Appendices to Teaching and Examination regulations: Bachelor's degree programme in Applied Mathematics

2018-2019

Appendix I Learning outcomes of the Bachelor's degree programme (Article 3.1.a)

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 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 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 history 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 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

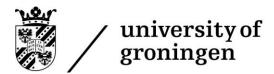
- 1.1. have mastered the basic concepts and techniques of mathematics, in particular single and multivariable calculus, linear algebra, analysis, ordinary differential equations, probability theory and statistics, and algebra.
- 1.2. have knowledge of more advanced subjects within the fields of applied 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.

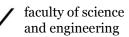
Appendix II Specified skills related learning outcomes

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.

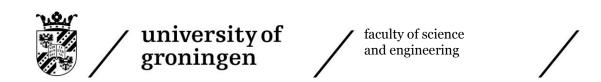




- 2.2 are able to formulate (relatively simple) problems in the mathematical language, pose relevant mathematical questions and address them in an exact way, and if necessary adapt the problem to make it mathematically tractable.
- 2.3 are able to articulate assumptions, understand the importance of 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, analyze 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)

The Bachelor's degree programme in Applied Mathematics comprises

- 1) an Applied Mathematics Major (150 ECTS)
- 2) a compulsory deepening Minor in Applied Mathematics (30 ECTS)

Appendix III Course units in the propaedeutic phase

- List of course units (Article 4.1.1)
- Compulsory order of examinations (Article 4.2.1)

The propaedeutic phase of the Bachelor's degree programme in Applied Mathematics comprises a compulsory programme and two electives.

3-1. Compulsory programme, year 1

| Course unit name | ECTS | Entry | Practical |
|--------------------------------|------|--------------|-----------|
| | | requirements | |
| Calculus 1 | 5 | - | X |
| Kaleidoscope Mathematics | 5 | - | |
| Mechanics and Relativity 1 | 5 | - | |
| Linear Algebra 1 | 5 | - | X |
| Analysis | 5 | - | |
| Elective 1 | 5 | See 3-2 | |
| Calculus 2 | 5 | - | |
| Computer-Aided Problem-Solving | 5 | - | X |
| Linear Algebra 2 | 5 | - | |
| Linear Systems | 5 | - | |
| Probability Theory | 5 | - | |
| Elective 2 | 5 | See 3-2 | |

3-2 Optional course units, year 1

| Course unit name | ECTS | Entry | Practical |
|--|------|--------------|-----------|
| | | requirements | |
| Elective 1, 1 out of: | | | |
| OR Modelling | 5 | - | X |
| Introduction to Logic | 5 | - | |
| Mechanics and Relativity 2 | 5 | - | |
| Elective 2, 1 out of: | | | |
| First-year Project Mathematics | 5 | - | X |
| First-year Project Applied Mathematics | 5 | - | X |

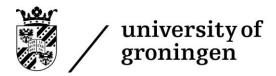
Appendix IV Course units in the post-propaedeutic phase

- List of course units (Article 7.1.1)
- Practicals (Article 7.2.1)
- Compulsory order of examinations (Article 9.2)

The post-propaedeutic programme (major and deepening minor Applied Mathematics (30 ects)) consists of compulsory courses (110 ects) and elective courses (10 ects)

Compulsory courses (110 ects):

| Course unit name | ECTS | Entry | Practical |
|--|------|---|-----------|
| | _ | requirements | |
| Group Theory | 5 | - | |
| Statistics | 5 | - | |
| Complex Analysis | 5 | - | |
| Partial Differential Equations | 5 | - | |
| Dynamical Systems | 5 | - | |
| Project Systems Theory | 5 | - | X |
| Metric and Topological Spaces | 5 | - | |
| Fluid Dynamics | 5 | - | |
| Multivariable Analysis | 5 | - | |
| Numerical Mathematics | 5 | - | X |
| Mathematics: history, ethics and career | 5 | - | X |
| Project Modelling | 5 | - | X |
| Mathematical Modelling | 5 | - | |
| Computational Methods of Science | 5 | - | X |
| Advanced Systems Theory | 5 | - | |
| Calculus of Variations and Optimal Control | 5 | - | |
| Advanced Numerical Mathematics | 5 | - | Х |
| Functional Analysis | 5 | - | |
| Bachelor Workgroup Applied Mathematics | 5 | - | Х |
| Bachelor Project Applied Mathematics | 15 | Passed 150 ECTS of the Bachelor's programme in Mathematics | X |



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Optional course units (10 ects)

