Programme syllabus

Master's Programme, Applied and Computational Mathematics, 120 credits
Masterprogram, tillämpad matematik och beräkningsmatematik
120.0 credits

Valid for students admitted to the education from autumn 19 (HT - Autumn term; VT - Spring term).

This is a translation of the Swedish, legally binding, programme syllabus.

Programme objectives

The main objective of this programme is to train skilled applied mathematicians, well prepared for advanced industrial positions or continued graduate studies.

Knowledge and understanding

A Master of Science in Applied and Computational Mathematics shall:

- demonstrate knowledge and understanding in Applied Mathematics, including both broad knowledge of the field and a considerable degree of specialised knowledge within the chosen area of specializationas well as insight into current research and development work,
- demonstrate specialised methodological knowledge in Applied Mathematics, including techniques of mathematical mo- delling, analysis of mathematical models, and simulation.
- be able to formulate and approach new problem settings in a scientific manner, by having a creative, critical and systematic attitude towards applied mathematics.

Skills and abilities

A Master of Science in Applied and Computational Mathematics shall be able to:

- demonstrate the ability to critically and systematically integrate knowledge and analyse, assess and deal with complex phenomena, issues and situations even with limited information,
- demonstrate the ability to identify and formulate issues critically, autonomously and creatively as well as to plan and, using appropriate methods, undertake advanced tasks within predetermined time frames and so contribute to the formation of knowledge as well as the ability to evaluate this work,
- demonstrate the ability in speech and writing both nationally and internationally to clearly report and discuss his or her conclusions and the knowledge and arguments on which they are based in dialogue with different audiences,
- demonstrate the skills required for participation in research and development work or autonomous employment in some other qualified capacity,
- independently apply mathematical theories, methods, and models,
- formulate mathematical models, select suitable methods to investigate those models including the efficient use of computer tools.

Ability to make judgements and adopt a standpoint

A Master of Science in Applied and Computational Mathematics shall be able to:

- demonstrate the ability to make assessments in Applied Mathematics informed by relevant disciplinary, social and ethical issues and also to demonstrate awareness of ethical aspects of research and development work,

- demonstrate insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used,
- critically judge the validity and limitations of results obtained from different types of mathematical models,
- demonstrate the ability to identify the personal need for further knowledge and take responsibility for his or her ongoing learning.

Extent and content of the programme

Applied and Computational Mathematics is a two-year (120 university credits) Master's programme at the advanced level (second cycle). The instruction language is entirely English. The programme consists of a basic curriculum followed by four tracks: (i) computational mathematics, (ii) optimization and systems theory, (iii) mathematics of data science, and (iv) financial mathematics. The courses in the basic curriculum are compulsory and worth 30 university credits. To obtain sufficient depth in a track, a student is required to complete courses worth approximately 30 university credits among the profile courses for the track in question.

Eligibility and selection

General eligibility requirements

- A completed Bachelor's degree, corresponding to a Swedish Bachelor's degree (180 ECTS), or equivalent academic qualifications from an internationally recognised university. Students in their final year of undergraduate education may also apply to KTH and if qualified, receive a conditional acceptance.
- English language proficiency equivalent to (the Swedish upper secondary school) English course B/6. There are different ways to fulfill the English language requirements, see: www.kth.se

Specific eligibility requirements

A Swedish or foreign degree equivalent to Bachelor of Science of 180 university credits, with at least 45 university credits in mathematics. The students are required to have documented knowledge corresponding to basic university courses in analysis in one and several variables, linear algebra, numerical analysis, ordinary and partial differential equations and integral transforms, mathematical statistics, and basics of programming in a higher programming language.

Selection process

The selection process is based on a total evaluation of the following criteria: university, study performance, course work related to the programme (mathematics in a wide sense), and letter of motivation. The evaluation scale is 1-75.

Implementation of the education

Structure of the education

The duration of the academic year at KTH is 40 weeks. The academic year is divided into four periods. Each period lasts approximately seven weeks with at least 33 days of study. Each period is followed by an examination period. In addition to the four regular examination periods, there are four re-examination periods: at Christmas, in March, June and August, immediately before the start of the academic year. Teaching activities may, if necessary, be scheduled outside the academic year. Details about the structure follow the general rules stated by KTH.

Courses

The programme is course-based. Lists of courses are included in appendix 1.

