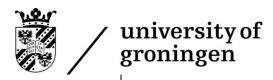


Appendices for the Master's degree programme(s) in Applied Mathematics

2023-2024

- I. Learning outcomes
- II. Tracks/specializations
- III. Content of the degree programme
- IV. Electives
- V. Entry requirements and compulsory order
- VI. Admission to the degree programme
- VII. Transitional provisions
- VIII. Additional Requirements Open Degree Programmes

1



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

Objective of MSc Applied 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 Applied Mathematics aims to train mathematicians who meet this profile.

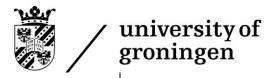
The master's degree programme in Applied Mathematics aims to impart knowledge, skills, understanding and an academic attitude in the field of mathematics by means of a broadly based curriculum building on a bachelor's degree in Applied Mathematics, such that Master's graduates are able to pursue an independent career as independent professionals and are also qualified for further training to become academic researchers or designer in the field.

Learning outcomes MSc Applied 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 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.

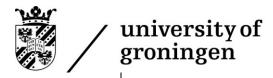
The master graduate in Applied Mathematics:

- 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]

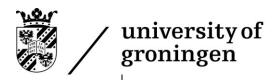


Appendix II Tracks/Specializations of the degree programme

(art. 3.6)

The degree programme has the following specializations

- 1. Computational Mathematics
- 2. Systems and Optimization
- 3. Statistics and Data Science

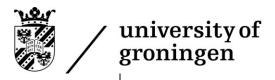


Appendix III Content of the degree programme (art. 3.8)

The Master's degree programme in Applied Mathematics has a workload of at least 120 ECTS and it should not be possible to remove 1 course and still have more than 120 ECTS. The Master's programme comprises a compulsory specialization independent course set with a workload of 65 ECTS and a specialization specific part.

Compulsory joint programme

Course unit	Course code	ECTS	Practical	Entry requirements
Mathematics and its Environment	WMMA013-05	5		
Student Colloquium	WMMA029-05	5		
Research Seminar in Applied	WMMA050-05	5		
Mathematics				
Master's Research Project in Applied	WMMA901-35	35		See Appendix V
Mathematics				
Internship Applied Mathematics	WMMA001-15	15		See Appendix V



Specialization Computational Mathematics

The Computational Mathematics programme is composed of compulsory course units (35 ECTS) and electives. The compulsory courses are listed below, the electives can be found in App. IV.

Compulsory courses Computational Mathematics

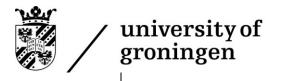
Course unit	Course code	ECTS	Practical	Entry requirements
Computational Fluid Dynamics	WMMA012-05	5	PR	
Iterative Algorithms	WMMA057-05	5		
Finite Element Methods and	WMMA051-05	5	PR	
Applications				
Coupled Problems (24/25)	WMMA052-05	5	PR	
Multiscale Numerical Methods (23/24)	WMMA054-05	5	PR	
Model Reduction for PDE (24/25)	WMMA053-05	5		
Numerical Bifurcation Analysis (23/24)	WMMA055-05	5	PR	

Specialization Systems and Optimization

The Systems and Optimization programme is composed of compulsory course units (min. 40 ECTS) and electives. The compulsory courses are listed below, the electives can be found in App. IV.

Compulsory courses Systems and Optimization

Course unit	Course code	ECTS	Practical	Entry requirements
Robust Control	WMMA021-05	5		
Convex Analysis (24/25)	WMMA060-05	5		
Iterative Algorithms	WMMA057-05	5		
Modeling and Identification (24/25)	WMMA007-05	5		
Modeling and Control of Complex	WMMA020-05	5		
Nonlinear Engineering Systems				
Calculus of Variations and Optimal	WMMA056-05	5		
Control				
Evolution Equations (23/24)	WMMA059-05	5		
Data-based Analysis and Control	WMMA058-05	5		
(23/24)				
Systems and Control (22/23,	WMMA003-06	6		
Mastermath)				



Specialization Statistics and Data Science

The Statistics and Data Science programme is composed of compulsory course units (35 ECTS) and electives. The compulsory courses are listed below, the electives can be found in App. IV.

