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

2015-2016

Appendix I Learning outcomes of the degree programme (Article 1.3a)

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, drawn up in general terms by the Faculty of Mathematics and Natural Sciences of the University of Groningen. First, a number of generic learning outcomes are formulated, which apply to the Bachelor's degree programmes in Astronomy, Physics, Applied Physics, Chemistry, Chemical Engineering, Mathematics and Applied Mathematics, to which specific learning outcomes for each degree programme are subsequently added.

A. Generic learning outcomes – Knowledge

A1. Bachelor's graduates have general knowledge of the foundations and history of mathematics, natural sciences and technology, in particular those of their own discipline.

A2. Bachelor's graduates have mastered the basic concepts of their own discipline (see Appendix I for further specification) to a certain extent and are familiar with the interrelationships of these concepts within their own discipline as well as with other disciplines.

A3. Bachelor's graduates have in-depth knowledge of several current topics within their own discipline.

A4. Bachelor's graduates are familiar with the quantitative character of the fields of mathematics and natural sciences and have an understanding of the methods used in these fields, and particularly within their own discipline, including computer-aided methods.

A5. Bachelor's graduates have sufficient knowledge and understanding of mathematics and natural sciences to successfully complete a follow-up Master's degree programme in their own discipline.

A6. Bachelor's graduates are aware of the societal, ethical and social aspects involved in the fields of mathematics and natural sciences.

B. Generic learning outcomes – Skills

B1 (Research) Bachelor's graduates are able to draw up a research question, design, plan and conduct research and report on it independently with a certain degree of supervision. Bachelor's graduates are able to evaluate the value and limitations of their research and assess its applicability outside their own field.

B2 (Designing and Modelling) Bachelor's graduates 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.

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

B4 (Collaborating) Bachelor's graduates are able to collaborate in teams (including multidisciplinary teams) on technical-scientific problems.

B5 (Communicating) Bachelor's graduates 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) Bachelor's graduates 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) Bachelor's graduates 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.

B8 Additional subject-specific skills are listed in Appendix II.

Appendix I Degree programme-specific learning outcomes – Basic knowledge

1.1. Bachelor's graduates 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. Bachelor's graduates 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. Bachelor's graduates have knowledge of more advanced topics in the fields of Computational Science and Numerical Mathematics, and Systems, Control and Optimization.
1.4. Bachelor's graduates have gained knowledge of and experience in the 'heart' of mathematics, i.e. the truth and value of exact mathematical proof.
1.5. Bachelor's graduates have knowledge of mathematical applications in various other fields of study.
1.6. Bachelor's graduates are able to use mathematical software packages in an effective way or, if necessary, develop programs themselves.

Appendix II Degree programme-specific learning outcomes – Skills

Research

2.1 Bachelor's graduates have an academic attitude, which means they are curious, critical, creative and dare to show initiative.
2.2 Bachelor's graduates are able to formulate relatively simple mathematical questions and problems in an exact way, and if necessary adapt them to make them tractable. Bachelor's graduates 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 Bachelor's graduates 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 Bachelor's graduates 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 Bachelor's graduates are able to formulate concrete problems from application areas as mathematical problems.

2.6 Bachelor's graduates 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 Bachelor's graduates 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 Bachelor's graduates 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 Follow-on Master's degree programmes (Article 1.3c)

The Bachelor's degree programme will grant unconditional admission to the following Master's degree programmes at the University of Groningen:

- Mathematics
- Applied Mathematics
- Education and Communication in Mathematics and Natural Sciences (Science Communication and Education programme, language of instruction is Dutch)
- Energy and Environmental Sciences

Appendix III Majors and Minors in the degree programme (Article 2.1.2)

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 IV Course units in the propaedeutic phase

- **List of course units; Article 3.1.1**
- **Course units with one or more practicals; Article 3.2**
- **Compulsory order of examinations; Article 8.2**

2013-2014 and earlier cohorts: See the appendices to the OER for the starting year of the degree programme.

