1 Assessment plan for the curriculum of the Master's degree programme in Applied 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 Applied 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 2022-2023 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 Applied 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 Applied Mathematics aims to train mathematicians who meet this profile.

The master's degree programme in Applied 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 Applied 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 or designer 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 the Master's degree programme in Mathematics as well) which are supplemented with programme-specific learning outcomes. For each learning outcome a reference to the Dublin descriptors is given between brackets.

The master graduate in Applied Mathematics:

A1. has an understanding of the most important concepts of the field, [applying knowledge and understanding]
A2. is able to contribute to the scientific advancement of a subfield of applied mathematics, [applying knowledge and understanding]
A3. is able to use abstract thinking and mathematical modelling 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 communicate effectively ideas, problems and solutions with the mathematical, science and engineering communities. [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 Applied Mathematics:

T1. has general knowledge of the theories, methods and techniques in the field of applied mathematics, [knowledge and understanding]
T2. has specialized knowledge in at least one of the following subfields of applied mathematics: [knowledge and understanding]
    a. Computational Mathematics
    b. Systems, Control and Optimization
    c. Statistics
T3. has wide experience with the mathematical modelling of problems from actual practice, [applying knowledge and understanding]
T4. has extensive experience with using the relevant mathematical tools. [applying knowledge and understanding]

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 2020-2021 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 core Applied Mathematics modules are:

Module	**offered**	**ECTS**	**First examiner**	**Second examiner (if necessary)**	**Prac-tical**	**Assessment type**
Track Computational Mathematics:						
Finite Element Methods and Applications	annual	5	dr. C.A. Bertoglio	dr.ir. F.W. Wubs	x	PR, WE
Computational Fluid Dynamics	annual	5	dr. ir. R. Luppes	prof.dr.ir. R.W.C.P. Verstappen	x	PR, WE
Iterative Algorithms	annual	5	prof.dr. J.G. Peypouquet	dr. C.A. Bertoglio	x	AST, PR, WE
Model Order Reduction for PDE	biennial, in 2022/23	5	dr. J. Koellermeier	prof.dr.ir. R.W.C.P. Verstappen	x	PR, WE
Coupled Problems	biennial, in 2022/23	5	dr. C.A. Bertoglio	dr. J. Koellermeier	x	PR, WE
Numerical Bifurcation Analysis	biennial, in 2023/24	5	dr.ir. F.W. Wubs	dr. C.A. Bertoglio	x	PR, P, R
Multiscale Numerical Methods	biennial, in 2023/24	5	dr. J. Koellermeier	prof.dr.ir. R.W.C.P. Verstappen	x	PR, WE
Track Systems and Control :						
Iterative Algorithms	annual	5	prof.dr. J.G. Peypouquet	dr. C.A. Bertoglio	x	AST, PR, WE
Modelling and Identification	biennial, in 2022/23	5	dr.ir. B. Besselink dr. H. van Waarde			AST, WE
Calculus of Variations and Optimal Control	annual	5	dr. A.M.S. Waters	prof.dr. J.G. Peypouquet		AST, WE
Systems and Control (Mastermath)	annual	6	prof.dr. S. Trenn dr. J.W. Polderman			AST, WE
Modeling and Control of Complex Nonlinear Engineering Systems	annual	5	dr.ir. B. Besselink prof.dr.ir. J.M.A. Scherpen			AST, WE

Robust Control	annual	5	prof.dr. H.L. Trentelman dr. H. van Waarde			AST, WE
Convex Analysis	biennial, in 2022/23	5	prof.dr. J.G. Peypouquet	prof.dr. H.K. Camlibel		AST, WE
Data-based Analysis and Control	biennial, in 2023/24	5	dr. H. van Waarde	dr.ir. B. Besselink		AST, WE
Evolution Equations	biennial, in 2023/24	5	prof.dr. J.G. Peypouquet	prof.dr. S. Trenn		AST, WE
Specialization Statistics and Data Science:						
Contemporary Statistics with Applications	annual	5	prof.dr. M.A. Grzegorczyk	dr. W.P. Krijnen		AST, R
Statistical Consulting	biennial, in 2022/23	5	prof.dr. M.A. Grzegorczyk prof.dr. P. Trapman dr. W.P. Krijnen			AST, P, R
Topics in Probability and Statistics	annual	5	prof.dr. P. Trapman	prof.dr. M.A. Grzegorczyk		AST, WE
Introduction to Data Science	annual	5	see MSc CS	see MSc CS		AST, WE
Statistical Genomics	biennial, in 2023/24	5	prof.dr. P. Trapman	prof.dr. M.A. Grzegorczyk		AST, R
Mathematical modelling and statistical analysis of the spread of infectious diseases	biennial, in 2023/24	5	prof.dr. P. Trapman	prof.dr. M.A. Grzegorczyk		AST, R
Statistical Signal Processing	annual	5	see MSc AS	see MSc AS		AST, WE
Fitting dynamical models to data	annual	5	See MSc IEM	See MSc IEM		WE
General modules						
Mathematics and its Environment	annual	5	dr. A. Mali	prof.dr.ir. R.W.C.P. Verstappen		AST, P, R
Student Colloquium	annual	5	prof.dr. P. Trapman dr. A.V. Kiselev dr. M. Seri			P, R

			dr. A.M.S. Waters dr. J. Koellermeier			
Research Seminar in Applied Mathematics	annual	5	prof.dr. J.G. Peypouquet prof.dr.ir. R.W.C.P. Verstappen			P, R
Research Project and Internship						
Master's Research Project	annual	35	See list below	See list below		PR, P, R
Internship	annual	15	See list below	See list below		PR, P, R

