Applied mathematics and mathematical statistics

The graduate school is organised within the Department of Mathematical Sciences..
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Syllabus

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1. Description of subject and goals

The purpose of the graduate school in applied mathematics and mathematical statistics is to give the student fundamental knowledge within applied mathematics, orientation about current problems and applications, a deeper insight into one or several parts of the subject, and the ability to independently carry out research work. The aim of the program until the licentiate degree is to give the student the ability to independently take part in research and development work. The aim of the program until the doctoral degree is to give the student the ability to critically and independently plan, lead, carry through, and present research and development work.

The studies within the school are typically performed in connection to research topics that are actively pursued at the faculty. Example of such topics are:

Computational mathematics

Computational mathematics is a field that studies problems both in pure and applied mathematics, using methods based on a synthesis of mathematical analysis and numerical/symbolical computation. Computational mathematics treats the whole process from mathematical model to computer implementation. Development and analysis of computational algorithms are crucial components. Questions considered include stability, convergence, and efficiency of computational methods. An important area in computational mathematics is the modelling and numeric of partial differential equations. This area includes the construction and analysis of efficient computational algorithms in numerical linear algebra, methods of discretization such as the finite element method, as well as different aspects of high performance computing such as adaptivity and effective use of parallel computer architectures. Common applications in computational mathematics are structural mechanics, fluid mechanics, biomedicine, architecture, and mathematical physics.

Modelling of kinetics and dynamical system

Kinetic and dynamical models are tools for studying systems whose state change over time. A prime example of this is the Boltzmann equation that describes the position and velocity of molecules in a gas. Research on this topic consists both of formulating models

based on reasonable assumptions, and analyzing the behavior of such models. The models usually take the form of ordinary or partial differential equations, but discrete models also exist. In order to study these, a combination of computer simulation and mathematical theory is employed, e.g. functional analysis, stochastic analysis and measure theory. The questions investigated are often motivated by the domain of application and include stability of solutions, stationary (time-independent) solutions and asymptotic behavior. Examples of applications are flocking behavior among animals, bacterial movement and the growth of tumors.

Mathematical statistics

Mathematical statistics is used to describe, analyze and predict random events and uncertainty in data. The subject comprises two main subparts: probability theory, that provides the theoretical foundation and deals with the underlying stochastic processes and mathematical models of random phenomena, and statistical inference, that treats all aspects of data management, such as the collection, organization, analysis and presentation of data. The access to new technologies for data collection and the rapidly increasing possibilities of virtual data sharing has led to a massive increase in available data within a number of fields, something that places an ever increasing demand on the access to efficient and robust analysis tools. Thereby, mathematical statistics constitutes a fundamental component within most sciences. Many of the researchers within the department work interdisciplinary, examples being the identification of functional elements in DNA, the movement of particles in particle systems, spatial processes in climate and material sciences, genetic epidemiology of inheritable diseases, characteristics of the growth and extinction of populations, analysis and prediction of traffic data, and models of cell signaling systems.

Optimization

Mathematical optimization is an applied mathematical field comprising modelling, theory, and solution methodology for decision problems. Since the subject is closely connected with applications, also the modelling of real problems in a mathematical form is central. The development of theory as well as methodology has over the years walked hand in hand with the development of computers and software. The goal of the postgraduate education is to give a broad overview of the research field and an advanced scientific training in a specific research area within the field. The research in the research group of mathematical optimization comprises theory, modelling, and methodology development for large-scale structured linear, non-linear, integer, and combinatorial optimization, as well as graph and polyhedral theory. The research spans a wide field − from fundamental mathematical research to more applied research in cooperation with industrial companies. Applications include scheduling of industrial production and maintenance activities, simulation based design optimization, planning of electricity production and distribution, safety in electrical networks, and traffic and transport planning.

2. Prerequisites

To be eligible for the graduate school in applied mathematics and mathematical statistics, the student must have completed a Master of Science or a Master of Engineering degree. Students who have acquired a similar degree by other means as well as students with an undergraduate degree from a Faculty of Science are also eligible. The student should also be judged to have the capacity to successfully complete a postgraduate research education. For more details about admission requirements, see the Chalmers guidelines for graduate education (Rules of Procedure and Policies, Dnr 2014-0464) or the Handbook for doctoral studies ("Doctoral studies").

3. Organization and structure of the program

The doctor education comprises 240 credits (hec) and the licentiate education 120 credits; one year's full time study should give 60 credits. The graduate education consists of the following parts

- scientific work leading to a scientific thesis
- required and elective courses
- participation at scientific conferences, departmental seminars, guest lectures and other activities within the graduate school
- supervision of the education process and the scientific work

Each graduate student is given a supervisor and at least one co-supervisor. An examiner is also selected for each student.

Parts of the education may be located at another university or research institute, domestic or in foreign countries.

4. Courses

The individual study plan should include courses that provide the necessary depth within the student's research area, as well as broader courses in other relevant topics. The study plan should thus include both courses that are oriented towards mathematics and the application area of the thesis. Courses on professional skills, such as academic writing, presentation techniques, literature search, etc., are also compulsory. The courses should be selected according to the guidelines outlined below and after consultation with the examiner and supervisor.

The graduate school in applied mathematics and mathematical statistics provides courses in several topics. The courses are divided into common courses, which aim to give the students of the graduate school a common scientific foundation, and the more specialized courses which aim to provide a deeper understanding of a specific topic. The common courses are given on a regular basis.

