



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

2022-2023

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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 tracks

1. Computational Mathematics
2. Systems and Control

and the specialization

Statistics and Data Science

The tracks will be discontinued as soon as possible (taking into account the applicable period) and be replaced by the specializations

1. Computational Mathematics
 2. Systems and Optimization
- respectively



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 joint programme with a workload of 65 ECTS and a track/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 Mathematics	WMMA030-05	5		
Master's Research Project in Applied Mathematics	WMMA901-35	35		Successful completion of 40 ECTS of modules of the Master's degree programme in Applied Mathematics
Internship Applied Mathematics	WMMA001-15	15		Successful completion of 35 ECTS of modules of the Master's degree programme in Applied Mathematics



Track 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 Applications	WMMA051-05	5	PR	
Coupled Problems (22/23)	WMMA052-05	5	PR	
Multiscale Numerical Methods (23/24)	WMMA054-05	5	PR	
Model Reduction for PDE (22/23)	WMMA053-05	5		
Numerical Bifurcation Analysis (23/24)*	WMMA055-05	5	PR	

* In 22/23, the biennial course Numerical Bifurcation Analysis (23/24) of 5 ECTS may be replaced by the Mastermath course Numerical Bifurcation Analysis of Large Systems (WMMA014-08) of 8 ECTS.

Track Systems and Control

The Systems and Control 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 Control

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



Systems and Control (22/23, Mastermath)	WMMA003-06	6		
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* A student may only take Calculus of Variations and Optimal Control if it was not part of his/her Bachelors' programme.

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 Applications	WMMA015-05	5		
Statistical Genomics (23/24)	WMMA008-05	5		
Statistical Consulting (22/23)	WMMA024-05	5		
Introduction to Data Science	WMCS002-05	5		
One out of <ul style="list-style-type: none"> – Statistical Signal Processing – Fitting dynamical models to data 	WMAS011-05 WMIE007-05	5		
Topics in Probability and Statistics	WMMA039-05	5		
Mathematical modelling and statistical analysis of the spread of infectious diseases (23/24)	WMMA061-05	5		



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.

Track Computational Mathematics

The electives in the track Computational Mathematics have a workload of 20-24 ECTS, of which 0-8 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	TBA	5		
Machine Learning	WMAI010-05	5		
Neural Networks and Computational Intelligence	WMCS010-05	5		
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 programme (at the discretion of the Board of Examiners).		6/8		



The Mastermath courses mentioned below are certainly relevant.				
Numerical Linear Algebra (Mastermath)	WMMA002-08	8		
Parallel Algorithms (Mastermath)		8		
Discrete Optimization (Mastermath)		6		
Inverse Problems in Imaging (Mastermath)		6		
Contemporary Statistics with Applications	WMMA015-05	5		
Statistical Consulting (22/23)	WMMA024-05	5		
Modelling and Control of Complex Nonlinear Engineering Systems	WMMA020-05	5		
Data-driven Optimization	WMME011-05	5		
Robust Control	WMMA021-05	5		
Modeling and Identification (22/23)	WMMA007-05	5		
Data-based Analysis and Control (23/24)	WMMA058-05	5		
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.

Track Systems and Control

The electives in the track Systems and Control have a workload of 9-18 ECTS, of which 0-8 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 Control

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 Systems	WMIE014-05	5		
Data-driven Optimization	WMME011-05	5		
Computational Fluid Dynamics	WMMA012-05	5		
Finite Element Methods for Fluid Dynamics	WMMA016-05	5		
Introduction to Data Science	WMCS002-05	5		
Contemporary Statistics with Applications	WMMA015-05	5		
Statistical Consulting (22/23)	WMMA024-05	5		
Fitting Dynamical Models to Data	WMIE007-05	5		
Relevant courses from the Mastermath programme (at the discretion of the Board of Examiners)		6/8		
Can only be followed together:				
- Basiscursus Master	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 0-8 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 Computational Intelligence	WMCS010-05	5		
Web and Cloud Computing	WMCS005-05	5		
Astronomical Data Science	WMAS007-05	5		
Statistical Signal Processing	WMAS011-05	5		



Fitting dynamical models to data	WMIE007-05	5		
Big Data & Applications in Biomedicine	WMBM025-05	5		
Data Science in Biomedicine	WMBM023-05	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 Methods and Applications	WMMA051-05	5		
Data-based Analysis and Control (23/24)	WMMA058-05	5		
Data-driven Optimization	WMME011-05	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)	TEM0105	5		
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 Project Applied Mathematics	35	Successful completion of 40 ECTS of modules of the Master's degree programme in Applied Mathematics
Internship Applied Mathematics	15	Successful completion of 35 ECTS of modules of the Master's degree programme in Applied Mathematics



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



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.

