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

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

The Bachelor's degree programme in Mathematics aims to impart knowledge, skills, understanding and an academic attitude in the field of 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 the field.

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 Dutch and 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 specific knowledge of one of the fields of Pure Mathematics, Physics, Logic, Philosophy, Statistics or Econometrics.
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.
1.7. (Minor) Bachelor's graduates have a broad-based knowledge of subjects within their own or a different discipline.

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 1.5)

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 programme, language of instruction is Dutch)
- Energy and Environmental Sciences

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

The Bachelor's degree programme in Mathematics has two specializations:

- General Mathematics
- Statistics and Econometrics

The General Mathematics specialization comprises

1) a Mathematics Major (150 ECTS)
2) a Minor (30 ECTS) to be chosen from
    a. University-wide broadening Minors
    b. Faculty-wide deepening Minors
    c. Deepening Minors for General Mathematics
        - Mathematics & Physics
        - Mathematics, Logic & Philosophy
        - Mathematics
    d. Optional Minor, based on an individual choice of course units to be approved by the Board of Examiners.

The Statistics and Econometrics specialization comprises

1) a Statistics and Econometrics Major (150 ECTS)
2) a deepening Minor in Statistics and Econometrics (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**
- **Form of examinations; Article 7.4**

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

2014-2015 cohort:
The propaedeutic phase of the Bachelor's degree programme in Mathematics with specializations in General Mathematics (including three structured tracks in the interest fields of 'Mathematics & Physics', 'Mathematics, Logic & Philosophy' and 'Mathematics') and Statistics and Econometrics comprises a compulsory joint programme as well as electives that dovetail with the students' specialization/interest field.

1-1. Compulsory programme, year 1

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Calculus 1	5		basic skills assessment, written exam	x
	Introduction to Mathematics	5		written exam	
	Elective, period 1a	5	See 1-2		
Ib	Linear Algebra 1	5		practical assessment, written exam	x
	Mechanics and Relativity 1	5		written exam	
	Elective, period 1b	5	See 1-2		
IIa	Calculus 2	5		written exam	
	Computer-Assisted Problem-Solving	5		assessment computer practicals,, written exam	x
	Linear Algebra 2	5		written exam	
IIb	Analysis	5		written exam	
	Probability Theory	5		written exam	
	Propaedeutic Project	5		journal, project proposal, article, oral presentation, poster, poster presentation	x

1-2 Optional course units, year 1

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Physics Laboratory 1*	5	-	written exam, , practical assessment (preparation, experimental skills, lab journal, reports, discussion of results)	x
	Molecules: Structure, Reactivity, and Function	5	-	practical assessment, report, written exam	x
	Introduction to Logic**	5	-	homework assignments, midterm test, written exam	
1b	Operations Research 1#	5	-	assignments, written exam	x
	Thermodynamics*	5	-	written exam	

* Programme component for the Mathematics & Physics interest field
** Programme component for the Mathematics, Logic & Philosophy interest field. Also an elective in year 2.
# Compulsory for the Statistics and Econometrics specialization

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 7.2**
- **Form of examinations; Article 7.4**

Part A: Applicable to students that start in the academic year 2014-2015

A new bachelor curriculum of the post-propaedeutic phase will be introduced in the following two years. The new curriculum of year 2 will start in 2015-2016 and the new curriculum of year 3 will start in 2016-2017.

The post-propaedeutic phase of the Bachelor's degree programme in Mathematics with specializations in General Mathematics and Statistics and Econometrics comprises a compulsory joint programme, an elective programme dovetailing with the student's specialization/interest field, and a Minor that also dovetails with the student's specialization/interest field or can be entirely freely chosen. During each period that includes electives, students must choose one of the available electives that dovetails with their specialization/interest field.

