

# MASTER'S PROGRAMME IN MATHEMATICAL SCIENCES 2014/15

## INTRODUCTION

The Master's programme in mathematics is stipulated to take two years and builds on the three-year bachelor programme. The aim of the programme is to give the students a deep understanding of a specific field within mathematics or statistics, as well as practice in working independently. The programme is suitable for students with a genuine interest for mathematics, it being the theoretical aspect of the subject or its vast potential in applications.

## LEARNING OBJECTIVES FOR THE MASTER'S PROGRAMMES

The Master's programmes in mathematics provide the students with an in-depth knowledge of a chosen mathematical area. The programme combines research based teaching in close collaboration with the civil engineering programmes and independent work with the help of modern mathematical/statistical literature and software. The degree provides the student with a strong background for future work in teaching and research, as well as in the public and private sector where a solid education within mathematics is required.

### Knowledge

Upon graduation, the candidate has:

- a broad competence in mathematics, including mathematical analyses, algebra, numerical methods, topology, probability and statistics
- a solid knowledge in a chosen area within mathematics (corresponding to the student's specialization)
- depth knowledge in a specific field of mathematics, related to active research, including ability to understand and convey new results of research.

### Skills

Upon graduation, the candidate is able to:

- use formal and stringent mathematical language in both theoretical and applied problem solving
- construct, analyse and communicate mathematical methods, models and arguments
- conduct independent research projects and present research results both verbally and in writing
- participate in interdisciplinary teamwork and implement relevant mathematical methods and models to problem solving

- asses their own adequacy, seek new sources of mathematical knowledge and to renew and develop their mathematical skills.

### **General competence**

Upon graduation, the candidate is able to:

- follow the professional development within a mathematical field and is prepared to continuously strengthen their professional competency
- make informed choices in forming their own education

### **WORK OPPORTUNITIES**

With a Master's degree in mathematics or statistics you are qualified to work in a variety of interesting jobs and sectors. Some of the sectors where your competence is needed include, among others, the oil industry, medicine, finance, research and teaching, both in the public and private sector. One can also choose to do a PhD in mathematics or statistics.

After a Master's degree in mathematics it is also possible to take one year of practical pedagogy studies, which allows you to teach at secondary level schools (provided you also have teaching competence corresponding to 60 ECTS in a second subject). There is a high demand for teachers with competence in mathematics in the secondary school, and the demand will continue to rise in the years to follow.

### **ADMISSION**

The general rules regulating the admission to the Master's programme is described here:

<http://www.ntnu.no/documents/314472/0/DegreeProgr13-14.pdf/d3b5c8da-b205-4c84-8b49-2bc083a2349a>

The specific criteria for admission to the Master's programme in mathematics are described below.

Both internal and external applicants must fulfil the following criteria for admission to the Master's programme:

- A Bachelor degree, cand.mag. degree or similar
- Fulfil criteria for a specialization (at least 80 ECTS in mathematics), where courses equivalent to the following must be included:
  - MA1101 Basic Calculus I (7.5 ECTS)

- MA1102 Basic Calculus 2 (7.5 ECTS)
- MA1103 Vector Calculus (7.5 ECTS)
- MA1201 Linear Algebra and Geometry (7.5 ECTS)
- MA1202 Linear Algebra with Applications (7.5 ECTS)

For the specializations in Algebra, Analysis and Topology, additional courses must be included:

- TMA4120 Calculus 4K (7.5 ECTS)
- MA2201 Algebra (7.5 ECTS)
- 2 courses in pure mathematics, where at least one must be on an intermediate level

For the specialization in Applied Mathematics, additional courses must be included:

- TMA4120 Calculus 4K (7.5 ECTS)
- MA2501 Numerical Methods (7.5 ECTS) or TMA4215 Numerical Mathematics (7.5 ECTS). The latter is specifically relevant for this specialization.

