |
| Advanced System Theory | WBMA001-05 | 5 | | |
| Statistical Modelling | WBMA028-05 | 5 | PR | |

**Elective courses from Mathematics**
Elective course units can be chosen from the second and third year courses of the Bachelor's programme in Mathematics as long as they are not already part of the student's programme.

| **Course unit name** | **Course code** | **ECTS** | **Practical** | **Entry requirements** |
|---|---|---|---|---|
| Geometry | WBMA034-05 | 5 | | |

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|---|---|---|---|---|
| Group Theory | WBMA005-05 | 5 | | |
| Project Security and Coding | WBMA026-05 | 5 | PR | |
| Dynamical Systems | WBMA031-05 | 5 | | |
| Project Chaos Theory (24/25) | WBMA025-05 | 5 | PR | |
| Algebraic Structures | WBMA039-05 | 5 | | |
| Analysis on Manifolds | WBMA013-05 | 5 | | |
| Advanced Algebraic Structures | WBMA011-05 | 5 | | |
| Discrete Mathematics | WBMA019-05 | 5 | | |
| Probability and Measure | WBMA024-05 | 5 | | |
| Stochastic Processes | WBMA048-05 | 5 | | |
| Project Statistical Reasoning (25/26) | WBMA038-05 | 5 | PR | |
| Elementary Number Theory | WBMA057-05 | 5 | | |
| Percolation Theory | WBMA059-05 | 5 | | |
| Algebraic Topology | WBMA058-05 | 5 | | |

**Elective courses from other degree programmes**

| **Course unit name** | **Course code** | **ECTS** | **Practical** | **Entry requirements** |
|---|---|---|---|---|
| One out of:<br>- Functional Programming<br>- C++ fundamentals | <br>WBCS002-05<br>WBCS033-05 | <br>5<br>5 | <br>PR<br>PR | |
| One out of:<br>- Object-Oriented Programming (for CS)<br>- Object-Oriented Programming (for AI) | <br>WBCS028-05<br>WBAI045-05 | <br>5<br>5 | | |
| Programming in C++ | WBCS034-05 | 5 | PR | |
| Mechatronics | WBIE011-05 | 5 | PR | |
| Fundamentals of Electronics | WBPH070-05 | 5 | PR | |
| Astrophysical Hydrodynamics | WBAS011-05 | 5 | | |
| Physics of Fluids | WBPH042-05 | 5 | | |
| Philosophy of Science | FI180WET | 5 | | |
| Introduction to Science and Education (Dutch) | WBEC002-05 | 5 | | |

# Appendix V Contact hours (Article 3.6)

| **Degree programme year 1** | |
|---|---|
| **Structure contact hours** | **Contact hours per year** |
| Lectures | 352 |
| Tutorials | 320 |
| Practicals | 24 |
| Computer practicals | 32 |
| Study support/mentor groups | 70 |
| Supervision during an internship | |
| Examinations | 50 |
| Misc. contact hours (seminars and symposia) | 20 |

| **Degree programme year 2 and 3** | |
|---|---|
| **Structure contact hours** | **Contact hours per year** |
| Lectures | 384 |
| Tutorials | 384 |
| Practicals | 48 |
| Computer practicals | 64 |
| Study support/mentor groups | |
| Supervision during an internship | |
| Examinations | 40 |
| Misc. contact hours (seminars and symposia) | 20 |

Note: contact hours in year 2 and 3 might deviate from the table above due to choices of the Minor and elective courses.

# Appendix VI 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 Applied Mathematics must include the following course units:

| **Course unit name** | **Course code** | **ECTS** | **Practical** | **Entry requirements** |
|---|---|---|---|---|
| Two out of:<br>- Project Mathematical Modelling<br>- Project Systems Theory<br>- Project Statistical Reasoning (25/26) | <br>WBMA055-05<br><br>WBMA027-05<br>WBMA038-05 | 10 | PR | |
| Differential Equations in Science and Engineering | WBMA061-05 | 5 | PR | |
| Functional Analysis | WBMA033-05 | 5 | | |
| Numerical Mathematics 1 | WBMA045-05 | 5 | PR | |
| Partial Differential Equations | WBMA008-05 | 5 | | |
| Mathematical Modelling | WBMA007-05 | 5 | | |
| Mathematics & Society: Ethical and Professional Aspects | WBMA049-05 | 5 | | |
| Introduction to Optimization | WBMA054-05 | 5 | PR | |
| Two out of:<br>- Computational Methods of Science<br>- Numerical Mathematics 2<br>- Advanced Systems Theory<br>- Statistical Modelling | <br>WBMA004-05<br><br>WBMA023-05<br>WBMA001-05<br>WBMA028-05 | 10 | <br>PR<br><br><br>PR | |
| Preparation Bachelor's Project | WBMA056-05 | 5 | | |
| Bachelor's Project Applied Mathematics | WBMA901-15 | 15 | PR | Passed 150 ECTS of the Open Degree programme in Applied Mathematics, including Preparation Bachelor's Project. Approval of the |

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|---|---|---|---|---|
| | | | | study programme by the BOE, approval of Career Portfolio and enrolment Bachelor's Project Applied Mathematics in Progress. |

# Appendix VII 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 Applied Mathematics, regardless of the starting date of students, transitional provisions are in place.

**For cohort 2023-2024 and earlier**
In 2024-2025, the courses Mechanics and Relativity for Mathematicians and Calculus 2 will be scheduled in different blocks. As a result of this change, there is no longer the possibility to choose the course Introduction to Logic as an elective. Students from the cohort 2023-2024 and earlier may replace a discontinued course according to the table below, provided the discontinued course was passed before September 1, 2024.

| Old course | New course |
|---|---|
| Introduction to Logic | Mechanics and Relativity for Mathematicians |

In 2024-2025, the compulsory deepening minor of 30 ECTS has been replaced by a more flexible minor space of 15 ECTS. In addition, the courses Dynamical Systems and Group Theory are no longer mandatory in the Bachelor's programme Applied Mathematics, but they still can be taken as elective courses. Students from the cohort 2022-2023 and earlier who already passed these courses before 1 September 2024, can add these courses to a personal minor together with one extra elective that is not already a part of the student's programme.

**For cohort 2021-2022 and earlier**
In 2022-2023, three new compulsory course units were introduced in the first year: Sets and Numbers, Scientific Programming and Introduction to Graph Theory. In addition, the elective course Mechanics and Relativity for Mathematicians was introduced. Four courses (Kaleidoscope Mathematics, Mechanics and Relativity 1, Mechanics and Relativity 2 and Computer-Aided Problem Solving) were discontinued. Students from the cohort 2021-2022 and earlier may replace a discontinued course according to the table below, provided the discontinued course was passed before September 1, 2022.

| 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 second and third year, the following substitutions are allowed, provided the discontinued course is passed before September 1, 2022.

| **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 |
| Imperative Programming | Functional Programming or C++ Fundamentals |

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