Compulsory courses Statistics and Data Science

Course unit	Course code	ECTS	Practical	Entry
				requirements
Contemporary Statistics with	WMMA015-05	5		
Applications				
Statistical Genomics (23/24)	WMMA008-05	5		
Statistical Consulting (24/25)	WMMA024-05	5		
Introduction to Data Science	WMCS002-05	5		
One out of		5		
 Statistical Signal Processing 	WMAS011-05			
 Fitting dynamical models to 				
data	WMIE007-05			
Topics in Probability and Statistics	WMMA039-05	5		
Mathematical modelling and statistical	WMMA061-05	5		
analysis of the spread of infectious				
diseases (23/24)				

Possibility of double master degrees

It is possible to study the MSc Applied Mathematics in parallel to other master programmes. Individual courses can then count for both programmes, however in order to obtain two degrees at least 180 distinct ECTS have to be obtained. Furthermore, an internship/design project as well as a master research project can only be used for one of the degree programmes, unless the Board of Examiners allows a joint internship or research project.



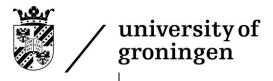
Appendix IV Electives (art. 3.9.1)

This appendix sets out the optional course units of the Master's degree programme in Applied Mathematics. Based on a well-founded request by a student, the Board of Examiners may grant permission to choose electives other than those listed here (from the University of Groningen or another university in the Netherlands or abroad). The programme or a part of it must in any case be coherent and of master level (at the discretion of the Board of Examiners).

External electives

The Departments of Mathematics of the Dutch universities organise a joint Mastermath programme consisting of about 60 Master's courses; see http://elo.mastermath.nl for details. The degree programme may contain elective modules of Mastermath. Because the workload of these modules is not 5 ECTS, but 6 or 8 ECTS, it may be that the total size of the programme is not exactly equal to 120 ECTS. If so, the size must be at least 120 ECTS and it should not be possible to remove 1 course and still have more than 120 ECTS; hence the total workload of the degree programme can be at most 124 ECTS. Note, at the discretion of the Board of Examiners, courses may be added as extracurricular.

The degree programme in Applied Mathematics may also contain courses from other degree programmes. For information on the modules offered by other degree programmes at the University of Groningen, see also the Teaching and Examination Regulations of the corresponding programme.



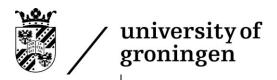
Specialization Computational Mathematics

The electives in the track Computational Mathematics have a workload of 20-24 ECTS, of which o-8 ECTS can be chosen freely (modules on Master level, relevant for Applied Mathematics, at the discretion of the Board of Examiners), the remaining electives must be chosen from the list below.

Guided Choice Computational Mathematics

Course unit	Course code	ECTS	Practical	Entry
				requirements
Computational Solid Mechanics	WMME028-05	5		
Machine Learning	WMAI010-05	5		
Neural Networks and Computational	WMCS010-05	5		
Intelligence				
Introduction to Data Science	WMCS002-05	5		
Image Processing	WMCS008-05	5		
Scalable Computing	WMCS017-05	5		
Fitting Dynamical Models to Data	WMIE007-05	5		
Relevant courses from the Mastermath		6/8		
programme				
(at the discretion of the Board of				
Examiners).				
The Mastermath courses mentioned				
below are certainly relevant.				
Numerical Linear Algebra	WMMA002-08	8		
(Mastermath)				
Parallel Algorithms (Mastermath)		8		
Discrete Optimization (Mastermath)		6		
Inverse Problems in Imaging		6		
(Mastermath)				
Contemporary Statistics with	WMMA015-05	5		
Applications				
Statistical Consulting (24/25)	WMMA024-05	5		
Modelling and Control of Complex	WMMA020-05	5		
Nonlinear Engineering Systems				
Data-driven Optimization	WMME011-05	5		
Robust Control	WMMA021-05	5		
Modeling and Identification (24/25)	WMMA007-05	5		
Data-based Analysis and Control	WMMA058-05	5		
(23/24)				
Can only be followed together:				
- Basiscursus Master	TEM0105	5		
Lerarenopleiding (Dutch)	TEM0205	5		
- Masterstage 1 (Dutch)				

Note: The two last courses offer students the possibility to get acquainted with the work of a high school Mathematics teacher in the Netherlands. The courses are taught in Dutch and have



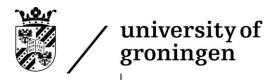
to be followed simultaneously. Upon successful completion of both courses students have the possibility to follow the post-master degree programme 'Leraar Voorbereidend Hoger Onderwijs in de Betawetenschappen' (LVHO) where they only still have to follow 50 ECTS, instead of the normal 60 ECTS.

Specialization Systems and Optimization

The electives in the specialization Systems and Optimization have a workload of 9-18 ECTS, of which o-8 ECTS can be chosen freely (modules on Master level, relevant for Applied Mathematics, at the discretion of the Board of Examiners), the remaining elective(s) must be chosen from the list below.

