Linnæus University

Dnr: 2021/4617-3.1.1.3

Programme syllabus

Organisational Committee

Faculty of Technology

Matematik och modellering, masterprogram, 120 högskolepoäng
Mathematics and Modelling, Master Programme, 120 credits

Level
Second Level

Date of Ratification
Approved by Faculty of Technology 2009-03-26

Revised 2021-12-10

The programme syllabus is valid from autumn semester 2022

Prerequisites
General entry requirements for second-cycle studies and specific entry requirements:

- Bachelor Degree of 180 credits or the equivalent
- At least 90 credits in mathematics
- English 6 or the equivalent.

Description of Programme

In today's modern society, mathematics plays an increasingly significant role in science, humanities and industry. The increasing rate at which information and data are collected places a great demand on effective mathematical models and methods for dealing with this knowledge.

A master's degree in mathematical modeling opens up opportunities for an interesting career with a lot of variety in business and academia. Future professions can be found at companies that use advanced mathematical models, for example in audio and image processing, information security, electric power, machine and the construction industry. Students who follow the Mathematical Statistics and Financial Mathematics specialization are also interesting for insurance companies and banks.

The aim of this programme is to provide the students with extended depth of knowledge in Mathematics and Applied Mathematics and an ability to develop mathematical models in an area of application. You can also continue with a postgraduate education in the field of mathematics.

Objectives

Knowledge and understanding

For a Degree of Master (Two Years) students must

- demonstrate knowledge and understanding in their main field of study, including both broad knowledge in the field and substantially deeper knowledge of certain parts of the field, together with deeper insight into current research and development work
- demonstrate deeper methodological knowledge in their main field of study.

Skills and abilities

For a Degree of Master (Two Years) students must

- demonstrate an ability to critically and systematically integrate knowledge and to analyse, assess and deal with complex phenomena, issues and situations, even when limited information is available
- demonstrate an ability to critically, independently and creatively identify and formulate issues and to plan and, using appropriate methods, carry out advanced tasks within specified time limits, so as to contribute to the development of knowledge and to evaluate this work
- demonstrate an ability to clearly present and discuss their conclusions and the knowledge and arguments behind them, in dialogue with different groups, orally and in writing, in national and international contexts
- demonstrate the skill required to participate in research and development work or to work independently in other advanced contexts.

Judgement and approach

For a Degree of Master (Two Years) students must

- demonstrate an ability to make assessments in their main field of study, taking into account relevant scientific, social and ethical aspects, and demonstrate an awareness of ethical aspects of research and development work
- demonstrate insight into the potential and limitations of science, its role in society and people’s responsibility for how it is used
- demonstrate an ability to identify their need of further knowledge and to take responsibility for developing their knowledge.

Programme Specific Objectives

Knowledge and Understanding

Upon completion of the master’s degree programme, students should be able to demonstrate:

- demonstrate a broad knowledge of the area of mathematics that are applied within the chosen specialization and deeper methodological knowledge for how it is applied, when it comes to methods for building mathematimatical models that describes a realistic problem.

Skills and ability

Upon completion of the master’s degree programme, students should be able to demonstrate the ability to :

- critically and systematically integrate knowledge in Pure and Applied Mathematics and analyse and manipulate mathematical models
- critically, individually and creatively identify questions in pure mathematics and be able to build models.

Judgement and approach
Upon completion of the master's degree programme, students should be able to demonstrate the ability to:

- make judgements with regards to relevant scientific and social perspectives for mathematical modelling in economics, information technology and within the industry.

Content

Programme Overview
The degree program comprises 120 credits and includes a final degree project consisting of 30 credits.

The programme has three separate specializations: (1) Algebra with Cryptography and Coding, (2) Analysis and Mathematical Physics, (3) Mathematical Statistics and Financial Mathematics. Some courses are common to all specializations.

Algebra with Cryptography and Coding specialization:
The students should acquire the knowledge and abilities to make them attractive for companies in telecommunications and information security. The students will have the opportunity to start a PhD programme in Mathematics or Applied Mathematics.

Analysis and Mathematical Physics specialization:
The students should acquire the requisite knowledge and abilities to make them attractive for companies making use of mathematical analytical methods in their work. The students will have opportunities to start on a PhD programme in Mathematics or Apploed Mathematics.

Mathematical Statistics and Financial Mathematics specialization:
Students should acquire the requisite knowledge and abilities to make them attractive for companies and institutions making use of statistics and statistical approaches, especially for insurance companies and banks. The students will have the opportunity to start a PhD programme in Mathematics, Applied Mathemats, or Economics.

Programme Courses
The placement of the courses in the different semesters could change from one year to the next. Courses on the programme may be replaced by similar courses within the framework of the programme, in dialogue with the programme director. In particular credits may betransferred from earlier studies. In these cases, the programme director checks that the learning outcomes of the programme are fulfilled. Prerequisites for courses and the local rules for degrees at Linnaeus University must be satisfied. The list of elective courses are preliminary and may be the subject of alterations.