The optional course units can be chosen from the post-propaedeutic track specific courses General Mathematics, and the post-propaedeutic track specific courses Probability and Statistics electives as long as they are not otherwise part of the student's programme. In addition the electives can be chosen from the following list of courses:

| Course unit name | ECTS | Entry | Practical |
|---------------------------------|------|--------------|-----------|
| | | requirements | |
| At most one out of: | | | |
| - Imperative Programming | 5 | - | X |
| - C++, part I | 5 | - | X |
| C++, part II | 5 | - | X |
| Mechatronics | 5 | - | X |
| Waves and Optics | 5 | - | |
| Nanophysics & Nanotechnology | 5 | - | |
| Electronics & Signal Processing | 5 | - | X |
| Astrophysical Hydrodynamics | 5 | - | |
| Queuing Theory and Simulation | 5 | - | x |

Appendix V Entry requirements (Article 2.2.1, 2.2.2, 2.2.3)

A. Deficient VWO-diploma

1. The following requirements apply to the entrance examination as defined in Article 7.28.3 of the Act:

| Bacheloropleiding | N+T | N+G | E+M | C+M |
|--|----------|---------------------------|---|---|
| Bachelor's degree programme | | | | |
| Biology | Biologie | Natuurkunde | Wiskunde A of B Natuurkunde Scheikunde Biologie | Wiskunde A of B Natuurkunde Scheikunde Biologie |
| Farmacie Pharmacy | V | Natuurkunde | Natuurkunde Scheikunde | Wiskunde A of B Natuurkunde Scheikunde |
| Life Science and Technology Scheikunde Chemistry Scheikundige Technologie Chemical Engineering | V | Wiskunde B Natuurkunde | Wiskunde B Natuurkunde Scheikunde | Wiskunde B Natuurkunde Scheikunde |
| Informatica Computing Science Technische Bedrijfskunde Industrial Engineering and Management (Technische) Wiskunde (Applied) Mathematics | V | Wiskunde B | Wiskunde B | Wiskunde B |
| Kunstmatige Intelligentie Artificial Intelligence | V | V | V | Wiskunde A of B |
| (Technische) Natuurkunde (Applied) Physics Sterrenkunde Astronomy | V | Wiskunde B Natuurkunde | Wiskunde B Natuurkunde | Wiskunde B Natuurkunde |

2. The Admissions Board Bachelor's programmes FSE will determine whether deficiencies have been compensated satisfactorily.

B. HBO (university of applied science) propaedeutic certificate, other universities

1. The following requirements apply to the entrance examination as defined in Article 7.28.3 of the Act:

| Bachelor's degree programme | Subjects at VWO (pre- university) level | Requirement: Dutch as a Second Language (programme II) for non- native speakers of Dutch |
|--|--|---|
| B Biology | wia or wib + na+sk+bio | Yes |
| B Pharmacy | wia or wib + na+sk | Yes |
| B Life Science and Technology | wib+na+sk | Yes |
| B Computing Science | wib | |
| B Artificial Intelligence | wia or wib | |
| B Physics | wib+na | |
| B Chemistry | wib+na+sk | |
| B Astronomy | wib+na | |
| B Mathematics | wib | |
| B Chemical Engineering | wib+na+sk | |
| B Industrial Engineering and Management Science | wib | |
| B Applied Physics | wib+na | |
| B Applied Mathematics | wib | |

wia = Mathematics A; wib = Mathematics B; na = Physics; sk = Chemistry; bio = Biology

2. In addition, candidates are required to be competent in English:

| IELTS (Academic) | 6.5 - no less than 6.0 on each section | |
|--|--|--|
| TOEFL IBT (internet-based test) | 92 - no less than 21 on each section | |
| TOEFL CBT (computer-based test) | 237 - no less than 21 on each section | |
| TOEFL PBT (paper-based test) | 580 - no less than 55 on each section | |
| Cambridge English | CAE or CPE Certificate | |
| English language test - University of Groningen Language | Minimum section scores C2 or C1 (one | |
| Centre | B2 allowed) | |

3. The Admissions Board Bachelor's programmes FSE will determine whether deficiencies have been compensated satisfactorily.

C. Foreign qualifications (EEA)

- 1. Any certificate that grants access to a university in a European country will also grant access to Dutch universities.
- 2. In the entrance examination, as referred to in art. 7.28, paragraph 3 of the Act, per country and educational institution specific training conditions are mentioned. These are standardized. The entrance examination is, in accordance with the Admissions Board Bachelor's programmes FSE, carried out by the Admissions Office. If for a specific diploma no standardisation has taken place then the requirements as formulated for candidates with a HBO (university of applied science) propaedeutic certificate will apply to these candidates in the entrance examination as defined in Article 7.28.3 of the Act (see A).
- 3. In addition, candidates are required to be competent in English:

| IELTS (Academic) | 6.5 - no less than 6.0 on each section |
|--|--|
| TOEFL IBT (internet-based test) | 92 - no less than 21 on each section |
| TOEFL CBT (computer-based test) | 237 - no less than 21 on each section |
| TOEFL PBT (paper-based test) | 580 - no less than 55 on each section |
| Cambridge English | CAE or CPE Certificate |
| English language test - University of Groningen Language | Minimum section scores C2 or C1 (one |
| Centre | B2 allowed) |

4. The Admissions Board Bachelor's programmes FSE will determine whether deficiencies have been compensated satisfactorily.

