university of groningen / faculty of science and engineering

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

2017-2018

Appendix I Learning outcomes of the Bachelor's degree programme (Article 1.3.a)

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 work as independent professionals and are also qualified for further training to become academic researchers in these fields.

This 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 mathematics and applied mathematics.

A2. have mastered the basic concepts of mathematics and 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 mathematics and applied mathematics and have an understanding of the methods used in these fields, and particularly within their own discipline, 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 the requirements of the client and/or technical preconditions – find a solution. 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 in teams (including multidisciplinary teams) on technical-scientific problems.

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 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 algebra and geometry, analysis and numerical mathematics, as well as dynamical systems and systems theory.
1.3. have knowledge of more advanced topics in the fields of Computational Mathematics, and Systems and Optimization.
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 mathematical applications in various other fields of study.
1.6. are able to use mathematical software packages in an effective way or, if necessary, develop programs themselves.

Appendix I 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 mathematical questions and problems in an exact way, and if necessary adapt them to make them tractable and 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.
2.3 are able to 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

2.4 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.
2.5 are able to formulate concrete problems from application areas as mathematical problems.
2.6 are able to approach mathematical problems on the basis of a certain logical system and with determination to find the right method of approach.

2.7 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.

2.8 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.

Appendix II Majors and Minors of the degree programme (Article 2.1.4)

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 3.1.1)**
- **Compulsory order of examinations (Article 8.2)**

The propaedeutic phase of the Bachelor's degree programme in Applied Mathematics comprises a compulsory joint programme as well as electives that dovetail with the students' interest.

1-1. Compulsory programme, year 1

Period	Course unit name	ECTS	Entry requirements	Practical
Ia	Calculus 1	5	-	x
	Introduction to Mathematics	5	-	
	Mechanics and Relativity 1	5	-	
Ib	Linear Algebra 1	5	-	x
	Mechanics and Relativity 2	5	-	
	Elective, period Ib	5	See 1-2	
IIa	Calculus 2	5	-	
	Computer-Aided Problem-Solving	5	-	x
	Linear Algebra 2	5	-	
IIb	Analysis	5	-	
	Probability Theory	5	-	
	First-year Project Applied Mathematics	5	-	x

1-2 Optional course units

Period	Course unit name	ECTS	Entry requirements	Practical
Ib	Operations Research 1*	5	-	x
	Introduction to Energy and Environment 1*	5	-	

* Choose one of two

Appendix IV Course units in the post-propaedeutic phase

- **List of course units (Article 6.1.1)**
- **Compulsory order of examinations (Article 8.2)**

The post-propaedeutic phase of the Bachelor's degree programme in Applied Mathematics comprises a compulsory programme and an elective programme (the deepening Minor in Applied Mathematics is integrated into the programme). During each period that includes electives, students must choose one of the available electives.

Year 2

2-1 Compulsory programme, year 2

Period	Course unit name	ECTS	Entry requirements	Practical
Ia	Ordinary Differential Equations	5	-	
	Statistics	5	-	
	Project Mathematical Physics	5	-	x
Ib	Complex Analysis	5	-	
	Group Theory	5	-	
	Project Systems Theory	5	-	
IIa	Project Dynamical Systems	5	-	x
	Metric Spaces	5	-	
	Partial Differential Equations	5	-	
IIb	Numerical Mathematics 1	5	-	x
	Geometry	5	-	
	Fluid Dynamics	5	-	

Year 3

3-1 Compulsory programme, year 3

Period	Course unit name	ECTS	Entry requirements	Practical
Ia	Mathematical Modelling	5	-	x
	Computational Methods of Science	5	-	x
	Elective, period Ia	5	See A3-2	
Ib	Calculus of Variations and Optimal Control	5	-	
	Advanced Systems Theory#	5	-	
	Numerical Mathematics 2#	5	-	x
	Elective, period Ib	5	See A3-2	
IIa	History of Mathematics##	5	-	x
	CS: Ethical and Professional Issues##	5	-	x
	Functional Analysis	5	-	
	Elective, period IIa	5	See A3-2	
IIb	Bachelor's Project	15	Passed 150 ECTS of the Bachelor's programme in Applied Mathematics	