Guided Choice Systems and Optimization

Course unit	Course code	ECTS	Practical	Entry
				requirements
Analysis and Control of Smart Systems	WMIE015-05	5		
Robotics for IEM	WMIE005-05	5		
Advanced Digital and Hybrid Control	WMIE014-05	5		
Systems				
Data-driven Optimization	WMME011-05	5		
Computational Fluid Dynamics	WMMA012-05	5		
Finite Element Methods and	WMMA051-05	5		
Applications				
Introduction to Data Science	WMCS002-05	5		
Contemporary Statistics with	WMMA015-05	5		
Applications				
Statistical Consulting (24/25)	WMMA024-05	5		
Fitting Dynamical Models to Data	WMIE007-05	5		
Relevant courses from the Mastermath		6/8		
programme				
(at the discretion of the Board of				
Examiners)				
Can only be followed together:				
- Basiscursus Master	TEM0105	5		
Lerarenopleiding (Dutch)	TEM0205	5		
- Masterstage 1 (Dutch)				

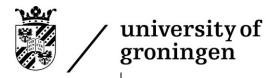


Specialization Statistics and Data Science

The electives in the specialization Statistics and Data Science have a workload of 20-24 ECTS, of which o-8 ECTS can be chosen freely (modules on Master level, relevant for Applied Mathematics, at the discretion of the Board of Examiners), the remaining electives must be chosen from the list below.

Guided Choice Statistics and Data Science

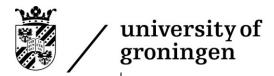
Course unit	Course code	ECTS	Practical	Entry requirements
Pattern Recognition	WMCS011-05	5		•
Machine Learning	WMAI010-05	5		
Neural Networks and	WMCS010-05	5		
Computational Intelligence				
Cloud Computing and Cloud-based	WMCS032-05	5		
Applications				
Astronomical Data Science	WMAS007-05	5		
Statistical Signal Processing	WMAS011-05	5		
Fitting dynamical models to data	WMIE007-05	5		
Big Data & Applications in	WMBM025-05	5		
Biomedicine				
Data Science in Biomedicine	WMBM023-05	5		
Robust Control	WMMA021-05	5		
Computational Fluid Dynamics	WMMA012-05	5		
Modeling and Control of Complex	WMMA020-05	5		
Nonlinear Engineering Systems				
Finite Element Methods and	WMMA051-05	5		
Applications				
Data-based Analysis and Control	WMMA058-05	5		
(23/24)				
Data-driven Optimization	WMME011-05	5		
Relevant courses from the		6/8		
Mastermath programme				
(at the discretion of the Board of				
Examiners)				
Can only be followed together:				
- Basiscursus Master	TEM0105	5		
Lerarenopleiding (Dutch)				
Masterstage 1 (Dutch)				
	TEM0205	5		



Appendix V Entry requirements and compulsory order of examinations

(art. 4.4)

Course unit	ECTS	Entry requirements
Master's Research	35	- Successful completion of 35 ECTS of modules of the Master's
Project Applied		degree programme in Applied Mathematics
Mathematics		- Enrolment in progress for the research project course
		- Approval of research plan including project schedule by
		supervisors and Master Project coordinator.
Internship Applied	15	- Successful completion of 35 ECTS of modules of the Master's
Mathematics		degree programme in Applied Mathematics
		- Enrolment in progress for the internship
		- Approval of internship including schedule by supervisors and
		the Internship coordinator.

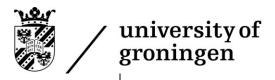


Appendix VI Admission to the degree programme (art. 2.1A.1 + 2.1B.1)

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 Applied Mathematics:

- BSc Mathematics
- BSc Applied Mathematics

The above degrees from other Dutch universities are considered equivalent to the corresponding UG degrees.



Appendix VII Transitional provisions (art. 7.1)

Since the TER for this academic year is applicable to all students registered in the Master's degree programme in Applied Mathematics, regardless of the starting date of students, transitional arrangements are in place.

In 2023/24 the tracks Computational Mathematics and Systems and Control are discontinued. Students who were enrolled in these tracks can finish these tracks according to the TER MSc Applied Mathematics 2022/23.

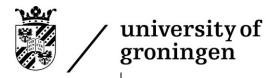
The 2022/23 curriculum has more and other compulsory course units than before. Therefore, a transitional arrangement applies to the cohort 2021/22 and earlier. Students from the cohort 2021/22 and earlier may replace the newly introduced, compulsory courses Student Colloquium and Research Seminar in Applied Mathematics by the discontinued courses Mathematical Modelling Colloquium (WMMA023-05) and Complexity and Networks (WMMA005-05), respectively, provided the discontinued courses have been completed before September 1, 2022. The transitional arrangements for the track-specific parts of the degree programme can be found below.