All courses listed below have Mathematics as their Main field of study.

Specialization: Algebra with Cryptography and Coding

Year 1

• *Statistical Data Analysis*, 7.5 credits (A1N). Advanced course in mathematical statistice and data analysis that deals with e.g., analysis of multi dimensional data
• *Algebraic Structures II*, 7.5 credtis (A1N). Advanced course in abstract algebra. Contains among other things Sylow's Theorems, unique factorization in integral domains, and theory of field extensions
• *Foundation of Probablity*, 7.5 credits (A1N). The mathematical foundation for the theory of probability based on measure theory.
• *Mathematical Cryptography*, 7.5 credits (A1F). Deals with Public Key Cryptography and information theory
• *Dynamical Systems*, 7.5 credits (A1N). Introduction to the theory of non-linear dynamical systems
• *Coding Theory*, 7.5 credits (A1F). Introduces the most common methods for error correcting codes
• Elective courses (15 credits): *Algebraic Structures I*, 7.5 credits (G2F) or *Integration Theory*, 7.5 credtis (A1N) or *Topology*, 7.5 credits (A1N) or *Monte Carlo Methods*, 7.5 credits (A1N) or *Stochastic Analysis*, 7.5 credits (A1F) or *Mathematics - Project Course (small)*, 7.5 credits (A1F).

Year 2
• *Matemathical Modelling II*, 7.5 credits (A1F). Modelling and problem solving within the chosen specialization, report writing with LaTeX and a larger project
• *Research Methodology*, 7.5 credits (A1F). Theory of science, research methodology, oral and written presentations, planning research projects
• *Master's Thesis*, 30 credits (A2E). Independent work where the student develops his or her acquired knowledge, understanding, abilities and judgements in mathematics and mathematical modeling.
• Elective courses (15 hp): *Integration Theory*, 7.5 credits (A1N) or *Topology*, 7.5 credits (A1N) or *Functional Analysis*, 7.5 credits (A1N) or *Mathematics - Project Course* (small), 7.5 credits (A1F) or *Mathematics - Project Course (large)*, 15 hp (A1F).

Specialization: Analysis and Mathematical Physics

Year 1
• *Topology*, 7.5 credits (A1N). Introduction to the theory of topological spaces
• *Integration Theory*, 7.5 credits (A1N). Introduction to measure theory, especially the Lebesgue measure and the Lesbegue integral
• *Functional Analysis*, 7.5 credits (A1N). The theory of metric and normed spaces and the theory of linear operators
• *Algebraic Structures II*, 7,5 hp (A1N). Advanced course in abstract algebra. Contains among other things Sylow's Theorems, unique factorization in integral domains, and theory of field extensions, **alternatively** *Foundation of Probablity*, 7.5 credits (A1N). The mathematical foundation for the theory of probability based on measure theory (Both these courses are compulsory on this specialziation)
• *Calculus Advanced Course II*, 7.5 credts (A1N). Differential calculus in Banach spaces, including the Inverse and Implicit Function Theorems for functions definined on a Banach space, and integration of functions definied on curved spaces of any dimension
• *Dynamical systems*, 7.5 credits (A1N). Introduction to the theory of non-linear dynamical systems
• *Distribution Theory*, 7.5 credits (A1F). Theory of distributions and their applications to mathematical physics
• Elective course (7.5 credits): *Monte Carlo Methods*, 7.5 credits (A1N) or *Stochastic*

analysis, 7.5 credits (A1F) or *Matemathical Cryptography*, 7.5 credits (A1F) or *Mathematics - Project Course (small)*, 7.5 credits (A1F).

Year 2
• *Matemathical Modelling II*, 7.5 credits (A1F). Modelling and problem solving within the chosen specialization, report writing with LaTeX and a larger project
• *Foundation of Probablity*, 7.5 credits (A1N). The mathematical foundation for the theory of probability based on measure theory, **alternatively** *Algebraic Structures II*, 7,5 hp (A1N). Advanced course in abstract algebra. Contains among other things Sylow's Theorems, unique factorization in integral domains, and theory of field extensions (Both these courses are compulsory on this specialziation)
• *Research Methodology*, 7.5 credits (A1F). Theory of science, research methodology, oral and written presentations, planning research projects
• *Master's Thesis*, 30 credits (A2E). Independent work where the student develops his or her acquired knowledge, understanding, abilities and judgements in mathematics and mathematical modeling.

• Elective course (7.5 credits): *Partial Differential Equations*, 7.5 credits (A1N) or *Statistical Data Analysis*, 7.5 credits (A1N) or *Mathematics - Project Course (small)*, 7.5 credits (A1F) or *Mathematics - Project Course (large)*, 15 hp (A1F).