A2-1 Compulsory programme, year 2

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

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Ordinary Differential Equations	5	-	written exam	
	Statistics	5	-	written exam	
	Specialization course unit, period Ia	5	See A2-2		
Ib	Complex Analysis	5	-	written exam	
	Group Theory	5	-	written exam	
	Project Systems Theory	5	-	presentation, report, written exam	x
IIa	History of Mathematics#	5	-	Literature study, review, report, presentation	
	Science, Ethics, Technology and Society#	5	-	Written exam, performance, essay, presentation, mandatory attendance	
	Metric Spaces	5	-	written exam	
	Partial Differential Equations	5	-	written exam	
IIb	Numerical Mathematics 1	5	-	assignments, written exam	x
	Project Dynamical Systems	5	-	presentation, report, written exam	
	Specialization course unit, period IIb	5	See A2-2		

Choose one of these two

A2-2 Specialization programme, year 2

Specialization General Mathematics, year 2

- Mathematics & Physics interest field, year 2

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

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Project Mathematical Physics	5	-	assignments, presentation, report	x
IIb	Electricity and Magnetism I	5	-	written examination, practical assessment	x

- Mathematics, Logic & Philosophy interest field, year 2

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

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Project Mathematical Physics #	5	-	assignments, presentation, report	x
	Statistical Reasoning #	5	-	written exam	
	Introduction to Logic#	5	-	, homework assignments, midterm test, written exam	
IIb	Advanced Logic	5	Introduction to Logic	written exam, assignment	x

Choose one of these three. Introduction to Logic is obligatory in year 2 if it was not chosen in year 1.

- Mathematics interest field, year 2

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

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Project Mathematical Physics#	5	-	assignments, presentation, report	x
	Statistical Reasoning#	5	-	written exam	
IIb	Algebraic Structures	5	-	written exam	

Choose one of these two

- General Mathematics without specific field of interest and free minor, year 2

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Project Mathematical Physics#	5	-	assignments, presentation, report	x
	Statistical Reasoning#	5	-	written exam	
IIb	Algebraic Structures##	5	-	written exam	
	Advanced Logic##	5	Introduction to Logic	written exam, assignments	x
	Fluid Dynamics##	5		oral examination	

Choose one of these two
Choose one of these three

Specialization Statistics and Econometrics, year 2

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

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Statistical Reasoning	5	-	written exam	
IIb	Risk Insurance##	5	-	written exam assignments	x
	Dynamic Econometrics##	5	-	written exam assignments, report	
	Game theory##	5	-	written exam	

Choose one of these three

A3-1 Compulsory programme, year 3

(This curriculum of year 3 will start in 2016-2017)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Minor	15	-		
Ib	Minor	15	-		
IIa	Analysis on Manifolds	5	-	written exam	
	Functional Analysis	5	-	written exam	
	Elective, period IIa	5	See A3-2		
IIb	Bachelor's Project	15	Passed 150 ECTS of the Bachelor's programme in Mathematics	implementation of project, oral presentation, report	x

A3-2 Elective programme, year 3

(This curriculum of year 3 will start in 2015-2016)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
IIa	Statistical Modelling#	5	-	assignments, written exam	
	Mechanics and Relativity 2*	5	-	written exam, practical assessment	x
	Philosophy of Science, Technology & Society**	5	-	presentation, report	

Compulsory for the Statistics and Econometrics specialization
Programme component for the General Mathematics specialization with Mathematics interest field
Programme component for General Mathematics without specific field of interest and free minor
* Programme component for the General Mathematics specialization with Physics interest field
* Programme component for General Mathematics without specific field of interest and free minor
** Programme component for the General Mathematics specialization with Logic & Philosophy interest field
** Programme component for General Mathematics without specific field of interest and free minor

A3-3 Deepening Minor, Mathematics & Physics interest field

(This curriculum of year 3 will start in 2016-2017)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Measure Theory and Integration	5	-	homework, oral exam	
	Electricity and Magnetism 2	5	-	written exam	
	Quantum Physics 1	5	-	written exam	
Ib	Chaos Theory	5	-	presentation, essay	
	Waves and Optics	5	-	written examination, practical assessment	x
	Calculus of Variations and Optimal Control##	5	-	written exam	
	Geometry##	5	-	written exam, homework assignment	
	Advanced Systems Theory##	5	-	written exam	

Choose one of these three

A3-4 Deepening Minor, Mathematics, Logic & Philosophy interest field

(This curriculum of year 3 will start in 2016-2017)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Measure Theory and Integration	5	-	homework, oral exam	
	Mathematical Modelling	5	-	assignments	
	Security and Coding#	5	-	assignments	
	Quantum Physics 1#	5	-	written exam	
Ib	Philosophy of Natural Sciences	5	-	homework exam	
	Chaos Theory ##	5	-	presentation, essay	
	Advanced Systems Theory ##	5	-	written exam	
	Numerical Mathematics 2##	5	-	assignments, written exam	x
	Calculus of Variations and Optimal Control##	5	-	Assignments, written exam	

