university of groningen / faculty of science and engineering

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

2021-2022

Appendix I Learning outcomes of the degree programme (art. 3.1)

Objectives of MSc Mathematics

As a consequence of the ongoing automation of society and the technological innovations that go along with it, 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 mathematicians. The master's degree programme in Mathematics aims to train mathematicians who meet this profile.

The master'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 building on a bachelor's degree in Mathematics, such that Master's graduates are able able to pursue an independent career as independent professionals and are also qualified for further training to become academic researchers in the field.

Learning outcomes MSc Mathematics

The above objective has been translated into a set of learning outcomes for the programme. The learning outcomes consist of general learning outcomes with respect to both knowledge and skills, which are applicable for all tracks of the programme, supplemented with track-specific learning outcomes. For each learning outcome a reference to the Dublin descriptors is given between brackets.

The master graduate in Mathematics:

A1. has an understanding of the most important concepts of the field, [knowledge and understanding]
A2. is able to contribute to the scientific advancement of a subfield of mathematics, [applying knowledge and understanding]
A3. is able to use abstract thinking and mathematical reasoning 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]
A4. is able to function in multidisciplinary teams, [applying knowledge and understanding]
A5. is familiar with the social and ethical aspects of applying mathematics in practice, [judgement]
A6. understands the scientific relevance of problem definitions and results, and the validity of the scientific method, [judgement]
A7. is able to describe solutions in both general and formal mathematical terms, [communication]
A8. is able to express him- or herself well both orally and in writing, [communication]
A9. is able to evaluate the scientific literature so as to keep their knowledge up to date. [learning]

In addition, the master graduate in Mathematics track Mathematics and Complex Dynamical Systems or track Statistics and Big Data

P1. 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. Dynamical Systems and Analysis
    c. Statistics and Probability

P2. has experience with formulating ideas and problems in the mathematical language and with interpreting the mathematical results in the light of the original, non-mathematical problem, [applying knowledge and understanding]
P3. 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]
P4. is familiar with and experiences mathematics as a coherent organic unit. [judgement]

Whereas the master graduate in Mathematics track Science, Business and Policy:

M1. Has an understanding of the way in which businesses and policy organizations are functioning (governments and non-governmental organizations, NGO's)[knowledge and understanding]
M2. Understands the connections between natural science research, business, and policy [knowledge and understanding]
M3. Is able to integrate aspects of natural science, business and management [applying knowledge and understanding]
M4. Has developed his/her social and communicative skills, is able to work project-based, and is capable of taking professional responsibility [communication, judgement]

Appendix II Tracks/Specializations of the degree programme (art. 3.5 + art. 3.6)

The degree programme has three tracks:

1. Mathematics and Complex Dynamical Systems
2. Statistics and Big Data
3. Science, Business and Policy

Appendix III Content of the degree programme (art. 3.7)

1. The programme for Mathematics and Complex Dynamical Systems is:

Course unit	Course code	ECTS
Mathematics and its Environment	WMMA013-05	5
Mathematical Modelling Colloquium	WMMA023-05	5
Complexity and Networks	WMMA005-05	5
≥ 23 ECTS out of: - Caput Dynamical Systems and Chaos - Caput Mathematical Physics - Hamiltonian Mechanics - Caput Algebra and Geometry - Caput Differential Geometry - Geometry and Topology - Geometry and Differential Equations - Caput Number Theory - Topics in Topology - Relevant courses from the Mastermath programme (at the discretion of the Board of Examiners) Min. 3 courses have to be local non-Mastermath courses	 WMMA004-05 WMMA022-05 WMMA019-05 WMMA027-05 WMMA010-05 WMMA018-05 WMMA017-05 WMMA025-05 WMMA026-05	 5 5 5 5 5 5 5 5 5 6/8
≥ 15 ECTS guided choice: have to be chosen from Electives below (see art. 3.7)		≥ 15
≤15 ECTS free choice: modules on Master level, relevant for Mathematics (at the discretion of the Board of Examiners)		≤15
Master Research Project in Mathematics	WMMA902-50	50

The total has to be at least 120 ECTS, but it should not be possible to remove 1 course and still have more than 120 ECTS. At the discretion of the Board, these extra courses could be added as extracurricular.

2. The programme for Statistics and Big Data is:

Course unit	Course code	ECTS
Mathematics and its Environment	WMMA013-05	5
Mathematical Modelling Colloquium	WMMA023-05	5
Complexity and Networks	WMMA005-05	5
≥ 23 ECTS out of: - Contemporary Statistics with Applications	 WMMA015-05	 5

- Statistical Genomics - Statistical Consulting - Caput Statistics - Introduction to Data Science - Relevant courses from the Mastermath programme (at the discretion of the Board of Examiners) Min. 3 courses have to be local non-Mastermath courses	WMMA008-05 WMMA024-05 WMMA011-05 WMCS002-05	5 5 5 5
≥ 15 ECTS guided choice: have to be chosen from Electives below (see art. 3.7)		≥ 15
≤15 ECTS free choice: modules on Master level, relevant for Mathematics (at the discretion of the Board of Examiners)		≤15
Master Research Project in Mathematics	WMMA902-50	50

The total has to be at least 120 ECTS, but it should not be possible to remove 1 course and still have more than 120 ECTS. At the discretion of the Board, these extra courses could be added as extracurricular.

