Mathematical Sciences

/ Matematiska vetenskaper /

SCB-codes:

- Computational Mathematics: 10105
- Mathematics: 10199
- Mathematical Statistics: 10106
- Optimization: 10105
- Interdisciplinary Mathematics: 10199

1 General description of the research area

The PhD studies area of Mathematical Sciences covers research questions of a mathematical nature, either from a purely theoretical perspective or based on practical applications. In both cases, the focus lies on studying the mathematical problem and its properties. The methods used in research consist of mathematical proofs and/or computer-assisted computations.

PhD studies in Mathematical Sciences prepare the PhD student both for an academic career involving research and teaching, and for a professional career outside academia. Mathematical expertise, together with the ability to understand new theory and oversee complex phenomena, is needed in large parts of the labor market. Future societal challenges require mathematical expertise both directly, for example in optimization, mathematical modeling, and dynamical systems, and indirectly, since scientific and technological development fundamentally relies on mathematical concepts.

2 Eligibility requirements and selection

The basic eligibility requirements as well as the general principles for selection are specified in the faculty's *Study Handbook for PhD Studies*.

2.1 Specific eligibility requirements

Eligibility for admission to PhD studies in Mathematical Sciences requires that the applicant has completed degree requirements at the master's level, including at least 60 ECTS at the advanced level in an area related to the PhD research area, including an independent project (master's thesis) of at least 30 ECTS, or has acquired essentially equivalent knowledge in Sweden or abroad. Courses or thesis work in mathematically oriented applied subjects are also included in this requirement.

3 Degree

PhD studies in Mathematical Sciences lead to a Degree of Doctor or a Degree of Licentiate**.** The latter may also constitute an intermediate stage of the PhD studies. A Degree of Licentiate **c**omprises 120 ECTS, of which the licentiate thesis corresponds to 70 ECTS and courses to 50 ECTS, of which at least 25 ECTS must be at the PhD level. A Degree of Doctor comprises 240 ECTS, of which the doctoral thesis corresponds to 140 ECTS and courses to 100 ECTS, of which at least 50 ECTS must be at the PhD level.

4 Goals and implementation of the PhD studies

The general goals and objectives of PhD studies are specified in the introduction to the faculty's *Study Handbook for PhD Studies*, as well as in the Higher Education Ordinance (reprinted in the *Study Handbook*'s appendix A).

PhD studies in Mathematical Sciences aim to ensure that the PhD student acquires the ability to independently conduct high-quality research within one of the subject areas and becomes well prepared for a professional career, within or outside academia, in the same field.

Therefore, the PhD student must acquire:

- broad knowledge of Mathematical Sciences in general and the chosen subject area in particular,
- deep knowledge within parts of the chosen subject area,
- the ability to identify, formulate, and analyze relevant research questions,
- the ability to critically review both their own and others' scientific work,
- the ability to present research results both in writing and orally.
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PhD studies in Mathematical Sciences provide the PhD student with the prerequisites to meet all required degree outcomes. The studies consist of research and thesis work, coursework, participation in seminars, and involvement in national and international conferences.

Breadth in Mathematical Sciences is achieved through fulfilling the basic course requirements (specified for each subject area), as well as participation in the research environment of the Department of Mathematics, which includes expertise in many areas of pure and applied mathematics. Additional breadth may be achieved through courses at other departments. All PhD students are expected to participate regularly in the department's seminar activities.

Depth within the subject area and, in particular, within the chosen research direction is achieved by attending advanced courses according to the subject-specific requirements, by carrying out independent research, and by participating in relevant conferences and seminars.

The PhD student develops familiarity with scientific methodology through independent research, collaboration with supervisors and possibly other senior researchers, and by completing a mandatory course in research methodology.

Skills and abilities are further developed by independently planning and conducting theoretical research work, actively participating in and presenting research at conferences and seminars, and possibly through teaching at the undergraduate level.

Judgement and attitudes are strengthened through mandatory training in research ethics and through participation in seminars in the subject area.

PhD students demonstrate intellectual independence by authoring and defending a thesis.

The studies provide the PhD student with an enhanced understanding of the potential of science to contribute to sustainable societal development. This is achieved through the faculty-wide course requirements as well as through participation in ongoing discussions, such as research seminars, and through reflection on the sustainability aspects of the PhD student's own research.