Choose one of these two
Choose two of these four

A3-5 Deepening Minor, Mathematics interest field

(This curriculum of year 3 will start in 2016-2017)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Measure Theory and Integration	5	-	Homework, oral exam	
	Mathematical Modelling	5	-	assignments	
	Security and Coding	5	-	assignments	
Ib	Geometry	5	-	written exam, homework assignment	
	Advanced Systems Theory*	5	-	written exam	
	Advanced Algebraic Structures*	5	-	written exam	
	Chaos Theory #	5	-	presentation, essay	
	Calculus of Variations and Optimal Control#	5	-	assignments, written exam	

* Choose one of these two
# Choose one of these two

A3-6 Deepening Minor, Statistics and Econometrics specialization

(This curriculum of year 3 will start in 2016-2017)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Measure Theory and Integration	5	-	Homework, oral exam	
	Mathematical Modelling	5	-	assignments	
	Asymptotic Statistics	5	-	assignments, written exam	
Ib	Calculus of Variations and Optimal Control	5	-	assignments, written exam	
	Stochastic Models	5	-	written exam	x
	Advanced Systems Theory#	5	-	written exam	
	Numerical Mathematics 2#	5	-	assignments, written exam	x

Choose one of these two course units

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

In the next two years a new bachelor curriculum will be introduced. This means that the old curriculum of year 2 will be offered for the last time in 2014-2015 and the old curriculum of year 3 will be offered for the last time in 2015-2016. The new curriculum is listed in Part A of this Appendix.

The post-propaedeutic phase of the Bachelor's degree programme in Mathematics with specializations in General Mathematics and Statistics and Econometrics comprises a compulsory joint programme, an optional programme dovetailing with the student's specialization/interest field, and a Minor that also dovetails with the student's specialization/interest field or can be entirely freely chosen. During each period that includes electives, students must choose one of the available electives that dovetails with their specialization/interest field.

B2-1 Compulsory programme, year 2

(This old curriculum of year 2 will be offered for the last time in 2014-2015)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Analysis	5	-	homework assignments, written exam	
	Statistics	5	-	written exam	
	Specialization course unit, period Ia	5	See B2-2		
Ib	Complex Analysis	5	-	written exam	
	Ordinary Differential Equations	5	-	written exam	
	Project Systems Theory	5	-	presentation, report, written exam	x
IIa	History of Mathematics#	5	-	literature study, review, report, presentation	
	Science, Ethics, Technology and Society#	5	-	written exam, performance, essay, presentation, mandatory attendance	
	Metric Spaces	5	-	written exam	
	Specialization course unit, period IIa	5	See B2-2		
IIb	Numerical Mathematics 1	5	-	assignments, written exam	x
	Group Theory	5	-	written exam	
	Specialization course unit, period IIb	5	See B2-2		

choose one of these two

B2-2 Specialization programme, year 2

(This old curriculum of year 2 will be offered for the last time in 2014-2015)

Due to changes to the curriculum of other bachelor programmes, the elective programme is different from that in the 2013-2014 OER.

General Mathematics specialization

- Mathematics & Physics interest field, year 2

(This old curriculum of year 2 will be offered for the last time in 2014-2015)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Project Mathematical Physics	5	-	assignments, presentation, report	x
IIa	Partial Differential Equations	5	-	written exam	
IIb	Electricity and Magnetism I	5	-	written examination, practical assessment	x

- Mathematics, Logic & Philosophy interest field, year 2

(This old curriculum of year 2 will be offered for the last time in 2014-2015)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Project Mathematical Physics #	5	-	assignments, presentation, report	x
	Statistical Reasoning #	5	-	written exam	
	Introduction to Logic #	5	-	, homework, assignments, midterm test, written exam	
IIa	Partial Differential Equations	5	-	written exam	
IIb	Advanced Logic	5	Introduction to Logic	written exam, assignment	x

Choose one of these three. Introduction to Logic is obligatory in year 2 if it was not chosen in year 1.

