university of groningen / faculty of science and engineering

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

2021-2022

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, 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 3.6)

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	**Course Code**	**EC TS**	**Entry requirements**
Calculus 1	WBMA003-05	5	-
Kaleidoscope Mathematics	WBMA006-05	5	-
Mechanics and Relativity 1	WBPH009-05	5	-
Linear Algebra 1	WBMA020-05	5	-
Analysis	WBMA012-05	5	-
Elective 1 (see 3-2)		5	-
Calculus 2	WBMA029-05	5	-
Computer-Aided Problem-Solving	WBMA030-05	5	-
Linear Algebra 2	WBMA035-05	5	-
Linear Systems	WBMA043-05	5	-
Probability Theory	WBMA046-05	5	-
Elective 2 (see 3-2)		5	-

3-2 Optional course units year 1

Course unit name	**Course code**	**EC TS**	**Entry requirements**
Elective 1 , one out of:			
- OR Modelling	EBP821B05	5	-
- Introduction to Logic	WBAI013-05	5	-
- Mechanics and Relativity 2	WBPH021-05	5	-
Elective 2, one out of:	WBMA041-05		
- First-year Project Mathematics		5	-
- First-year Project Applied Mathematics	WBMA040-05	5	-

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 9.3)**

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

Compulsory major courses (90 ECTS):

Course unit name	**Course code**	**ECTS**	**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	-
Project Systems Theory	WBMA027-05	5	-
Dynamical Systems	WBMA031-05	5	-
Fluid Dynamics	WBMA032-05	5	-
Functional Analysis	WBMA033-05	5	-
Numerical Mathematics 1	WBMA045-05	5	-
Partial Differential Equations	WBMA008-05	5	-
Project Modelling	WBMA047-05	5	-
Computational Methods of Science	WBMA004-05	5	-
Bachelor Workgroup Applied Mathematics	WBMA050-05	5	-
Mathematics & Society: Ethical and Professional Aspects	WBMA049-05	5	-
Bachelor's Project Applied Mathematics	WBMA901-15	15	Passed 150 ECTS of the Bachelor's programme in Mathematics

Compulsory minor courses (30 ECTS):

Numerical Mathematics 2	WBMA023-05	5	-
Advanced Systems Theory	WBMA001-05	5	-
Mathematical Modelling	WBMA007-05	5	-
Calculus of Variations and Optimal Control	WBMA016-05	5	-
Electives (see optional course units below)	-	10	-

Optional course units
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.

Course unit name	**Course code**	**EC TS**	**Entry requirements**
Geometry	WBMA034-05	5	-
Project Security and Coding	WBMA026-05	5	-
Project Chaos Theory	WBMA025-05	5	-
Algebraic Structures	WBMA039-05	5	-
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	-
Discrete Mathematics	WBMA019-05	5	-
Probability and Measure	WBMA024-05	5	-
Stochastic Processes	WBMA048-05	5	-
Max one out of: - Introduction to Actuarial Sciences - Introduction to Econometrics	 EBB827A05 EBB828A05	5	-
Project Statistical Reasoning	WBMA038-05	5	-
Asymptotic Statistics	WBMA002-05	5	-
Stochastic Models	EBB878A05	5	-
Statistical Modelling	WBMA028-05	5	-

In addition, the electives can be chosen from the following list of courses:

Course unit name	**Course code**	**EC TS**	**Entry requirements**
At most one out of: - Imperative Programming - C++ fundamentals	 WBCS003-05 WBCS033-05	 5 5	 - -
Programming in C++	WBCS034-05	5	-
Mechatronics	WBIE011-05	5	-
Waves and Optics	WBPH032-05	5	-
Nanophysics & Nanotechnology	WBPH025-05	5	-
Electronics & Signal Processing	WBPH038-05	5	-
Astrophysical Hydrodynamics	WBAS011-05	5	-
Queuing Theory and Simulation	EBB074A05	5	-

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 *Bachelor's degree programme*	**N+T**	**N+G**	**E+M**	**C+M**
Biologie *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 Centre	Minimum section scores C2 or C1 (one 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 Centre	Minimum section scores C2 or C1 (one 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 Centre	Minimum section scores C2 or C1 (one 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 VWO level**	**or**	**Nature and 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 Technology	en, wib, sk, bio, na		en, wib, na, sk
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 Management Science	en, wib, sk, bio		en, wib, na, sk
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 Centre	Minimum section scores C2 or C1 (one 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

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 and post-propaedeutic phase (Article 3.5)

Bachelor propaedeutic phase	
Type of contact	**Number of contact hours per year**
Lectures	335
Tutorials	290
Practical	25
Computer practical	40
Study support/Mentor groups	70
Internship support and guidance	-
Examinations	80
Misc. contact hours (symposia)	20

Bachelor post-propaedeutic phase	
Type of contact	**Number of contact hours per year**
Lectures	620
Tutorials	450
Practical	40
Computer practical	70
Study support/Mentor groups	-
Internship support and guidance	10
Examinations	240
Misc. contact hours (symposia)	30

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

1. Neurosciences (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.

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 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 arrangements (Article 12.1)

For cohort 2019-2020 and earlier

Course	May be replaced with
C++, part I	C++ fundamentals
C++, part II	Programming in C++
Mathematics: history, ethics and career	Mathematics & Society: Ethics and Professional Aspects

For cohort 2017-2018 and earlier

Course	May be replaced with
Linear Models in Statistics (EBB072A05)	Discrete Mathematics OR Linear Models in Statistics (EBB072A05)
Ordinary Differential Equations	Linear Systems
Metric Spaces	Metric and Topological Spaces
History of Mathematics	Mathematics: history, ethics and career *or* Mathematics & Society: Ethics and Professional Aspects
Project Mathematical Physics	Project Modelling
Measure and Integration	Probability and Measure
Security and Coding	Project Security and Coding
Chaos Theory	Project Chaos Theory
Statistical Reasoning	Project Statistical Reasoning
Project Dynamical Systems	Dynamical Systems