D. Foreign qualifications (non-EEA)

- 1. A non-European certificate that according to NUFFIC and/or NARIC standards is equivalent to a Dutch VWO certificate will grant access to university in the Netherlands.
- 2. In the entrance examination, as referred to in art. 7.28, paragraph 3 of the Act, per country and educational institution specific training conditions are mentioned. These are standardized. The entrance examination is, in accordance with the Admissions Board Bachelor's programmes FSE, carried out by the Admissions Office. If for a specific diploma no standardisation has taken place then the requirements as formulated for candidates with a HBO (university of applied science) propaedeutic certificate will apply to these candidates in the entrance examination as defined in Article 7.28.3 of the Act (see A).
- 3. In addition, candidates are required to be competent in English:

| IELTS (Academic) | 6.5 - no less than 6.0 on each section | |
|--|--|--|
| TOEFL IBT (internet-based test) | 92 - no less than 21 on each section | |
| TOEFL CBT (computer-based test) | 237 - no less than 21 on each section | |
| TOEFL PBT (paper-based test) | 580 - no less than 55 on each section | |
| Cambridge English | CAE or CPE Certificate | |
| English language test - University of Groningen Language | Minimum section scores C2 or C1 (one | |
| Centre | B2 allowed) | |

4. The Admissions Board Bachelor's programmes FSE will determine whether deficiencies have been compensated satisfactorily.

E. Entrance examination (Colloquium Doctum)

1. The following requirements apply to the entrance examination as defined in Article 7.29 of the Act:

| Degree programme | Nature and Health | or | Nature and |
|------------------------------|---------------------------|----|----------------------|
| | VWO level | | Technology |
| | | | VWO level |
| B Biology | en, wia or b, sk, bio, na | | en, wib, na, sk, bio |
| B Pharmacy | en, wia or b, sk, bio, na | | en, wib, na, sk |
| B Life Science and | en, wib, sk, bio, na | | en, wib, na, sk |
| Technology | | | |
| B Computing Science | en, wib, sk, bio | | en, wib, na, sk |
| B Artificial Intelligence | en, wia or b, sk, bio | | en, wib, na, sk |
| B Physics | en, wib, sk, bio, na | | en, wib, na, sk |
| B Chemistry | en, wib, sk, bio, na | | en, wib, na, sk |
| B Astronomy | en, wib, sk, bio, na | | en, wib, na, sk |
| B Mathematics | en, wib, sk, bio | | en, wib, na, sk |
| B Chemical Engineering | en, wib, sk, bio, na | | en, wib, na, sk |
| B Industrial Engineering and | en, wib, sk, bio | | en, wib, na, sk |
| Management Science | | | |
| B Applied Physics | en, wib, sk, bio, na | | en, wib, na, sk |
| B Applied Mathematics | en, wib, sk, bio | | en, wib, na, sk |

en = English; wia = Mathematics A; wib = Mathematics B; na = Physics; sk = Chemistry; bio = Biology

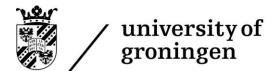
2. In addition, candidates are required to be competent in English:

| IELTS (Academic) | 6.5 - no less than 6.0 on each section |
|--|--|
| TOEFL IBT (internet-based test) | 92 - no less than 21 on each section |
| TOEFL CBT (computer-based test) | 237 - no less than 21 on each section |
| TOEFL PBT (paper-based test) | 580 - no less than 55 on each section |
| Cambridge English | CAE or CPE Certificate |
| English language test - University of Groningen Language | Minimum section scores C2 or C1 (one |
| Centre | B2 allowed) |

3. The Admissions Board Bachelor's programmes FSE will determine whether deficiencies have been compensated satisfactorily.