Specialization: Mathematical Statistics and Financial Mathematics

Year 1
• *Statistical Data Analysis*, 7.5 credits (A1N). Advanced course in mathematical statistice and data analysis that deals with e.g., analysis of multi dimensional data
• *Integration Theory*, 7.5 credits (A1N). Introduction to measure theory, especially the Lebesgue measure and the Lesbegue integral
• *Functional Analysis*, 7.5 credits (A1N). The theory of metric and normed spaces and the theory of linear operators
• *Foundation of Probablity*, 7.5 credits (A1N). The mathematical foundation for the theory of probability based on measure theory.
• *Stochastic Analysis*, 7.5 credits (A1F). Theory of stochastic differential equations. Pricing and hedging under Black-Scholes model
• *Dynamical systems*, 7.5 credits (A1N). Introduction to the theory of non-linear dynamical systems
• *Insucrance Mathematics*, 7.5 credits (A1F). Principles for premium calculations, risk theory and probabilities for ruin and reinsurance
• Elective course (7.5 credits): *Monte Carlo Methods*, 7.5 credits (A1N) or *Mathematics - Project Course (small)*, 7.5 credits (A1F).

Year 2
• *Matemathical Modelling II*, 7.5 credits (A1F). Modelling and problem solving within the chosen specialization, report writing with LaTeX and a larger project
• *Financial Modelling with Stochastic Processes*, 7.5 credits (A1F). Modelling and pricing with Levy and jump processes
• *Risk and Portfolio Analysis*, 7.5 credits (A1F). Investment and risk management decisions
• *Research Methodology*, 7.5 credits (A1F). Theory of science, research methodology, oral and written presentations, planning research projects.
• *Master's Thesis*, 30 credits (A2E). Independent work where the student develops his or her acquired knowledge, understanding, abilities and judgements in mathematics and mathematical modeling.

Societal Relevance
The programme's students will during the programme meet representatives from the working life. These contacts consist of field trips, projects, workshops, etc. The workshops are mainly of a contact character where business problems are the focus, but also general issues occur. The main contact is in the final degree project which is for many designed to be a bridge to a future career in industry or academia. Students who choose the specialization Algebra with Cryptography and Coding may be involved in projects with companies that work with information security and information technology. Students who choose the specialization Analysis and Mathematical Physics may be involved in projects with companies that develop mathematical models within the industry. Students who choose the specialization in Mathematical Statistics and financial mathematics can be involved in projects with insurance companies and banks, but also other companies or institutions for statistical (and also non-financial) projects.

Internationalization
Parts of the programme can, after consultation with the programme director, be conducted at foreign universities. This can be done in the 3rd semester. The programme director decides whether the foreign courses are relevant to the program and can in such a case approve that these replace certain courses in the programme.

Scope of Programme
By using mathematical models and simulations, one can find methods for a more efficient use of resources. Mathematics and modeling are therefore an important basis for sustainable development. This is not at least highlighted in courses such as *Mathematical Modeling II* in which the students are trained in building mathematical models for e.g., climate change, epidemics, or information security. Sustainable development comes also into play within the framework of other courses on the programme, such as e.g., *Risk and Portfolio Analysis*, where one studies methods for calculating risks, and in *Mathematical Cryptography*, where information security is discussed.

In the course *Research Methodology*, students get to identify and discuss ethical as well as societal aspects linked to research in mathematics.

The fact that mathematics is a universal language provides a good basis for internationalization. The programme is also conducted in a very international environment and has a large proportion of international students. Even among teachers and researchers many nationalities are represented. Periodically, guest professors and other teaching staff are in attendance.

The programme management works to promote increased diversity within the education in mathematics. This applies to teaching, research and marketing, as well as the recruitment of teaching staff.

Quality Development
The programme is administered by a programme director who has the overall responsibility for the programme and is responsible for student contact.
Students are involved in both the program and course evaluations. The programme coordinator and the students meet regularly and discuss courses and help to choose the right specialization and elective courses. Compilations of course and program evaluations are filed by the department.

Degree Certificate

After completing programme studies, corresponding to the requirements expressed in the Higher Education Ordinance degree order as well as Linnaeus University degree order, the student may apply for a degree. Those who have completed Mathematics and Modelling Master Programme, 120 credits, may obtain the following degree:

Masterexamen med inriktning mot Algebra med kryptering och kodning alt. Analys och matematisk fysik alt. Matematisk statistik och finansmatematik
(Huvudområde: Matematik/Tillämpad Matematik)

Master of Science, 120 credits (with specialization in Algebra with Cryptography and Coding, or Analysis and Mathematical Physics, or Mathematical Statistics and Financial mathematics)
Main field of study: Mathematics/Applied Mathematics.

The degree certificate is bilingual (Swedish/English) and is accompanied by a Diploma Supplement (in English).

Other Information

The teaching of the program takes place in its entirety in English.
It is recommended that the student has access to their own computer.