For cohort 2021-2022 and earlier, Track Computational Mathematics

For cohort 2021-2022 and earlier, the track-specific part of the Computational Mathematics programme is composed of compulsory course units (min 23 ECTS), a guided choice (min 15 ECTS) and electives (max 15 ECTS) that can be chosen freely (modules on Master level, relevant for Applied Mathematics, at the discretion of the Board of Examiners). The guided choice is to be taken from the list of electives in App. IV (Computational Math), or the list of electives in App IV (Computational Math) of the TER 2020-2021. The compulsory part is described below.

Compulsory courses Computational Mathematics cohort 2020-2021 and earlier

Course unit	Course code	ECTS	Pract	Entry
			ical	requirements
\geq 23 ECTS out of:				
- Computational Fluid Dynamics	WMMA012-05	5	PR	
- Finite Element Methods and	WMMA051-05	5	PR	
Applications				
- Computational Solid Mechanics	WMME028-05	5	PR	
- Iterative Algorithms	WMMA057-05	5	PR	
- Coupled Problems (24/25)	WMMA052-05	5	PR	
- Multiscale Numerical Methods	WMMA054-05	5	PR	
(23/24)				
- Numerical Bifurcation Analysis	WMMA055-05	5	PR	
(23/23) or				
Numerical Bifurcation Analysis				
of Large-Scale Systems	WMMA014-08	8	PR	
(Mastermath)				
,				



- Numerical Linear Algebra	WMMA002-08	8	PR	
(Mastermath)				
 Relevant courses from 		6/8		
Mastermath (at the discretion of				
the Board of Examiners)				
Min. 3 courses have to be local non-				
Mastermath courses				

For cohort 2021-2022 and earlier, Track Systems and Control

For cohort 2021-2022 and earlier, the track-specific part of the Systems and Control programme is composed of compulsory course units (min 23 ECTS), a guided choice (min 15 ECTS) and electives (max 15 ECTS) that can be chosen freely (modules on Master level, relevant for Applied Mathematics, at the discretion of the Board of Examiners). The guided choice is to be taken from the list of electives in App. IV (Systems and Control), or the list of electives in App IV (Systems and Control) of the TER 2020-2021. The compulsory part is described below.

Compulsory courses Systems and Control cohort 2020-2021 and earlier

Course unit	Course code	ECTS	Pract	Entry
			ical	requirements
\geq 23 ECTS out of:				
- Robust Control	WMMA021-05	5		
- Convex Analysis	WMMA060-05	5		
 Modeling and Identification 	WMMA007-05	5		
(24/25)				
 Modeling and Control of 	WMMA020-05	5		
Complex Nonlinear Engineering				
Systems				
- Systems and Control (22/23,	WMMA003-06	6		
Mastermath)				
 Iterative Algorithms 	WMMA057-05	5		
 Calculus of Variations and 	WMMA056-05	5		
Optimal Control				
 Evolution Equations 	WMMA059-05	5		
- Data-based Analysis and Control	WMMA058-05	5		
(23/24)				
- Relevant courses from		6/8		
Mastermath (at the discretion of				
the Board of Examiners)				
Min. 3 courses have to be local non-				
Mastermath courses				
The transitional provisions below are an arre	1	1 .	•	c .

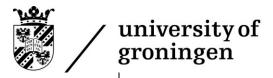
The transitional provisions below are an arrangement that students can use as a reference to courses that previously existed.



For cohort 2021-2022 and earlier

Old Course	New Course
Mathematical Modelling Colloquium	Student Colloquium
Complexity and Networks	Research Seminar in Applied Mathematics
Finite Element Methods for Fluid Dynamics	Finite Element Methods and Applications
Convex Optimization	Convex Analysis
Finite Element Modelling for Advanced	Computational Solid Mechanics
Processing	
Caput Statistics	Topics in Probability and Statistics

See also the transitional arrangements in the appendices TER of previous years. For information on transitional arrangements for courses offered by other degree programmes, see also the Teaching and Examination Regulations of the corresponding programme.



Appendix VIII Additional Requirements Open Degree Programmes (Art. 3.10)

In exceptional circumstances, students wishing to pursue an open degree programme may file a request with the Board of Examiners. An Open Degree Programme must always be approved in advance by 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.

The Open Degree Programme in Applied Mathematics must include the compulsory joint programme mentioned in App. III and at least 35 ECTS is to be taken from the lists of compulsory courses of the specializations, see App. III for details.