Appendix VI Clustering of Bachelor's degree programmes (Article 5.3.4, Article 5.6.1)

| Degree programme CROHO code | Name of degree programme | Clustered with CROHO code | Name of degree programme |
|-----------------------------------|----------------------------------|----------------------------------|---|
| 56286 | B Life Science and Technology | 56860 56157 | B Biology B Pharmacy |
| 56860 | B Biology | 56286 56157 | B Life Science and Technology B Pharmacy |
| 56157 | B Pharmacy | 56860 56286 | B Biology B Life Science and Technology |
| 56980 | B Mathematics | 56965 50206 56962 50205 | B Applied Mathematics B Physics B Applied Physics B Astronomy |
| 56965 | B Applied Mathematics | 56980 50206 56962 50205 | B Mathematics B Physics B Applied Physics B Astronomy |
| 50206 | B Physics | 56962 50205 56965 56980 | B Applied Physics B Astronomy B Applied Mathematics B Mathematics |
| 56962 | B Applied Physics | 50206 50205 56965 56980 | B Physics B Astronomy B Applied Mathematics B Mathematics |
| 50205 | B Astronomy | 56962 56965 50206 56980 | B Applied Physics B Applied Mathematics B Physics B Mathematics |
| 56857 | B Chemistry | 56960 | B Chemical Engineering |
| 56960 | B Chemical Engineering | 56857 | B Chemistry |



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Appendix VII Admission to the post-propaedeutic phase (Article 6.1)

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

- a. Students who have been issued a positive study advice from the bachelor's degree programme in Applied Mathematics
- b. Students who have been issued a positive study advice from the bachelor's degree programme in Mathematics:

Appendix VIII Contact hours propaedeutic phase (Article 3.6)

| Bachelor year 1 | | |
|---------------------------------|----------------------------------|--|
| Type of contact | Number of contact hours per year | |
| Lectures | 335 | |
| Tutorials | 290 | |
| Practical | 25 | |
| Computer practical | 40 | |
| Study support/Mentor groups | 8 | |
| Internship support and guidance | - | |
| Examinations | 80 | |
| Misc. contact hours (symposia) | 10 | |

Appendix IX University Minors of the faculty of Science and Engineering (Article 8.5.1)

- 1. Neurosciences Minor (taught in English):
 - Neuroscience (15 ECTS)
 - Behavioural Neuroscience (15 ECTS)

Future Planet Innovation (taught in English):

- Global Challenges (10 ECTS)
- Sustainability in perspective (5 ECTS)
- Sustainable contributions to society (15 ECTS)

Astronomy through Space and Time Minor (taught in English):

- The Evolving Universe (5 ECTS)
- Cosmic Origins (5 ECTS)
- Astrobiology (5 ECTS)

Einstein's physics: Space-time and parallel worlds (taught in English):

- Einstein's Universe (5 ECTS)
- Quantum World (5 ECTS)
- Building blocks of matter (5 ECTS)
- 2. The Programme Committee for the Bachelor's degree programmes in Biology and Life Science and Technology also has authority in the field of the Minor "Neurosciences" and/or its course units.

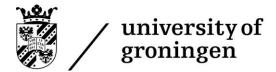
The Programme Committee for the Master's degree programme in Energy and Environmental Sciences also has authority in the field of the Minor "Future Planet Innovation" and/or its course units.

The Programme Committee for the Bachelor's degree programme in Astronomy also has authority in the field of the Minor "Astronomy through Space and Time" and/or its course units.

The Programme Committee for the Bachelor's degree programmes in Physics and Applied Physics also has authority in the field of the Minor "Einstein's physics: Space-time and parallel worlds" and/or its course units.

3. The Board of Examiners for the Bachelor's degree programmes in Biology and Life Science and Technology and the Master's degree programmes in Biology, Ecology and Evolution, Marine Biology and Molecular Biology and Biotechnology also has authority in the field of the Neurosciences Minor and/or its course units.

The Board of Examiners for the Master's degree programme in Energy and Environmental Sciences also has authority in the field of the "Future Planet Innovation" Minor and/or its course units.



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The Board of Examiners for the Bachelor's degree programme in Astronomy also has authority in the field of the Astronomy through Space and Time Minor and/or its course units.

The Board of Examiners for the Bachelor's degree programmes in Physics and Applied Physics also has authority in the field of the Physics Minor "Einstein's physics: Space-time and parallel worlds" and/or its course units.

4. These Teaching and Examination Regulations also apply in their entirety to the Minors in Neurosciences, Future Planet Innovation, Astronomy through Space and Time and Einstein's physics: Space-time and parallel worlds and/or their course units.

Appendix X Transitional arrangement (Article 12.1)

For cohort 2017-2018 and earlier

| Course | May be replaced with | Reason |
|-----------------------------|-----------------------------|--------------------------------|
| Operations Research 1 | OR Modelling (EBP821B05) | First course no longer offered |
| (EBB857A05) | or Operations Research (BSc | as of 2018-2019 |
| | IEM) | |
| Introduction to Mathematics | Kaleidoscope Mathematics | Change of course name in |
| (WIOW-10) | (WPMA18002) | 2018-2019 |

See also the transitional arrangements in the appendices TER of previous years