At least 90 university credits worth of courses must be taken. Of these, courses worth 30 credits are mandatory for all students of the programme. For each track there is an additional ca 30 credits worth of courses that are mandatory for that track. The remaining ca 30 credits are obtained by taking optional courses. The optional courses can be chosen freely if they are at the advanced level given by the department of mathematics, or if they have a strong connection to applied mathematics. A list of such optional courses is included in appendix 3. To some extent, other choices of courses are also possible. In particular, upto 15 credits can typically be non-technical ("teknikkomplementära") courses.

Note that the choice of optional courses must always be approved by the programme director.

Grading system

Courses in the first and the second cycle are graded on a scale from A to F. A-E are passing grades, A is the highest grade. The grades pass (P) and fail (F) are used for courses under certain circumstances.

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The grades pass (P) and fail (F) are used for thesis works.

Conditions for participation in the programme

Before the second semester each student must select one of the four tracks: computational mathematics, optimization and systems theory, statistical learning and data analytics or financial mathematics. At least 45 credits worth of course work must have been finished during the first year (including the re-examination period in August) to be allowed to move on to the second year of the programme.

For students starting their education from the autumn semester 2018, previous promotion requirements have been replaced with special admission requirements to each course. Admission requirements are specified in the course syllabus.

Course application

As a student at KTH programmes you have to apply for semester courses. The application is done via www.universityadmissions.se

Course registration

Students admitted to an educational programme at KTH must register for the courses they intend to study. Course registration is required for the examination and means that the student is active.

Recognition of previous academic studies

Under certain circumstances, and in agreement with the programme director, credits for previous studies can be received according to the local policy of KTH.

Studies abroad

Students have the opportunity to spend one semester at one of KTH’s partner universities abroad.

For more information and recommendation on the appropriate semester for exchange studies refer to the International coordinator.

Degree project

A 30-credit Master’s degree project is carried out at the end of the educational programme (usually the fourth semester). The purpose of the degree project is to develop the student's ability to perform independent project work, as well as to apply and deepen the skills obtained from the courses of the programme. The project may be carried out in an academic or industrial environment in Sweden or abroad.

The student must actively search for a suitable degree project; however KTH can provide some assistance with information on suitable points of contact. The choice of project must be approved by the master thesis responsible for the selected track.

To be allowed to start a degree project, a student must have accumulated at least 60 credits of the total course work, and enough depth within the selected track.

The degree project is graded with P/F.

Degree

In order to earn a Degree of Master of Science, passing grades in all courses which are included in the student’s study plan are required. The study plan must comprise 120 higher education credits which include a degree project consisting of 30 higher education credits, in the second cycle.

KTH’s local degree ordinance can be found at KTH's website, www.kth.se.

Application for degree certificate

When the studies at KTH are completed the student can apply for a degree certificate. Application is done through the “personal menu” at www.kth.se

Appendix 1 - Course list

Appendix 2 - Programme syllabus descriptions

Appendix 1: Course list

Master's Programme, Applied and Computational Mathematics, 120 credits (TTMAM), Programme syllabus for studies starting in autumn 2019

General courses

Year 1

Mandatory courses (22.5 credits)

Course code	Course name	Credits	Edu. level
AK2040	Theory and Methodology of Science with Applications Computational Science)	7.5	Second cycle
SF2520	Applied Numerical Methods	7.5	Second cycle
SF2940	Probability Theory	7.5	Second cycle

Conditionally elective courses

Course code	Course name	Credits	Edu. level
SF2812	Applied Linear Optimization	7.5	Second cycle
SF2832	Mathematical Systems Theory	7.5	Second cycle
SF2863	Systems Engineering	7.5	Second cycle

Recommended courses

Course code	Course name	Credits	Edu. level
DD2257	Visualization	7.5	Second cycle
DD2356	Methods in High Performance Computing	7.5	Second cycle
DD2365	Advanced Computation in Fluid Mechanics	7.5	Second cycle
DD2421	Machine Learning	7.5	Second cycle
DD2434	Machine Learning, Advanced Course	7.5	Second cycle
DD2435	Mathematical Modelling of Biological Systems	9.0	Second cycle
SF1811	Optimization	6.0	First cycle

Course code	Course name	Credits	Edu. level
SF2525	Computational Methods for Stochastic Differential Equations and Machine Learning	7.5	Second cycle
SF2526	Numerical algorithms for data-intensive science	7.5	Second cycle
SF2565	Program Construction in C++ for Scientific Computing	7.5	Second cycle
SG2212	Computational Fluid Dynamics	7.5	Second cycle
SG2224	Applied Computational Fluid Dynamics	5.0	Second cycle

Supplementary information

At least one of the conditionally elective courses has to be studied. The course/courses can be studies either during year one or two.