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	Practical	Entry requirements
≥ 23 ECTS out of:				
- Computational Fluid Dynamics	WMMA012-05	5	PR	
- Finite Element Methods in Fluid Dynamics* <i>or</i>	WMMA016-05	5	PR	
Finite Element Methods and Applications	WMMA	5	PR	
- Finite Element Modeling for Advanced Processing* <i>or</i>	WMME013-05	5	PR	
Computational Solid Mechanics	TBA	5	PR	
- Iterative Algorithms	WMMA057-05	5		
- Coupled Problems (22/23)	WMMA052-05	5	PR	
- Multiscale Numerical Methods (23/24)	WMMA054-05	5	PR	
- Numerical Bifurcation Analysis (23/23) <i>or</i>	WMMA055-05	5	PR	
	WMMA014-08	8	PR	



Numerical Bifurcation Analysis of Large-Scale Systems (Mastermath) - Numerical Linear Algebra (Mastermath) - Relevant courses from Mastermath (at the discretion of the Board of Examiners) Min. 3 courses have to be local non- Mastermath courses		8 6/8	PR	
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* Course is discontinued, must be completed before September 1, 2022.

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	Practical	Entry requirements
≥ 23 ECTS out of: <ul style="list-style-type: none"> - Robust Control - Convex Optimization* or Convex Analysis - Modeling and Identification (22/23) - Modeling and Control of Complex Nonlinear Engineering Systems - Systems and Control (22/23, Mastermath) - Iterative Algorithms - Calculus of Variations and Optimal Control - Evolution Equations - Data-based Analysis and Control (23/24) - Relevant courses from Mastermath (at the discretion of the Board of Examiners) 	WMMA021-05 WMMA006-05 WMMA060-05 WMMA007-05 WMMA020-05 WMMA003-06 WMMA057-05 WMMA056-05 WMMA059-05 WMMA058-05 6/8	5 5 5 5 5 6 5 5 5 5 6/8		



Min. 3 courses have to be local non-Mastermath courses				
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* Course is discontinued, must be completed before September 1, 2022.

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 Processing	Computational Solid Mechanics
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 tracks/specializations, see App. III for details.



Appendix IX

Application and decision deadlines for admission (art. 2.7.1 and 2.7.3)

Programmes starting on 1 September 2022

Programme	Deadline of Application	Deadline of decision
Behavioural and Cognitive Neurosciences	1 May 2022	1 June 2022
Biology	1 May 2022	1 June 2022
Biomedical Engineering	1 May 2022	1 June 2022
Biomedical Sciences	1 May 2022	1 June 2022
Biomolecular Sciences	1 May 2022	1 June 2022
Ecology and Evolution	1 May 2022	1 June 2022
Energy and Environmental Sciences	1 May 2022	1 June 2022
Human-Machine Communication	1 May 2022	1 June 2022
Marine Biology	1 May 2022	1 June 2022
Mechanical Engineering	1 May 2022	1 June 2022
Medical Pharmaceutical Sciences	1 May 2022	1 June 2022
Nanoscience: for non-EU/EEA students	1 February 2022	1 June 2022
Nanoscience: for EU/EEA students	1 May 2022	1 June 2022
Science Education and Communication	1 May 2022	1 June 2022

Programmes starting on 1 September 2022 and 1 February 2023

Programme	Deadline of Application for 1 September	Deadline of decision for 1 September	Deadline of Application for 1 February	Deadline of decision for 1 February
Applied Mathematics	1 May 2022	1 June 2022	15 October 2022	15 November 2022
Applied Physics	1 May 2022	1 June 2022	15 October 2022	15 November 2022
Artificial Intelligence	1 May 2022	1 June 2022	15 October 2022	15 November 2022
Astronomy	1 May 2022	1 June 2022	15 October 2022	15 November 2022
Chemical Engineering	1 May 2022	1 June 2022	15 October 2022	15 November 2022
Chemistry	1 May 2022	1 June 2022	15 October 2022	15 November 2022
Computing Science	1 May 2022	1 June 2022	15 October 2022	15 November 2022
Farmacie	1 May 2022	1 June 2022	15 October 2022	15 November 2022
Industrial Engineering and Management	1 May 2022	1 June 2022	15 October 2022	15 November 2022
Mathematics	1 May 2022	1 June 2022	15 October 2022	15 November 2022
Physics	1 May 2022	1 June 2022	15 October 2022	15 November 2022