4.1. Course requirements

For the doctoral degree, the course work should amount 90 credits of which 30 credits should come from common courses and 22.5 credits should come from specialized courses. Additionally, 15 credits should be from courses in Generic and Transferable Skills (GTS). The remaining credits (22.5) should be from elective courses.

For the licentiate degree, the course work should amount 45 credits of which 15 should come from common courses and 7.5 from specialized courses. Additionally, 9 credits should be from courses in Generic and Transferable Skills (GTS). The remaining credits (13.5) should be from elective courses.

4.2. Common courses

The common courses can be selected from three main topics. For the doctoral degree, at least 30 credits should come from common courses (i.e. four complete courses) where at least one course comes from each of the three main topics. For the licentiate degree, at least 15 credits should come from common courses (i.e. two complete courses) from at least two of the three main topics.

Computational mathematics

- Ordinary and partial differential equations
- Numerical linear algebra

Mathematical statistics

- Statistical inference
- Stochastic processes

Optimization

- Linear and non-linear optimization
- Combinatorial optimization

4.3 Specialized courses

The specialized courses aim to give the student a deeper understanding within specific topics. The specialized courses are selected by the student in consultation with the examiner and supervisor and can partially consist of self-study courses.

Example of topics for the specialized courses include

Computational mathematics

- The finite element method and its implementation
- Stochastic partial differential equations
- Computational geometry
- Multiscale methods
- Wavelet analysis

- Integration theory
- Functional analysis
- Geometric integration

Mathematical statistics

- Statistical inference
- Linear regression models
- Bayesian inference
- Analysis of time series
- Experimental design
- Stochastic processes, Markov theory and queueing theory
- Integration theory
- Weak convergence
- Martingales

Optimization

- Linear and non-linear optimization
- Convex analysis
- Discrete/integer optimization
- Combinatorial optimization
- Optimization on graphs and networks
- Simulation based optimization
- Optimization under uncertainty
- Multiple objective optimization
- Large-scale optimization

4.4 Generic and Transferable Skills

Generic and Transferable skills (GTS) aims to give doctoral students at Chalmers professional and individual development, and is a program of activities/courses not directly linked to the respective areas of research. For the doctoral degree, 15 credits should be from courses in Generic and Transferable Skills (GTS) of which 9 credits should be obtained for the licentiate degree.

In addition to the courses within Generic and Transferable Skills, the student is also required to participate in the introduction day for doctoral students (before the licentiate examination, at latest). Further requirements are an oral popular science presentation to be performed prior to the PhD thesis defence and a written popular science presentation to be published on the back of the PhD thesis.

Get more information:
General Introduction for Doctoral Students
Graduate Courses - Generic and Transferable Skills

5. Thesis

5.1. Licentiate thesis

A licentiate thesis requires that the scientific work is presented in the form of a report corresponding to at least 75 credits. The thesis should be presented at a public seminar. The thesis is graded with pass or fail.

5.2. Doctoral thesis

A doctoral thesis requires that the scientific work corresponding to 150 credits is presented in the form of a report and defended publically. The thesis should be of such quality that it fulfils the standard requirements for publication, either in its entirety or in abridged form, in a scientific journal of good quality. The dissertation is graded with pass or fail.

6. Requirement for the degree

6.1. Licentiate degree

A licentiate degree consists of 120 credits. The requirements for the licentiate degree include

1. completion of a licentiate thesis corresponding to 75 credits (as described above),
2. completion of a study course corresponding to 45 credits distributed over courses according to Section 4.1.

6.2. Doctoral degree

A doctoral degree consists of 240 credits. The requirements for the doctoral degree include

1. completion of the doctoral thesis corresponding to 150 credits (as described above),
2. completion of a study course corresponding to 90 credits distributed over courses according to Section 4.1.

7. Degree names

The names of the degrees within the graduate school in applied mathematics and mathematical statistics are

- Licentiate of engineering in applied mathematics and mathematical statistics,
- Doctor of engineering in applied mathematics and mathematical statistics

According to Swedish university tradition, the choice of engineering (teknologie) versus philosophy (filosofie) degree titles corresponds to the nature of the Bachelor's or Master's degree previously obtained by the student (engineering versus science).

8. Supervision

A postgraduate student is entitled to receive academic advice and guidance from the department at which he or she is pursuing doctoral work for the equivalent of four years' full-time study, or two years' full-time study for students pursuing the licentiate degree. Part time students receive the proportional amount of supervision over a longer period of time. The Head of the Department selects an examiner, whose is responsible for approving the study course, decide about higher education credits and grades for different courses, and confirm that the requirements for exams are fulfilled. The main supervisor and the examiner must not be the same person. The examiner, the supervisor and the student together write a study plan for the student's progress through the program. The study plan should be updated on a regular basis.

9. Examination of proficiency

The content of courses is tested by written and/or oral examinations; postgraduate students can receive the grades pass or fail. Course examination can also take other forms, e.g., by letting the student take responsibility for one or several seminars. The grade for the doctoral dissertation is determined by a grading committee that is appointed for each dissertation defense. The grade for the licentiate thesis is decided by the examiner.

10. Further instructions

The student shall at least once a year present an accounting of her/his progress.