2014-2015 cohort and later:
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	-	
	Elective, period 1a	5	See 1-2	
Ib	Linear Algebra 1	5	-	x
	Mechanics and Relativity 1	5	-	
	Elective, period 1b	5	See 1-2	
IIa	Calculus 2	5	-	
	Computer-Assisted Problem-Solving	5	-	x
	Linear Algebra 2	5	-	
IIb	Analysis	5	-	
	Probability Theory	5	-	
	Propaedeutic Project	5	-	x

1-2 Optional course units

Period	Course unit name	ECTS	Entry requirements	Practical
Ia	Physics Laboratory 1*	5	-	x
	Molecules: Structure, Reactivity, and Function*	5	-	x
	Introduction to Logic*	5	-	
1b	Operations Research 1**	5	-	x
	Thermodynamics**	5	-	

* Choose one of three
** Choose one of two

Appendix V Course units in the post-propaedeutic phase

- **List of course units; Article 6.1**
- **Course units with one or more practicals; Article 6.2**
- **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.

A new bachelor curriculum of the post-propaedeutic phase is introduces as of 2015-2016. The new curriculum of year 2 will start in 2015-2016 and the new curriculum of year 3 will start in 2016-2017.

2-1 Compulsory programme, year 2

(This curriculum of year 2 will start in 2015-2016)

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	History of Mathematics#	5	-	x
	Science, Ethics, Technology and Society#	5	-	x
	Metric Spaces	5	-	
	Partial Differential Equations	5	-	
IIb	Numerical Mathematics 1	5	-	x
	Project Dynamical Systems	5	-	
	Fluid Dynamics	5	-	

#Choose one of these two

Year 3
Part A: Applicable to students that started in the academic year 2014-2015 or later

A3-1 Compulsory programme, year 3
(This curriculum of year 3 will start in 2016-2017)

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

Chose one of these two

A3-2 Elective programme, year 3
(This curriculum of year 3 will start in 2016-2017)

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	-	
	Mechanics and Relativity 2**	5	-	x
	Physical Transport Phenomena 2**	5	-	
	Physics of Modern Technology**	5	-	
	Astrophysical Hydrodynamics**	5	-	

Choose one of these two
* Choose one of these four
** Choose one of these five

Year 3
Part B: Applicable to students that started in the academic year 2013-2014 or earlier

B3-1 Compulsory programme, year 3
(This old curriculum of year 3 will be offered for the last time in 2015-2016)

Period	Course unit name	ECTS	Entry requirements	Practical
Ia	Mathematical Modelling	5	-	
	Computational Methods of Science	5	-	x
	Elective	5	See B3-2	
Ib	Bachelor Workgroup	5	-	x
	Calculus of Variations and Optimal Control	5	-	
	Elective	5	See B3-2	
IIa	Analysis on Manifolds	5	-	
	Project Dynamical Systems	5	-	
	Elective	5	See B3-2	
IIb	Bachelor's Project	15	Passed 150 ECTS of the Bachelor's programme in Applied Mathematics	

B3-2 Elective programme, year 3 (2014-2016)
(This old curriculum of year 2 will be offered for the last time in 2015-2016)

Period	Course unit name	ECTS	Entry requirements	Practical
Ia	Control Engineering#	5	-	
	Imperative Programming#	5	-	x
Ib	Geometry*	5	-	
	Chaos Theory*	5	-	
	Waves and Optics*	5	-	x
IIa	Advanced Systems Theory**	5	-	
	Numerical Mathematics 2**	5	-	x

Choose one of these two
* Choose one of these three
** Choose one of these two

Appendix VI Entry requirements (Article 10.1)

A. HBO (university of applied science) propaedeutic certificate

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

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 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. The Faculty Committee for Special Admissions will determine whether deficiencies have been compensated satisfactorily.

B. Foreign qualifications (EEA)

1. Any certificate that grants access to a university in a European country will also grant access to Dutch universities.

2. The same requirements that also apply to candidates with an 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: an IELTS score of 6.5, a TOEFL score of 580 (paper-based), of 237 (computer-based) or of 92 (internet-based) or equivalent.

5. The Faculty Committee for Special Admissions will determine whether deficiencies have been compensated satisfactorily.