For this specialization it is also recommended with some knowledge in physics and informatics (programming)

For the specialization in Statistics at least 30 ECTS must be statistics courses, where the following courses must be included:

- ST1101 Probability and Statistics (7.5 ECTS)
- ST1201 Statistical Methods (7.5 ECTS)

In addition to one of the following courses:

- TMA4267 Linear Statistical Models (7.5 ECTS)
- TMA4265 Stochastic Processes (7.5 ECTS) or a different statistics course on the same level

The applicant must have a grade average of C in the courses required for admission. The grade average is calculated from both the obligatory and optional courses, in total 11 courses. In the case where the number of qualified applicants exceeds the number of spots available, the applicants will be ranked according to the rules determined by the NTNU.

## **PROGRAMME COMPONENTS**

The Master's programme in mathematics is stipulated to take two years (120 ECTS). The programme consists of a Master's thesis of 45 ECTS and courses corresponding to a total of

75 ECTS. The duration of each course is usually one semester (7.5 ECTS) with 4 hours of lecture a week. Depending on capacity and need, there will be arranged reading courses, seminars and colloquies in order to aid students in their work with the Master's thesis.

Activities and examination procedures for each course is described on the course's information page, and may consist of a final exam (oral or written), midterm exam, exercises and/or project work.

When the Master's thesis has been submitted and all the courses included in the degree plan have been passed, the candidate must pass a final oral examination based on their Master's thesis (cf. § 23 in "Utfyllende regler for realfagsstudiene"). The presentation is public and should last for approximately 30 minutes. After the presentation, the candidate will receive their grade.

The Master's program offers specialization in five different fields: Algebra, Analysis, Topology, Applied Mathematics and Statistics. Within each field of study the student may choose between studies in applied mathematics or pure mathematics of this field. Common for all the specializations are requirements that the student chooses certain courses that are in the given specialization, but also that the student chooses a certain amount of courses/credits from other fields of mathematics in order to achieve an in depth expertise in the field of specialization and a wide knowledge of mathematics in general.

The requirement to have a certain amount of courses/credits outside of the chosen specialization of the Master's program applies to the Bachelor program and Master's program combined. It's required to have four courses relevant to the specialization, each of 7.5 ECTS. These courses are specified for each specialization. The courses should be on a master level (higher level). In addition, the courses TMA4145 Linear Methods, TMA4212 Numerical Solution of Differential Equations by Difference Methods, TMA4165 Differential Equations and Dynamical Systems, TMA4275 Lifetime Analysis, TMA4265 Stochastic Processes and TMA4267 Linear Statistical Methods can be included. TMA4155 Cryptography, Introduction is on a master level, but cannot be included in the Master's degree. It's possible, and often advantageous, to take one or more of the courses in the field of specialization during the bachelor study.

The requirement for courses from other mathematical fields than the field of specialization applies to the Master's program in itself, and states that at least two mathematical courses on a master level (each of 7.5 ECTS) have to be outside of the specialization. In addition the course Experts in Team (7.5 ECTS) is mandatory and has to be taken within the first year of the master study.

The remaining courses are chosen from the ones offered by the department of mathematical sciences (provided they are on a master level), including courses from the technology and PhD programs. Courses offered by other departments may also be included in the Master's degree provided they are approved by the faculty. The students should contact the faculty at an early stage for approval of their degree plan.

Courses passed before admission to the master programme can only be included in the Master's degree upon approval of the faculty.

All students must include in their degree(s) (including credits taken during the bachelor program) at least 30 credits chosen from the following list of courses:

- MA3201 Rings and modules
- MA3202 Galois theory
- TMA4145 Linear Methods
- TMA4225 Foundations of Analysis
- TMA4190 Manifolds
- MA3402 Analysis on Manifolds
- TMA4195 Mathematical Modelling
- TMA4212 Numerical Solution of Differential Equations by Difference Methods
- TMA 4295 Statistical Inference
- TMA4300 Computer Intensive Statistical Methods

The workload of the programme will usually be distributed as follows:

Year	Sem- ester				
2	4 spring	Thesis			
	3 fall	Thesis		Elective course	Elective course
1	2 spring	Experts in team	Elective course	Elective course	Elective course
	1 fall	Elective course	Elective course	Elective course	Elective course
Credits/course		7,5 ECTS	7,5 ECTS	7,5 ECTS	7,5 ECTS

Depending upon the chosen specialization, the elective courses in the table, have to satisfy guidelines for mandatory courses (see list for each specialization). Note that in some cases it may be advisable to start work on the thesis already in the second semester, in order to make room for a course that only can be taken during the third semester of the program.

## **SPECIALIZATIONS**

### **Algebra**

Within the field of algebra, there are two available specializations, Algebraic Structures and Applied Algebra. The courses MA3201 Rings and Modules and MA3202 Galois Theory are mandatory for both specializations.

For specializations in algebraic structures it is also mandatory to take the course MA3203 Ring Theory and at least one other course in algebra, it is recommended that the fourth course is MA3204 Homological Algebra.

For specialization in applied algebra it is mandatory to take courses TMA 4185 Coding Theory and TMA4160 Cryptography. It is an advantage to have a background in informatics when choosing this specialization.

### **Analysis**

In the field of analysis there are three fields of specializations available: Differential Equations, Functional Analysis and Complex/Harmonic Analysis. Within all these three it is also possible to work with either applied problems for a master's degree, or problems in pure mathematics. The courses TMA4145 Linear Methods and TMA4225 Foundations of Analysis are both mandatory for all three specializations, it is to the students advantage to do the course TMA4145 already in the Bachelor program.

Specialization in differential equations also requires the course TMA4305 Partial Differential Equations to be taken, and at least one more course in analysis. It is recommended for the student to choose at least one of the following three courses: TMA4195 Mathematical Modelling, MA8103 Non-linear Partial Differential Equations or TMA4170 Fourier Analysis.

To specialize in the field of functional analysis it is mandatory to take the course TMA4230 Functional Analysis, and at least one more course in analysis.

For the third specialization, Complex/Harmonic Analysis it is mandatory to take TMA4175 Complex Analysis and at least one more course in analysis. It is recommended to take one of the three following courses: TMA4170 Fourier Analysis, TMA4195 Mathematical Modelling and MA3105 Advanced Real Analysis.

### **Topology**

Within topology it is possible to specialize in topology or geometry. Both applied and pure problems are possibilities for students working on their Master's thesis.

For both specializations mandatory courses are TMA4190 Manifolds, MA3402 Analysis on Manifolds and MA3403 Algebraic topology. It is also recommended to choose either MA3405 Algebraic Topology 2 or MA8402 Lie Groups and Lie Algebras, depending on specialization.

The courses MA3002 General Topology and TMA4165 Differential Equations and Dynamical Systems should be taken during the Bachelor degree.

### **Applied mathematics**

Mandatory courses for this specialization are TMA4145 Linear Methods and TMA4212 Numerical Solution of Differential Equations by Difference Methods. In addition to these, the student is advised to also choose at least three of the following courses: TMA4165 Differential Equations and Dynamical Systems, TMA4180 Optimization Theory, TMA4195 Mathematical Modelling, TMA4220 Numerical Solution of Partial Differential Equations Using Element Methods, TMA4205 Numerical Linear Algebra and TMA4305 Partial Differential Equations.

It is to the students advantage if the courses TMA4145 and TMA4212 are taken during the Bachelor degree.

### **Statistics**

The courses TMA4295 Statistical Inference and TMA4300 Computer Intensive Statistical Methods are mandatory for the master's programme in statistics. These courses can also be taken as part of the bachelor degree, in order to facilitate a gradual transition into higher level courses. In order to attain a master's degree in statistics, the student must have done courses of at least 82,5 ECTS in statistics, of which the courses done in the bachelor degree are also included. Other courses relevant to the study of statistics may also be included if preapproved for this purpose.