Choose one of these two
Choose one of these two

3-2 Elective programme, year 3

Period	Course unit name	ECTS	Entry requirements	Practical
Ia	Control Engineering#	5	-	
	Imperative Programming#	5	-	x
Ib	Advanced Systems Theory*	5	-	
	Numerical Mathematics 2*	5	-	x
	Waves and Optics*	5	-	x
	Chaos Theory*	5	-	
IIa	Statistical Modelling**	5	-	
	Electronics and Signal Processing**	5	-	x
	Structure of Matter I**	5	-	
	Astrophysical Hydrodynamics**	5	-	

Choose one of these two
* Choose one of these four, it is mandatory to take either advanced systems theory or numerical mathematics 2
** Choose one of these four

Appendix V Entry requirements (Article 10.2.1)

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. Non-native speakers of Dutch who wish to be admitted to the Bachelor's degree programmes in Biology, Life Science and Technology, or Pharmacy must also have passed the State Examination in Dutch as a Second Language, Programme II (NT2-II).

3. 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. Non-native speakers of Dutch who wish to be admitted to the Bachelor's degree programmes in Biology, Life Science and Technology, or Pharmacy must also have passed the State Examination in Dutch as a Second Language, Programme II (NT2-II).

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.

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. Non-native speakers of Dutch who wish to be admitted to the Bachelor's degree programmes in Biology, Life Science and Technology, or Pharmacy must also have passed the State Examination in Dutch as a Second Language, Programme II (NT2-II).

4. 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)

5. 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. Non-native speakers of Dutch who wish to be admitted to the Bachelor's degree programmes in Biology, Life Science and Technology, or Pharmacy must also have passed the State Examination in Dutch as a Second Language, Programme II (NT2-II).

4. 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)

5. 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. Non-native speakers of Dutch who wish to be admitted to the Bachelor's degree programmes in Biology, Life Science and Technology, or Pharmacy must also have passed the State Examination in Dutch as a Second Language, Programme II (NT2-II).

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.

Appendix VI Clustering of Bachelor's degree programmes (Article 4.3.4, Article 4.6.1)

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 5.1.1)

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

a. Students who have been issued a positive study advice from the 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 2.4)

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 7.5.1)

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
   - Quantum World
   - Building blocks of matter

2. The Programme Committee for the Bachelor's degree programmes in Biology and Life Science & 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 & 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 & Technology and the Master's degree programmes in Biology, Ecology & Evolution, Marine Biology and Molecular Biology & 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 & 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 Physics Minor "Einstein's physics: Space-time and parallel worlds" and/or its course units.

5. 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 2016-2017 and earlier

Course	May be replaced with	Reason
Mechanics for Mathematics (WPPH16007)	Mechanics and Relativity 1 (NAMR1-10) *or* Mechanics and Relativity 2 (NAMR2-10)	Curriculum change in 2017-2018: first course is no longer offered, second two courses in new curriculum
Introduction to Logic (WPAI14002)	Introduction to Logic (WPAI14001)	Curriculum change in 2017-2018: second course in new curriculum, first course is still offered. Content of courses is sufficiently similar
Physics of the Quantum Universe (WPPH16008)	Introduction to Energy and Environment 1 (WPPH16002)	Curriculum change in 2017-2018: second course in new curriculum, first course is still offered
Propaedeutic Project (WIPP-10)	First-year Project Applied Mathematics (WPMA17002)	Curriculum change in 2017-2018: first course no longer offered
Analysis on Manifolds (WIANVAR-07)	Geometry (WIMTK-08) *or* Geometry (WBMA17001) in case Geometry is not already part of the students programme in another way	Curriculum change in 2017-2018: first course will be offered in the minor and the course Geometry in the compulsory part of the programme