1 Assessment plan for the curriculum of the Master's degree programme in Mathematics, 2022-2023

1.1 Introduction

This assessment plan is a systematic description of the testing and assessment modes for all study components in the curriculum of the Master's degree programme in Mathematics, 2022-2023. The plan is based on the assessment policy of the Faculty of Science and Engineering, as set out in the 2016-2017 version of the FMNS Quality Assurance Manual (Chapter 6: Assessment) and the protocol setting out the duties and powers of the Faculty's Board of Examiners (December 2013).

The assessment plan for the curriculum consists of the following parts:

1. objective(s) of the degree programme
2. the learning outcomes of the degree programme
3. descriptions of the study components, as set out in the appendices to the Teaching and Examination Regulations 2022-2023 of the degree programme
4. descriptions of the content of each study component in Ocasys, the online course catalogue. The following elements are relevant in this context:
    - objectives
    - description of content
    - lecturers
    - assessment mode(s) and calculation of final mark
    - mode(s) of instruction.
5. An overview of the examiners and a detailed assessment mode for each study component. This overview is based on the curriculum approved by the Programme Committee, as set out in the appendices to the Teaching and Examination Regulations 2021-2022 for the degree programme.
6. A matrix showing the relationship between the study components and the detailed learning outcomes for each competence area.

Parts 3 and 4 are not included in this document. For the descriptions of the study components, see the Appendix to the Teaching and Examination Regulations 2022-2023 for the degree programme in Mathematics. Descriptions of the content of each study component can be found in Ocasys, the online course catalogue (http://www.rug.nl/ocasys/).

1.2 Objectives of the degree programme

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.

1.3 Learning outcomes of the degree programme

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, except for the track Science, Business and Policy,

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. Probability and Statistics

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]

1.4 Overview of examiners and testing and assessment modes for study components

In this section an overview of the examiners and a detailed assessment mode for each study component is given. This overview is based on the curriculum approved by the Programme Committee, as set out in the appendices to the Teaching and Examination Regulations 2018-2019 for the degree programme.

The abbreviations for the relevant modes of assessment:

- Written exam with open questions (WE)
- Oral exam (OR)
- Assignment (AST)
- Practical Work (PR)
- Presentation (P)
- Report (R)
- Interim test (IT)

If, as a result of the corona pandemic, a written exam cannot proceed, it may be converted into an open book online take-home exam, where
- Students have to sign a pledge swearing that the work has been completed autonomously and using only the allowed tools and aids;
- The first examiner/examiners can have short online discussions with (an unannounced selection of) students after the exam to check for possible fraud.

Alternatively, WE may also be replaced by OR if a written exam cannot proceed.

The Mathematics modules offered locally at the University of Groningen are:

module	**Offered**	**ECTS**	**First examiner**	**Second examiner (if necessary)**	**Prac-tical**	**Assessment type**
Research Seminar in Mathematics	annual	5	prof.dr. O. Lorscheid dr. S. Muller			P, R
Student Colloquium	annual	5	dr. M. Seri dr. A.M.S. Waters prof.dr. P. Trapman dr. A.V. Kiselev dr. J. Koellermeier			P, R
Mathematics and its Environment	annual	5	dr. A. Mali	prof.dr.ir. R.W.C.P. Verstappen		AST, P, R
Topics in Dynamical Systems and Chaos A 22/23	biennial	5	dr. A.E. Sterk	dr. H. Jardon Kojakhmetov		AST, OR
Topics in Dynamical Systems and Chaos B 23/24	biennial	5	tbd in 23/24	tbd in 23/24		AST, OR
Perturbation Theory 22/23	biennial	5	dr. H. Jardon Kojakhmetov	dr. N. Martynchuk		PR, WE
Singularity Theory 23/24	biennial	5	tbd in 23/24	tbd in 23/24		
Introduction to Algebraic Geometry	annual	5	prof.dr. C. Salgado	dr. J.S. Müller		OR
Hamiltonian Mechanics	annual	5	dr. M. Seri	prof.dr. H. Waalkens		AST, P, R
Topics in Number Theory (22/23)	biennial	5	dr. J. S. Müller	prof.dr. J. Top		AST, OR
Arithmetic Geometry (23/24)	biennial	5	tbd in 23/24	tbd in 23/24		AST, OR
Combinatorial Mathematics A (22/23)	biennial	5	tbd	prof.dr. T. Müller		AST, WE