3. The programme for Science, Business and Policy consists of a mathematical component (60 ECTS) and a Business and Policy component 60 ECTS:

Mathematical component – Mathematics and Complex Dynamical Systems		
Course unit	**Course code**	**ECTS**
Mathematics and its Environment	WMMA013-05	5
Complexity and Networks	WMMA005-05	5
≥20 ECTS courses out of: - Caput Dynamical Systems and Chaos - Caput Mathematical Physics - Hamiltonian Mechanics - Caput Algebra and Geometry - Caput Differential Geometry - Geometry and Topology - Geometry and Differential Equations - Caput Number Theory - Topics in Topology - Relevant courses from the Mastermath programme (at the discretion of the Board of Examiners) Min. 3 courses have to be local non-Mastermath courses	 WMMA004-05 WMMA022-05 WMMA019-05 WMMA027-05 WMMA010-05 WMMA018-05 WMMA017-05 WMMA025-05 WMMA026-05	 5 5 5 5 5 5 5 5 5 6/8
Master Research Project in Mathematics (for SBP)	WMMA903-30	30

Mathematical component – Statistics and Big Data		
Course unit	**Course code**	**ECTS**
Mathematics and its Environment	WMMA013-05	5
Complexity and Networks	WMMA005-05	5
≥ 20 ECTS out of: - Contemporary Statistics with Applications - Statistical Genomics	 - WMMA015-05 WMMA008-05	 5 5

- Statistical Consulting	WMMA024-05	5
- Caput Statistics	WMMA011-05	5
- Introduction to Data Science	WMCS002-05	5
- Relevant courses from the Mastermath programme (at the discretion of the Board of Examiners)		6/8
- Pattern Recognition *	WMCS011-05	5
- Machine Learning*	WMAI010-05	5
- Neural Networks and Computational Intelligence *	WMCS010-05	5
- Statistical Signal Processing *	WMAS011-05	5
Min. 3 courses have to be local non-Mastermath courses At most one out of the courses with a *		
Master Research Project in Mathematics (for SBP)	WMMA903-30	30

Business and Policy component		
Course unit	**Course code**	**ECTS**
Introduction Science and Business	WMSE001-10	10
Introduction Science and Policy	WMSE002-10	10
Work Placement Business and Policy	WMSE901-40	40
Acquisition Tools and Career Management		0

The total has to be at least 120 ECTS, but it should not be possible to remove 1 course and still have more than 120 ECTS. At the discretion of the Board, these extra courses could be added as extracurricular.

Double master's degree in Mathematics and Physics

For students who want to combine the Master's programmes in Mathematics and Physics 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 Mathematics and Physics after completing the total programme. The total programme comprises (at least) 180 ECTS: (at least) 100 ECTS of courses and 80 ECTS of research, and is feasible within 2 ½ years of study.

Mathematics			**Physics**		
Course unit	**Course code**	**ECTS**	**Course unit**	**Course code**	**ECTS**
Mathematics and its Environment	WMMA013-05	5	Advanced Quantum Mechanics	WMPH032-05	5
Mathematical Modelling Colloquium	WMMA023-05	5	Computational Physics	WMPH007-05	5
Complexity and Networks	WMMA005-05	5	Statistical Mechanics	WMPH029-05	5
Seven courses out of: - Caput Algebra and Geometry	-WMMA027-05	5	Mathematical Methods of Physics	WMPH016-05	5
- Geometry and Topology	-WMMA018-05	5	General Relativity	WMPH009-05	5

- Geometry and Differential Equations - Caput Differential Geometry - Caput Dynamical Systems and Chaos - Caput Mathematical Physics - Topics in Topology - Caput Number Theory - Hamiltonian Mechanics - Relevant courses from the Mastermath programme (at the discretion of the Board of Examiners)	-WMMA017-05 -WMMA010-05 -WMMA004-05 -WMMA022-05 -WMMA026-05 -WMMA025-05 -WMMA019-05	5 5 5 5 5 5 5 6/8	Particle Physics Phenomenology Electrodynamics of Radiation Processes Student Seminar Quantum Universe	WMPH026-05 WMAS008-05 WMPH039-05	5 5 5
Free choice of relevant modules on Master level (at the discretion of the Board of Examiners)		10	Two optional courses QU which are not part of the individual Mathematics programme of the student. Not allowed: - Geometry & Differential Equations -Geometry & Topology	- MMA017-05 - MMA018-05	10
Master Research Project Physics + Mathematics	WMPH903-80	80	Master Research Project Physics + Mathematics	WMPH903-80	80

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.

