faculty of mathematics
and natural sciences

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

2016-2017

Appendix I Teaching outcomes of the degree programme (art. 1.3)

The learning outcomes consist of general learning outcomes with respect to both knowledge and skills, which are applicable for both the the research profile and the Science, Business and Policy profile, supplemented with profile-specific learning outcomes. For each learning outcome a reference to the Dublin descriptors is given between brackets.

The master graduate in Mathematics:

1. has an understanding of the most important concepts of the field, [knowledge and understanding]
2. is able to contribute to the scientific advancement of a subfield of mathematics, [applying knowledge and understanding]
3. is able to use abstract thinking and mathematical modeling to get to the root of a problem and thus recognize whether existing methods are applicable, or to ascertain that new methods must be developed, [applying knowledge and understanding]
4. is able to function in multidisciplinary teams, [applying knowledge and understanding]
5. is familiar with the social and ethical aspects of applying mathematics in practice, [judgement]
6. understands the scientific relevance of problem definitions and results, and the validity of the scientific method, [judgement]
7. is able to describe solutions in both general and formal mathematical terms, [communication]
8. is able to express him- or herself well both orally and in writing, [communication]
9. is able to evaluate the scientific literature so as to keep their knowledge up to date. [learning]

In addition, the master graduate in Mathematics with a research profile

1. has specialized knowledge of theories, methods and techniques in at least one of the following subfields of mathematics: [knowledge and understanding]
    a. Algebra & Geometry
    b. Analysis
    c. Dynamical Systems
    d. Mathematical Physics
    e. Statistics and Probability
2. has experience with the mathematical modeling of non-mathematically formulated ideas and problems and with interpreting the mathematical results in the light of the original, non-mathematical problem, [applying knowledge and understanding]
3. is able to apply scientific results and insights to concrete problems in mathematics or in related fields (natural sciences or applied mathematics), [applying knowledge and understanding]
4. is familiar with and experiences mathematics as a coherent organic unit. [judgement]

Whereas the master graduate in Mathematics with the profile Science, Business and Policy:
(Since the Business and Policy part of the of this profile is taught in Dutch the profile-specific learning outcomes are in Dutch).

1. heeft inzicht in het functioneren van bedrijven en beleidsorganisaties (overheden en niet-gouvernementele organisaties, NGO's).
2. heeft inzicht in de verbanden tussen natuurwetenschappelijk onderzoek, het bedrijfsleven en overheidsbeleid.
3. is in staat natuurwetenschappelijke en bedrijf- en beleidsmatige aspecten te integreren, in concreto:
    (a) het kunnen vertalen van een concreet bedrijfs- of beleidsmatig probleem naar een natuurwetenschappelijk probleem
    (b) het kunnen relateren van natuurwetenschappelijke aspecten van een probleem aan andere relevante kennisvelden

   (c) het kunnen plaatsen van onderzoeksresultaten in een beleid- of bedrijfsmatige context
4. beschikt over sociale en communicatieve vaardigheden, in concreto:
   (a) het kunnen schrijven van doelgerichte teksten
   (b) het kunnen opstellen van een innovatie- en beleidsplan voor respectievelijk een bedrijf of overheid
   (c) het kunnen houden van overtuigende mondelinge presentaties
   (d) een actieve bijdrage kunnen leveren aan plenaire discussies
   (e) vergadertechnieken beheersen, waaronder voorzitten
   (f) het kunnen werken aan een project in teamverband
   (g) het geven en ontvangen van feedback op het functioneren in een team
5. is in staat projectmatig te werken, in concreto:
   (a) rekening kunnen houden met het belang of de doelstelling van een opdrachtgever
   (b) het zelfstandig kunnen plannen van een project
   (c) kunnen samenwerken met de voor het project relevante partijen
   (d) adequaat kunnen omgaan met beperkingen in tijd, informatie en middelen
   (e) het kunnen voorbereiden van de implementatie van een projectresultaat
6. is in staat beroepsverantwoordelijkheid te nemen, in concreto:
   (a) het kunnen nemen van verantwoordelijkheid voor de organisatie
   (b) het kunnen herkennen van strategische aspecten van het eigen project
   (c) praktische invulling kunnen geven aan ethische beroepscodes van het eigen vakgebied en de organisatie

Appendix II Specializations of the degree programme (art. 2.2)

The degree programme has a research profile and Science, Business and Policy profile with the following tracks:

Research profile:

- Mathematics and Complex Dynamical Systems
- Statistics and Big Data

The track Mathematics and Complex Dynamical Systems covers the specialisation areas Analysis, Dynamical Systems, Mathematical Physics, Algebra and Geometry. The track Statistics and Big Data covers Statistics and Probability Theory.

Science, Business and Policy

- No further subdivision.