Note that due to overlap it is not possible to select both SF2935 and DD2421.

The list of recommended courses is those that we think you will need for your future career.

Year 2

Conditionally elective courses

Course code	Course name	Credits	Edu. level
SF2832	Mathematical Systems Theory	7.5	Second cycle
SF2863	Systems Engineering	7.5	Second cycle

Recommended courses

Course code	Course name	Credits	Edu. level
DD2257	Visualization	7.5	Second cycle
DD2421	Machine Learning	7.5	Second cycle
DD2434	Machine Learning, Advanced Course	7.5	Second cycle
DD2435	Mathematical Modelling of Biological Systems	9.0	Second cycle
SF1811	Optimization	6.0	First cycle
SF2565	Program Construction in C++ for Scientific Computing	7.5	Second cycle

Supplementary information

At least one of the conditionally elective courses during year one and two has to be studied.

Note that due to overlap it is not possible to select both SF2935 and DD2421.

The list of recommended courses is those that we think you will need for your future career.

Year 3

Track, Computational Mathematics (COMA)

Year 1

Conditionally elective courses

Course code	Course name	Credits	Edu. level
DD2365	Advanced Computation in Fluid Mechanics	7.5	Second cycle
SF2521	Numerical Solutions of Differential Equations	7.5	Second cycle
SF2525	Computational Methods for Stochastic Differential Equations and Machine Learning	7.5	Second cycle
SF2567	Project Course in Scientific Computing	7.5	Second cycle
SF2568	Parallel Computations for Large- Scale Problems	7.5	Second cycle

Supplementary information

At least 3 conditionally elective course have to be studied.

At least one of SF2521 and SF2561 has to be studied.

Year 2

Mandatory courses (7.5 credits)

Course code	Course name	Credits	Edu. level
SF2524	Matrix Computations for Large-scale Systems	7.5	Second cycle

Conditionally elective courses

Course code	Course name	Credits	Edu. level
SF2561	The Finite Element Method	7.5	Second cycle
SF2565	Program Construction in C++ for Scientific Computing	7.5	Second cycle
SF2567	Project Course in Scientific Computing	7.5	Second cycle

Supplementary information

At least 3 conditionally elective course have to be studied.

At least one of SF2521 and SF2561 has to be studied.

Year 3

Track, Mathematics of Data Science (DAVE)

Year 1

Mandatory courses (7.5 credits)

Course code	Course name	Credits	Edu. level
SF2955	Computer Intensive Methods in Mathematical Statistics	7.5	Second cycle

Conditionally elective courses

Course code	Course name	Credits	Edu. level
DD2352	Algorithms and Complexity	7.5	Second cycle
SF2525	Computational Methods for Stochastic Differential Equations and Machine Learning	7.5	Second cycle
SF2526	Numerical algorithms for data-intensive science	7.5	Second cycle
SF2568	Parallel Computations for Large- Scale Problems	7.5	Second cycle
SF2930	Regression Analysis	7.5	Second cycle
SF2943	Time Series Analysis	7.5	Second cycle

Supplementary information

At least two conditionally elective courses has to be studied furing year 1 or 2: Compulsory courses + conditionally elective courses = 30 cr.

Year 2

Mandatory courses (7.5 credits)

Course code	Course name	Credits	Edu. level
SF2935	Modern Methods of Statistical Learning	7.5	Second cycle

Conditionally elective courses

Course code	Course name	Credits	Edu. level
SF2956	Topological Data Analysis	7.5	Second cycle
SF2957	Statistical Machine Learning	7.5	Second cycle

Supplementary information

At least two conditionally elective courses has to be studied furing year 1 or 2: Compulsory courses + conditionally elective courses = 30 cr.

Track, Financial Mathematics (FMIA)

Year 1

Mandatory courses (7.5 credits)

Course code	Course name	Credits	Edu. level
SF2701	Financial Mathematics, Basic Course	7.5	Second cycle

Conditionally elective courses

Course code	Course name	Credits	Edu. level
SF2930	Regression Analysis	7.5	Second cycle
SF2943	Time Series Analysis	7.5	Second cycle

Supplementary information

Among the conditionally elective courses at least one course from each year has to be studied: SF2943 or SF2930 and SF2975 or SF2980.