Combinatorial Mathematics B (23/24)	biennial	5	tbd in 23/24	tbd in 23/24		AST, WE
Integrable Systems	annual	5	dr. T.F. Görbe dr. N. Martynchuk			AST, P. R
Topics in Differential Geometry	annual	5	dr. N. Martynchuk	prof.dr. H. Waalkens		AST, P
Topics in Algebra and Geometry A (22/23)	biennial	5	prof.dr. J. Top	prof.dr. C. Salgado		AST, OR
Topics in Algebra and Geometry B (23/24)	biennial	5	tbd in 23/24	tbd in 23/24		AST, OR
Topics in Probability and Statistics	annual	5	prof.dr. P. Trapman	prof.dr. M.A. Grzegorczyk		AST, WE
Statistical Consulting (22/23)	bienial	5	prof.dr. M.A. Grzegorczyk prof.dr. P. Trapman dr. W.P. Krijnen			P, R
Geometry and Differential Equations (22/23)	biennial	5	dr. A.V. Kiselev	dr. R. van der Veen		WE
Geometry and Topology (23/24)	biennial	5	dr. A.V. Kiselev	dr. R. van der Veen		AST, WE
Random Geometry and Topology A (22/23)	biennial	5	dr. G. Bonnet	prof.dr. T. Müller		
Random Geometry and Topology B (23/24)	biennial	5	tbd in 23/24	tbd in 23/24		AST, WE
Topics in Topology A (22/23)	biennial	5	dr. R. van der Veen	dr. A.V. Kiselev		AST, OR
Topics in Topology B (23/24)	biennial	5	tbd in 23/24	tbd in 23/24		AST, OR
Mathematical Modelling and Statistical Analysis of the Spread of Infectious Diseases (23/24)	biennial	5	prof.dr. P. Trapman	prof.dr. M.A. Grzegorczyk		AST, WE
Spectral Theory (23/24)	biennial	5	tbd in 23/24	tbd in 23/24		AST, P, R
Statistical Genomics (23/24)	biennial	5	prof.dr. P. Trapman	prof.dr. M.A. Grzegorczyk		AST, WE
Contemporary Statistics with Applications	annual	5	prof.dr. M.A. Grzegorczyk	dr. W.P. Krijnen		AST, R

Introduction to Data Science	annual	5	See MSc CS			AST, WE
Master Research Project	annual	50	See list below	See list below		PR, P, R
Mathematical Research Project (Science, Business and Policy)	annual	30	See list below	See list below		PR, P, R

The modules of the Business and Policy component are

Module	**offered**	**ECTS**	**First examiner**	**Second examiner (if necessary)**	**Prac-tical**	**Assessment type**
Introduction Science and Business	annual	10	drs. A.J. Abma, dr. C. Carroll, prof.dr. G.J.W. Euverink, prof.dr. M.P. Gerkema, drs. S. Grooters, dr. H.J. van der Windt, dr. P.D.M. Weesie			AST, R, WE
Introduction Science and Policy	annual	10	drs. A.J. Abma, prof.dr. G.J.W. Euverink, prof.dr. M.P. Gerkema, drs. S. Grooters, dr. H.J. van der Windt, dr. P.D.M. Weesie			AST, R, WE
Internship Science, Business and Policy	annual	40	drs. A.J. Abma, prof.dr. G.J.W. Euverink, prof.dr. M.P. Gerkema, drs. S. Grooters, drs. C.M. Ree dr. P.D.M. Weesie	See list below		PR, R