Appendix III Content of the degree programme (art. 2.3)

Research profile

The research profile of the degree programme has the following tracks:

- Mathematics and Complex Dynamical Systems
- Statistics and Big Data

The track Mathematics and Complex Dynamical Systems covers the specialisation areas Analysis, Dynamical Systems, Mathematical Physics, Algebra and Geometry. The track Statistic and Big Data covers Statistics and Probability Theory.

The master programme comprises 120 ECTS.

The requirements on the programme are the following.

Parts	*Constraints*	*ECTS*
Group of three compulsory modules, followed jointly by all Master students Mathematics and Applied Mathematics	The following three modules are compulsory: - Mathematics and its Environment - Mathematical Modeling Colloquium - Complexity and Networks	15

Group of five modules either from the track Mathematics and Complex Dynamical Systems or the track Statistics and Big Data.	**Track Mathematics and Complex Dynamical Systems:** Five modules from the following list of modules should be chosen: - Caput Dynamical Systems & Chaos (annual) - Caput Mathematical Physics (every two years, not in 2016-2017) - Hamiltonian Mechanics (annual) - Caput Algebra & Geometry (annual) - Caput Differential Geometry (annual) - Geometry & Topology (every two years, 2015-2016) - Geometry & Differential Equations (every two years, 2016-2017) - Relevant courses from the Mastermath Programme, see www.mastermath.nl (at the discretion of the Exam Committee) **Track Statistics and Big Data:** The following five modules are compulsory: - Contemporary Statistics with Applications (every two years, 2016-2017) - Statistical Genomics (every two years, 2015-2016) - Statistical Consulting (annual) - Asymptotic Statistics (annual, local Master course or from the Mastermath Programme) - Introduction to Data Science (annual)	≥ 25
A group of three modules of 'guided choice'.	Three modules have to be chosen from the lists of compulsory modules of any of the tracks in Mathematics and Applied Mathematics. For the Track Statistics and Big Data the following courses are relevant: a. Statistics specialization i. Measure-Theoretic Probability (Mastermath) ii. Perculation (Mastermath) iii. INMPR-08: Pattern Recognition iv. KIM.ML09: Machine Learning v. STMASP-12: Statistical Signal Processing vi. Random graph theory (every two years; 17-18) vii. WMCS15001: Neural networks and computational in	15

	telligence b. Data Science i. INMWCC-12: Cloud Computing ii. INMSV-08: Scientific Visualization iii. WMCS16003 Scalable Computing iv. WMSC16000 Data Science and Visual Analytics c. Applied Mathematics i. WIRC-09: Robust control ii. WICFD-03: Computational fluid dynamics iii. WIMCCNES12: Modeling and control of complex nonlinear engineering systems iv. WICE-04: Computational engineering	
A group of three modules of 'free choice'	Free choice out of modules on Master level, relevant for the master Mathematics (at the discretion of the Exam Committee)	15
Final Research Project	Research project in the specialization area.	50

Science, business and policy profile

The second profile of the degree programme is called *Science, Business and Policy*.
The master programme comprises 120 ECTS and consists of a mathematical component (60 ECTS) and a Business and Policy component (60 ECTS)

The requirements on the programme are the following.

Mathematical component (60 ECTS)		
Parts	*Constraints*	*ECTS*
Group of three compulsory modules, followed jointly by all Master students Mathematics and Applied Mathematics	The following three modules are compulsory: - Mathematics and its Environment - Mathematical Modeling Colloquium - Complexity and Networks	15
Group of three modules, within either the track Mathematics and Complex Dynamical Systems or the track	Three modules from either the track Mathematics and Complex Dynamical Systems or the track Statistics and Big Data should be chosen. All three modules should be chosen within the specific specialization area of the student:	15

Statistics and Big Data.	**Track Mathematics and Complex Dynamical Systems:** - Caput Dynamical Systems & Chaos (annual) - Caput Mathematical Physics (every two years, not in 2016-2017) - Hamiltonian Mechanics (annual) - Caput Algebra & Geometry (annual) - Caput Differential Geometry (annual) - Geometry & Topology (every two years, 2015-2016) - Geometry & Diff. Equations (every two years, 2016-2017) - Relevant courses from the Mastermath Programme, see www.mastermath.nl (at the discretion of the Exam Committee) **Track Statistics and Big Data:** - Contemporary Statistics with Applications (every two years, 2016-2017) - Statistical Genomics (every two years, 2015-2016) - Statistical Consulting (annual) - Asymptotic Statistics (annual, from the Mastermath Programme) - Introduction to Data Science (annual)	
Mathematical Research Project	Research project in the specialization area.	30

Business and Policy component (60 ECTS)		
Parts	*Constraints*	*ECTS*
Module Science, Business and Policy		20
Internship Science, Business and Policy		40

For information on the modules of the Mastermath programme see http://www.mastermath.nl.

For information on the modules of programmes of the University of Groningen other than the master programmes mathematics and applied mathematics see the teaching and examination regulations of the corresponding programme.