- Mathematics interest field, year 2

(This old curriculum of year 2 will be offered for the last time in 2014-2015)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Project Mathematical Physics#	5	-	assignments, presentation, report	x
	Statistical Reasoning#	5	-	written exam	
IIa	Partial Differential Equations	5	-	written exam	
IIb	Functional Analysis	5	-	written exam	

Choose one of these two

Statistics and Econometrics specialization, year 2

(This old curriculum of year 2 will be offered for the last time in 2014-2015)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Statistical Reasoning	5	-	written exam	
IIa	Introduction to Econometrics#	5	-	written exam assignments	x
	Introduction to Actuarial Science#	5	-	written exam assignments	x
IIb	Risk Insurance##	5	-	written exam assignments	x
	Dynamic Econometrics ##	5	-	written exam assignments, report	x
	Game theory##	5	-	written exam	

Choose one of these two
Choose one of these three

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	Mode of assessment	Practical
Ia	Minor	15	-		
Ib	Minor	15	-		
IIa	Analysis on Manifolds	5	-	written exam	
	Project Dynamical Systems	5	-	presentation, report, written exam	
	Elective, period IIa	5	See B3-2		
IIb	Bachelor's Project	15	Passed 150 ECTS of the Bachelor's programme in Mathematics	implementation of project, oral presentation, report	x

B3-2 Specialization 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	Mode of assessment	Practical
IIa	Statistical Modelling#	5	-	assignments, written exam	
	Mechanics and Relativity 2*	5	-	written exam, practical assessment	x
	Philosophy of Science, Technology & Society **	5	-	presentation, report	
	Algebraic Structures***	5	-	written exam	

Compulsory for the Statistics and Econometrics specialization
* Programme component for the Mathematics & Physics interest field
** Programme component for the Mathematics, Logic & Philosophy interest field
*** Programme component for the Mathematics interest field

B3-3 Deepening Minor, Mathematics & Physics interest field

(This old curriculum of year 3 will be offered for the last time in 2015-2016)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Measure Theory and Integration	5	-	Homework, oral exam	
	Electricity and Magnetism 2	5	-	written exam	
	Quantum Physics 1	5	-	written exam	
Ib	Bachelor Workgroup	5	-	oral presentation, report	
	Geometry	5	-	written exam, homework assignment	
	Waves and Optics	5	-	written exam, practical assessment	x

B3-4 Deepening Minor, Mathematics, Logic & Philosophy interest field

(This old curriculum of year 3 will be offered for the last time in 2015-2016)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Measure Theory and Integration	5	-	Homework, oral exam	
	Mathematical Modelling	5	-	assignments	
	Security and Coding#	5	-	assignments	
	Quantum Physics 1#	5	-	written exam	
Ib	Bachelor Workgroup	5	-	oral presentation, report	
	Philosophy of Natural Sciences	5	-	homework exam	
	Chaos Theory	5	-	presentation, essay	

Choose one of these two

B3-5 Deepening Minor, Mathematics interest field

(This old curriculum of year 3 will be offered for the last time in 2015-2016)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Measure Theory and Integration	5	-	homework, oral exam	
	Mathematical Modelling	5	-	assignments	
	Security and Coding	5	-	assignments	
Ib	Bachelor Workgroup	5	-	oral presentation, report	
	Geometry	5	-	written exam, homework assignment	
	Chaos Theory	5	-	presentation, essay	

B3-6 Deepening Minor, Statistics and Econometrics specialization

(This old curriculum of year 3 will be offered for the last time in 2015-2016)

Period	Course unit name	ECTS	Entry requirements	Mode of assessment	Practical
Ia	Measure Theory and Integration	5	-	homework, oral exam	
	Mathematical Modelling	5	-	assignments	
	Asymptotic Statistics	5	-	written exam	
Ib	Bachelor Workgroup	5	-	oral presentation, report	
	Calculus of Variations and Optimal Control	5	-	assignments, written exam	
	Stochastic Models	5	-	written exam	x

Appendix VI Entry Requirements

Appendix VII Clustering of Bachelor programmes

Appendix VIII Admission to the post-propaedeutic phase

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

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

Appendix IX Contact Hours in the propaedeutic phase

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