Examiners for Research Project and Internship

Track Systems and Control
dr.ir B. Besselink
prof. dr. M.K. Camlibel,
prof.dr. J.G. Peypouquet
prof.dr.ir. J.M.A. Scherpen
prof.dr. S. Trenn
prof.dr. H.L. Trentelman
dr. H. van Waarde
dr. A.M.S. Waters

Track Computational Mathematics
dr. C.A. Bertoglio
dr. J. Koellermeier
dr. ir. R. Luppes
prof.dr.ir. R.W.C.P. Verstappen
dr.ir. F.W. Wubs

Specialization Statistics and Data Science
prof.dr. M.A. Grzegorczyk
prof.dr. P. Trapman
dr. W.P. Krijnen

The first examiner of a research project for a certain specialization must stem from the above list of examiners for that specific specialization. The examiners of the research project from the other specializations may act as a second examiner. Examiners of the research project of the master's degree programme in mathematics may act as a second examiner for the research project of the master's degree programme in applied mathematics as well.

On an individual basis the Board of Examiners can allow examiners of other degree progammes to act as examiner for the research project of the master's degree programme in applied 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 knowledge related learning outcomes (generic learning outcomes A1-A9 and programme-specific learning outcomes T1-T4) is given in the following set of tables.

Relation between the core courses and the learning outcomes

In the next tables the relation between the core (applied) mathematics courses and the learning outcomes is given.
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

	Course units track Systems and Control						Course units track Computational Mathematics			Common course units				
	Modelling and Identification	Modeling and Control of Complex Nonlinear Engineering Systems	Robust Control	Convex Optimization	Numerical Linear Algebra	Finite Element Methods for Fluid Dynamics	Finite Element Modeling for Advanced Processing	Numerical Bifurcation Analysis of Large Scale Systems	Computational Fluid Dynamics	Mathematical Modelling Colloquium	Complexity and Networks	Mathematics and its Environment	Master' s Rsesearch Project	Internship
A1	2	2	1	1	1	1	1	1	2		2		1	1
A2	2	1		1	1	1	1		1		1		2	1
A3	1	2	1	2	1	1	2	1		1	1		2	2
A4		1				1	1		1					2
A5												2	2	2
A6	1			1						1	1	1	2	2
A7	1	2	1	2	2	1	1	2	1	2	1		2	2
A8			2	1				1	1	2	1	2	2	2
A9				1		1				2	1		2	2
T1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
T2	2	2	2	2	2	2	2	2	2	1	2		2	2
T3	1	2		1	2	2	2	2	1	1	1		1	2
T4	2	2		2	2	1	2	2	1	1	1		2	2

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

	Common course units				
	Student Colloquium	Research Seminar in Applied Mathematics	Mathematics and its Environment	Master's Rsesearch Project	Internship
A1				1	1
A2		1		2	1
A3	1	1		2	2
A4					2
A5			2	2	2
A6	1	1	1	2	2
A7	2	2		2	2
A8	2	2	2	2	2
A9	2	2		2	2
T1	1	1	1	2	2
T2	1	1		2	2
T3	1	1		1	2
T4	1	1		2	2

	Course units track Computational Mathematics						
	Finite Element Methods and Applictions	Iterative Algorithms	Computational Fluid Dynamics	Model Order Reduction for PDE	Coupled Problems	Numerical Bifurcation Analysi	Multiscale Numerical Methods
A1	2	2	2	1	1	1	1
A2				1	1	1	1
A3				1	1	1	1
A4	1		1				
A5							
A6	1	1	1	1	1	1	1
A7	1	1	1	1	1	1	1
A8	1	1	1	1	1		
A9							
T1	1	1	1	1	1	1	1
T2	2	2	2	2	2	2	2
T3	1	1	1	1	1		1
T4	1	1	1	1	1	1	1

	Course units track Systems and Control							
	Modelling and Identification	Modeling and Control of Complex Nonlinear Engineering Systems	Robust Control	Calculus of Variations and Optimal Control	Systems and Control (mastermath)	Convex Analysis	Data-based Analysis and Control	Evolution Equations
A1	2	2	1	2	2	1	1	1
A2	2	1				1	1	1
A3	1	2	1	1	1	2	2	2
A4		1	1					
A5								
A6	1		1	1	1	1	1	1
A7	1	2	1		1	1	1	1
A8			2					
A9						1	1	1
T1	1	1	1	2	1	1		
T2	2	2	2	1	2	2	2	2
T3	1	2			1	1	1	1
T4	2	2		1	1	1	1	1

	Course units specialization Statistics and Data Science							
	Statistical Genomics	Contemporary Statistics with Applications	Topics in Probability and Statistics	Statistical Consulting	Introduction to Data Science	Mathematical modelling ... spread diseases	Statistical Signal Processing	Fitting Dynamical Models to Data
A1	2	2	2	1	1	1	1	1
A2	1	1	1		1	2		
A3			1	1	1	1		
A4	1			2			2	2
A5				1				
A6	1	2	2	2	1	1	1	1
A7	1	1	2	1	1	1	1	1
A8			1	2	1	1		
A9		1				1		
T1	2	2	2		2	1	1	1
T2			2		1	2	1	1
T3			1		1	2	1	1
T4			1			1	1	1