Double master's degree in Physics and Mathematics
For students who want to combine the master's programme in Physics and Mathematics the following programme is in place. In case the student is enrolled in both programmes, the student is awarded a master's degree in both Physics and Mathematics after completing the total programme. The total programme comprises (at least) 160 ects, (at least) 90 ects of courses and 70 ects of research, and is feasible within 2 ½ year of study.

Master Physics	**Master Mathematics**
Core Physics (20 ects) - Advanced Quantum Mechanics - Computational Physics - Statistical Mechanics - Mathematical Methods of Physics	*Three modules followed jointly by all Master students Mathematics and Applied Mathematics (15 ects):* - Mathematics and its Environment - Mathematical Modeling Colloquium - Complexity and Networks
Core QU (20 ects) - General Relativity - Particle Physics Phenomenology - Electrodynamics of Radiation Processes - Student Seminar Quantum Universe	*Five modules from the track Mathematics and Complex Dynamical Systems (25 ects)* - Caput Algebra & Geometry (annual) - Geometry & Topology (every two years, 2017-2018) - Geometry & Differential Equations (every two years, 2016-2017) - Caput Differential Geometry (annual) - Caput Dynamical Systems and Chaos (annual) - Caput Mathematical Physics (every two years, 2017-2018) - Hamiltonian Mechanics (annual) - Relevant courses from the Mastermath Programme, see www.mastermath.nl (at the discretion of the Board of Examiners)
Optional Courses QU (10 ects) - two optional courses QU which are not part of the individual mathematics programme of the student	*Free Choice (10 ects)* - Free choice out of modules on Master level, relevant for the master Mathematics (at the discretion of the Board of Examiners)
Joint Research Project (70 ects)	Joint Research Project (70 ects)

For information about the courses of the master's degree programme Physics and a list of optional courses QU see the Teaching and Examination Regulations of the master's degree programme in Physics.

The Mathematics and Applied Mathematics modules given at the University of Groningen are

module	**offered**	**ECTS**	**practical**
Caput Algebra and Geometry	annual	5	
Geometry and Topology	every two years	5	
Geometry and Differential Equations	every two years	5	
Caput Differential Geometry	annual	5	
Boundary Layers	every two years	5	x
Caput Dynamical Systems and Chaos	every two years	5	
Caput Mathematical Physics	every two years	5	
Computational Engineering	every two years	5	x
Computational Fluid Dynamics	annual	5	x
Contemporary Statistics with Applications	every two years	5	
Hamiltonian Mechanics	annual	5	
Final Research Project (Resarch profile only)	annual	50	
Mathematical Research Project (SBP profile only)	annual	30	
Modelling and Identification	every two years	5	
Modeling and Control of Complex Nonlinear Engineering Systems	annual	5	
Robust Control	annual	5	
Statistical Genomics	every two years	5	
Mathematical Modeling Colloquium	annual	5	
Mathematics and its Environment	annual	5	
Complexity and Networks	annual	5	
Mathematical Modeling Colloquium	annual	5	
Introduction to Data Science	annual	5	

The modules of the Business and Policy component are

module	offered	ECTS	practical
Science, Business and Policy	annual	20	
Internship Science, Business and Policy	annual	40	

Appendix IV Electives (art. 2.4)

See Appendix III.

Appendix V Entry requirements and compulsory order of examinations (art. 3.2)

The entry requirement for the Final Research Project (50 ects) is a successful completion of 45 ects of modules of the master's degree programme in Mathematics.

The entry requirement for the internship Science, Business and Policy is a successful completion of the module Science, Business and Policy (20 ECTS) and the mathematical research project (30 ECTS).

Appendix VI Admission to the degree programme and different specializations (art. 4.1.1 + art. 4.2)

Holders of the following Bachelor's degree from the University of Groningen are considered to have sufficient knowledge and skills and will be admitted to the Master's degree programme in Mathematics on that basis:

- BSc Mathematics
- BSc Applied Mathematics

Appendix VII

Application deadlines for admission (art. 4.6.1)

Deadline of Application	Non-EU students	EU students
Nanoscience	February 1st 2016	February 1st 2016
Behavioural and Cognitive Neurosciences	May 1st 2016	May 1st 2016
Biomolecular Sciences (topprogramme)	May 1st 2016	May 1st 2016
Evolutionary Biology (topprogramme/EM)	January 15th 2016	January 15th 2016
Remaining FMNS Masters (amongst which Mathematics)	May 1st 2016	May 1st 2016

Decision deadlines (art. 4.6.3)

Deadline of Decision	Non-EU students	EU students
Nanoscience	June 1st 2016	June 1st 2016
Behavioural and Cognitive Neurosciences	June 1st 2016	June 1st 2016
Biomolecular Sciences (topprogramme)	June 1st 2016	June 1st 2016
Evolutionary Biology (topprogramme/EM)	June 1st 2016	June 1st 2016
Remaining FMNS Masters (amongst which Mathematics)	June 1st 2016	June 1st 2016