Appendix IV Electives (art. 3.8)

1. Optional modules in the programme for Mathematics and Complex Dynamical Systems:

≤ 15 ECTS are free choice (at the discretion of the Board of Examiners)

≥ 15 ECTS are chosen from:

Course unit	Course code	ECTS
Contemporary Statistics with Applications	WMMA015-05	5
Statistical Genomics	WMMA008-05	5
Statistical Consulting	WMMA024-05	5
Caput Statistics	WMMA011-05	5
Introduction to Data Science	WMCS002-05	5
Computational Fluid Dynamics	WMMA012-05	5
Finite Element Modelling for Advanced Processing	WMME013-05	5
Finite Element Methods for Fluid Dynamics	WMMA016-05	5
Numerical Bifurcation Analysis of Large Scale Systems (Mastermath)	WMMA014-08	8
Numerical Linear Algebra (Mastermath)	WMMA002-08	8
Robust Control	WMMA021-05	5
Convex Optimization	WMMA006-05	5
Modeling and Identification	WMMA007-05	5
Modeling and Control of Complex Nonlinear Engineering Systems	WMMA020-05	5
Systems and Control (Mastermath)	WMMA003-06	6
Relevant courses from the Mastermath programme (at the discretion of the Board of Examiners)		6/8
Can only be followed together: - Basiscursus Master Lerarenopleiding (Dutch) - Masterstage 1 (Dutch)	 TEM0105 TEM0205	 5 5

2. Optional modules in the programme for Statistics and Big Data:

≤ 15 ECTS are free choice (at the discretion of the Board of Examiners)

≥ 15 ECTS are chosen from:

Course unit	Course code	ECTS
Pattern Recognition	WMCS011-05	5
Machine Learning	WMAI010-05	5
Statistical Signal Processing	WMAS011-05	5
Neural Networks and Computational Intelligence	WMCS010-05	5
Web and Cloud Computing	WMCS005-05	5
Scientific Visualization	WMCS018-05	5
Scalable Computing	WMCS017-05	5
Robust Control	WMMA021-05	5

Computational Fluid Dynamics	WMMA012-05	5
Modeling and Control of Complex Nonlinear Engineering Systems	WMMA020-05	5
Finite Element Modelling for Advanced Processing	WMME013-05	5
Finite Element Methods for Fluid Dynamics	WMMA016-05	5
Numerical Bifurcation Analysis of Large Scale Systems (Mastermath)	WMMA014-08	8
Numerical Linear Algebra (Mastermath)	WMMA002-08	8
Convex Optimization	WMMA006-05	5
Modeling and Identification	WMMA007-05	5
Modeling and Control of Complex Engineering Systems	WMMA020-05	5
Systems and Control (Mastermath)	WMMA003-06	6
Caput Dynamical Systems and Chaos	WMMA004-05	5
Caput Mathematical Physics	WMMA022-05	5
Hamiltonian Mechanics	WMMA019-05	5
Caput Algebra and Geometry	WMMA027-05	5
Caput Differential Geometry	WMMA010-05	5
Geometry and Topology	WMMA018-05	5
Geometry and Differential Equations	WMMA017-05	5
Caput Number Theory	WMMA025-05	5
Topics in Topology	WMMA026-05	5
Relevant courses from the Mastermath programme (at the discretion of the Board of Examiners)		6/8
Can only be followed together: - Basiscursus Master Lerarenopleiding (Dutch) - Masterstage 1 (Dutch)	 TEM0105 TEM0205	 5 5

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

For information on the modules of programmes of the University of Groningen other than the ones offered by the master's degree programme in mathematics see the Teaching and Examination Regulations of the corresponding programme.

Appendix V Entry requirements and compulsory order of examinations (art. 4.4)

The entry requirement for the Master Research Project in Mathematics (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 Introduction Science and Business (10 ECTS), the module Introduction Science and Policy (10 ECTS), the 60 ECTS mathematical component of the programme (including Master Research Project in Mathematics (for SBP) (30 ECTS)), and the module Acquisition Tools & Career Management (0 ECTS).

Appendix VI Admission to the degree programme and different specializations (art. 2.1.1 + art. 2.2)

Holders of the following Bachelor's degrees 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 Transitional arrangements (art. 7.1)

For cohort 2020-2021 and earlier

Course	May be replaced with
Advanced Asymptotic Statistics	Caput Statistics

For cohort 2018-2019 and earlier

Course	May be replaced with
Geometry and Differential Equations (WMMA14002)	Symmetries and Conservation Laws (Mastermath)

See also the transitional arrangements in the appendices TER of previous years.

Appendix VIII Application deadlines for admission (art. 2.6.1) and Additional requirements to Open Degree Programs (art. 5.6)

Deadline of Application	Non-EU students	EU students
Nanoscience	February 1st 2021	May 1st 2021
All other FSE Masters	May 1st 2021	May 1st 2021

Additional requirements to Open Degree Programs
In exceptional circumstances, students wishing to pursue an open degree programme may file a request with the Board of Examiners. The Board of Examiners will evaluate whether the proposed curriculum meets the learning outcomes of the degree programme and can determine further conditions in their rules and regulations.

Decision deadlines (art. 2.6.3)

Deadline of Decision	Non-EU students	EU students
All FSE Masters	June 1st 2021	June 1st 2021

Appendix IX Selection criteria selective master's degree programmes

Not applicable.