Examiners for Research Project (30 ECTS and 50 ECTS) and Internship Science, Business and Policy

dr. G. Bonnet
dr. T.F. Görbe
prof.dr. M.A. Grzegorczyk
dr. H. Jardon Kojakhmetov
dr. P. Kilicer
dr. A.V. Kiselev
dr. W.P. Krijnen
dr. O. Lorscheid
dr. A. Mali
dr. J.S. Müller
prof.dr. T. Müller
dr. N. Martynchuk
prof.dr. C. Salgado
dr. M. Seri
dr. A.E. Sterk
dr. P. Tibboel
prof.dr. P. Trapman
prof.dr. J. Top
dr. R. van der Veen
prof.dr. E.A. Verbitskiy
prof.dr. H. Waalkens

Examiners of the research project of the master's degree programme in applied mathematics may act as a second examiner for the research project of the master's degree programme in mathematics as well.

On an individual basis the Board of Examiners can allow examiners of other degree programmes to act as examiner for the research project of the master's degree programme in mathematics as well.

1.5 Relationship between course units and details of the learning outcomes

In this section the relation between the course units and the learning outcomes (generic learning outcomes A1-A9 and variant-specific learning outcomes P1-P4 and M1-M4) is shown. Here the following notation is used:

1 : the course makes a limited contribution to the specified learning outcome
2: the course makes a substantial contribution to the specified learning outcome

	Topics in Algebra and Geometry A/B	Geometry and Topology	Geometry and Differential Equations	Topics in Differential Geometry	Topics in Dynamical Systems and Chaos A/B	Hamiltonian Mechanics	Topics in Number Theory	Topics in Topology A/B	Statistical Genomics	Contemporary Statistics with Applications	Topics in Probability and Statistics	Statistical Consulting	Introduction to Data Science	Student Colloquium	Mathematics and its Environment	Master Research Project (50 ECTS)
A1	1	2	2	1	1	2	2	2	2	2	2	1	1			1
A2	1	1	1	1	1	1	1	1	1	1	1		1			2
A3	2			2	1		1	1			1	1	1	1		2
A4			1		1	1			1			2				
A5					1	1						1			2	2
A6	1	1	1	1	1	1	1	1	1	2	2	2	1	1	1	2
A7	1	1	1	1	1	1	1	1	1	1	2	1	1	2		2
A8		1	1	2	1	1					1	2	1	2	2	2
A9			1	1		1	1	1		1				2		2
P1	2	2	2	2	1	1	2	2	2	2	2		2	1	1	2
P2			1		1	1					2		1	1		2
P3	2	2		1	1	1	1	1			1		1	1		2
P4		1	1	1	1	1	1	1			1			1	1	2
M1																
M2																
M3																
M4												1		1	1	

	Research Seminar in Mathematics	Perturbation Theory	Singularity Theory	Introduction to Algebraic Geometry	Arithmetic Geometry	Combinatorial Mathematics A/B	Integrable Systems	Random Geometry and Topology A/B	Mathematical Modelling ... spread infectious diseases	Mathematical Research Project SBP (30 ECTS)	Introduction Science and Business	Introduction Science and Policy	Internship Science, Business and Policy
A1		2	2	2	2	2	2	1	1	1			
A2		1	1		1		1	1		2			
A3	1	1	1	1	1	1	1	1	1	2			
A4									1		2	2	2
A5									1	2	2	2	2
A6	1	1	1	1	1	1	1	1		2			
A7	2	1	1	1	1	1	1	1		2			2
A8	2									2	1	1	2
A9	2				1	1		1	1	2			
P1		1	1	1	2	2	1	2	1				
P2		1	1			1	1	1	2				
P3		1	1		1	1	1	1	2				
P4	1			1	1			1					
M1											2	2	2
M2											2	2	2
M3											2	2	2
M4										1	1	1	2