C. Foreign qualifications (German)

1. German candidates must have a Zeugnis der Allgemeinen Hochschulreife ('Abitur').

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

Degree programme	
B Biology	wi (LK or GK) na (LK or GK) sk (LK or GK) bio (LK or GK) (at least one subject at Leistungskurs level)
B Pharmacy B Life Science and Technology B Chemistry B Chemical Engineering	wi (LK or GK) na (LK or GK) sk (LK or GK) (at least one subject at Leistungskurs level)
B Computing Science B Mathematics B Applied Mathematics B Artificial Intelligence	wi (LK)
B Physics B Astronomy B Applied Physics	wi (LK) na (LK or GK)
B Industrial Engineering and Management Science	wi (LK or GK) na (LK or GK) (at least one subject at Leistungskurs level)

wi= Mathematics; na = Physics; sk = Chemistry; bio = Biology
LK = Leistungskurs level; GK = Grundkurs level followed until end of Class 13 or Class 12 (if Gymnasium education lasts 12 years).

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. The Faculty Committee for Special Admissions will determine whether deficiencies have been compensated satisfactorily.

D. Foreign qualifications (International Baccalaureate)

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

Degree programme	**from 2010/2011**
B Biology	Biology (SL or HL) Maths (SL or HL) Physics (SL or HL) Chemistry (SL or HL) two of these subjects at HL
B Pharmacy B Life Science and Technology B Chemistry B Chemical Engineering	Maths (SL or HL) Physics (SL or HL) Chemistry (SL or HL) two of these subjects at HL
B Computing Science B Mathematics B Applied Mathematics	Maths HL
B Artificial Intelligence	Maths SL **or** Maths HL
B Physics B Astronomy B Applied Physics B Industrial Engineering and Management Science	Maths HL Physics HL

SL = Standard Level, HL = Higher Level

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 Faculty Committee for Special Admissions will determine whether deficiencies have been compensated satisfactorily.

E. 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. The same requirements that also apply to candidates with an 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: an IELTS score of 6.5, a TOEFL score of 580 (paper-based), of 237 (computer-based) or of 92 (internet-based) or equivalent.

5. The Faculty Committee for Special Admissions will determine whether deficiencies have been compensated satisfactorily.

F. Entrance examination

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 of 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).

1. The Faculty Committee for Special Admissions will determine whether deficiencies have been compensated satisfactorily.

Appendix VII Clustering of Bachelor's degree programmes (Article 4.3.6, Article 4.4.2)

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	B Applied Mathematics
56965	B Applied Mathematics	56980	B Mathematics
50206	B Physics	56962 50205	B Applied Physics B Astronomy
56962	B Applied Physics	50206 50205	B Physics B Astronomy
50205	B Astronomy	56962 50206	B Applied Physics B Physics
56857	B Chemistry	56960	B Chemical Engineering
56960	B Chemical Engineering	56857	B Chemistry

Appendix VIII Admission to the post-propaedeutic phase (Article 5.1.1)

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

- Holders of a propaedeutic certificate of the bachelor's degree programmes in Mathematics or Applied Mathematics

Appendix IX Contact Hours in the propaedeutic phase (Article 2.3)

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	-
Exams	80
Misc. contact hours (symposia)	10

Appendix X University Minors of the faculty of Mathematics and Natural Sciences Article 7.5.1

1. Neurosciences Minor:
   - Neuroscience (18 ECTS)
   - Behavioral Neuroscience (6 ECTS)
   - Neuroscience essay (6 ECTS)

   People, Planet, Profit Minor:
   - Overview and Coherence People Planet Profit (10 ECTS)
   - People Planet Profit paper (5 ECTS)
   - Multidisciplinary Cooperation (5 ECTS)
   - Project Sustainability (10 ECTS)

2. The Programme Committee for the Bachelor's degree programmes in Biology and Life Science & Technology also has authority in the field of the Neurosciences Minor 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 People, Planet, Profit Minor 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 People, Planet, Profit Minor and/or its course units.

4. These Teaching and Examination Regulations also apply in their entirety to the Minors in Neurosciences and People, Planet, Profit and/or their course units.