Year 2

Mandatory courses (7.5 credits)

Course code	Course name	Credits	Edu. level
SF2942	Portfolio Theory and Risk Management	7.5	Second cycle

Conditionally elective courses

Course code	Course name	Credits	Edu. level
SF2975	Financial Derivatives	7.5	Second cycle
SF2980	Risk Management	7.5	Second cycle

Supplementary information

Among the conditionally elective courses at least one course from each year has to be studied: SF2943 or SF2930 and SF2975 or SF2980.

Track, Optimization and Systems Theory (OPST)

Year 1

Conditionally elective courses

Course code	Course name	Credits	Edu. level
SF2812	Applied Linear Optimization	7.5	Second cycle
SF2822	Applied Nonlinear Optimization	7.5	Second cycle
SF2832	Mathematical Systems Theory	7.5	Second cycle
SF2842	Geometric Control Theory	7.5	Second cycle
SF2863	Systems Engineering	7.5	Second cycle
SF2866	Applied Systems Engineering	7.5	Second cycle

Year 2

Conditionally elective courses

Course code	Course name	Credits	Edu. level
SF2832	Mathematical Systems Theory	7.5	Second cycle
SF2852	Optimal Control Theory	7.5	Second cycle
SF2863	Systems Engineering	7.5	Second cycle
SF2866	Applied Systems Engineering	7.5	Second cycle

Year 3

Appendix 2: Specialisations

Master's Programme, Applied and Computational Mathematics, 120 credits (TTMAM), Programme syllabus for studies starting in autumn 2019

Track, Computational Mathematics (COMA)

The field of computer simulations is of great importance for high-tech industry and scientific/engineering research, e.g. virtual processing, climate studies, fluid dynamics, advanced materials, etc. Thus, **Computational Science and Engineering** (CSE) is an enabling technology for scientific discovery and engineering design. CSE involves mathematical modeling, numerical analysis, computer science, high-performance computing and visualization. The remarkable development of large scale computing in the last decades has turned CSE into the "third pillar" of science, complementing theory and experiment.

The track **Computational Mathematics (COMA)** is mainly concerned with the mathematical foundations of CSE. However, in this track we will also discuss issues of high-performance computing. Given the interdisciplinarity, your final curriculum may vary greatly depending on your interests.

Track, Mathematics of Data Science (DAVE)

The technological progress and the increased availability of information contributes to the emergence of massive and complex data sets. A variety of scientific fields are contributing to the analysis of such data at the interface of mathematics, statistics, optimization and computational methods for learning. Optimal decision making under uncertainty based in such circumstances require modelling and discovering relevant features in data, optimization of decision policies and model parameters, dimension reduction and large scale computations. Data science based on applied mathematics has the potential for transformative impact on natural sciences, business and social sciences.

Track, Financial Mathematics (FMIA)

Financial mathematics is applied mathematics used to analyze and solve problems related to financial markets. Any informed market participant would exploit an opportunity to make a profit without any risk of loss. This fact is the basis of the theory of arbitrage-free pricing of derivative instruments. Arbitrage opportunities exist but are rare. Typically both potential losses and gains need to be considered. Hedging and diversification aim at reducing risk. Speculative actions on financial markets aim at making profits. Market participants have different views of the future market prices and combine their views with current market prices to take actions that aim at managing risk while creating opportunities for profits. Portfolio theory and quantitative risk management present theory and methods that form the theoretical basis of market participants’ decision making.

Financial mathematics has received lots of attention from academics and practitioners over the last decades and the level of mathematical sophistication has risen substantially. However, a mathematical model is at best a simplification of the real world phenomenon that is being modeled, and mathematical sophistication can never replace common sense and knowledge of the limitations of mathematical modeling.

Track, Optimization and Systems Theory (OPST)

Optimization and Systems Theory is a discipline in applied mathematics primarily devoted to methods of optimization, including mathematical programming and optimal control, and systems theoretic aspects of control and signal processing. The discipline is also closely related to mathematical economics and applied problems in operations research, systems engineering and control engineering.

Master’s education in Optimization and Systems Theory provides knowledge and competence to handle various optimization problems, both linear and nonlinear, to build up and analyze mathematical models for various engineering systems, and to design optimal algorithms, feedback control, and filters and estimators for such systems.
Optimization and Systems Theory has wide applications in both industry and research. Examples of applications include aerospace industry, engineering industry, radiation therapy, robotics, telecommunications, and vehicles. Furthermore, many new areas in biology, medicine, energy and environment, and information and communications technology require understanding of both optimization and system integration.