Instruction is given in the form of lectures, seminars, group studies, individual studies, and supervision. Examination of course components takes place in written or oral form and is graded Pass or Fail. PhD students are expected to actively participate in seminars, guest lectures, and conferences.

4.1 Thesis

The overall rules regarding the format, submission and grading of a thesis can be found in the faculty's *Study Handbook for PhD Studies*.

For both the Degree of Doctor and the Degree of Licentiate, the PhD student must author a thesis. The student must demonstrate intellectual independence and contribute substantially to the research results included in the thesis.

For a Degree of Doctor, the thesis must be of such scientific quality that the results can be published in an international scientific journal of good standard. The thesis may be written as a monograph or as a compilation thesis. A compilation thesis consists of copies of scientific articles together with a comprehensive introductory chapter ("kappa"). Articles must be authored by the PhD student; if co-authored, the student's contribution must be clearly identifiable. The kappa must always be written by the PhD student and must introduce the research area, describe the achieved results, and place them in a broader context. Doctoral theses in Mathematical Sciences normally consist of at least two accepted or published articles.

A licentiate thesis may consist of a scientific paper or a research-based report.

4.2 Individual study plan

An individual study plan will be formulated for each PhD student. The detailed planning of courses and other components will be conducted in consultation with the supervisor and documented in the individual study plan (see *Study Handbook for PhD Studies*, section 5.3). The study plan should be established within one month after admission to PhD studies, and it should be revised at least once a year.

4.3 Supervision

The general regulations for supervision can be found in the *Study Handbook for PhD Studies*, section 4, and in the faculty's policy for supervision of PhD studies.

4.4 Courses

The course component consists of three parts, which together amount to 100 ECTS for the Degree of Doctor, and 50 ECTS for the Degree of Licentiate:

- Faculty course requirements
- Subject-common course requirements
- Subject-specific course requirements.

The faculty course requirements ensure that certain degree outcomes are fulfilled and that PhD students who teach receive basic pedagogical training. The subject related course requirements ensure broad competence across the core areas of Mathematical Sciences. The subject-specific requirements provide both breadth and depth within the chosen subject area and research specialization.

4.4.1 Faculty course requirements

Scientific theory, methodology, ethics, gender equality and sustainability

All PhD students admitted should complete mandatory courses as decided by the faculty in Scientific theory, methodology, ethics, gender equality and sustainability, or be deemed to have equivalent competencies, in order to receive a degree.

Pedagogic studies
All PhD students who teach should complete a basic course in pedagogy. At least 3 ECTS from this course should be included in the PhD studies, and any remaining credits should be counted as departmental duties (see *Study Handbook for PhD Studies*, section 5.5).

4.4.2 Subject related courses

All PhD students should normally take at least 5 ECTS in each of the following subject areas (or be deemed to have acquired equivalent knowledge):

- Computational Mathematics
- Mathematics
- Mathematical Statistics
- Optimization

4.4.3 Accreditation

Accreditation of course credits is regulated by the *Study Handbook for PhD studies*, section 5.6.

5 Subject areas

Below, the subject areas within Mathematical Sciences are described together with the subject-specific course requirements. The purpose of the subject-specific requirements is both to ensure breadth within the field and provide depth within the chosen research specialization.
Each PhD student must take courses within the subject-specific requirements corresponding to:

- at least 40 ECTS for the Degree of Doctor,
- at least 20 ECTS for the Degree of Licentiate,

unless equivalent knowledge is demonstrated. Some courses may be relevant for multiple subject areas.

5.1 Computational Mathematics

Computational Mathematics includes research questions where mathematical methods and computational methods are closely related. It also includes the development and analysis of numerical methods for mathematical problems, often expressed in the form of equations or systems of equations.

Within this area, research often concerns the development, implementation, and analysis of algorithms for solving complex mathematical problems originating from applications in engineering, physics, financial mathematics, computer science, optimization, and more.

5.1.1 Subject-specific course requirements

Courses should provide both breadth in Computational Mathematics and depth in the dissertation subject. The course requirements include:

- Courses in numerical analysis
- Courses in scientific computing and algorithms
- Courses relevant to the thesis subject (e.g., numerics for differential equations, computational linear algebra, high-performance computing, numerical optimization, stochastic computation).

5.2 Mathematics

Mathematics includes theoretical and applied research in algebra, analysis, geometry, topology, dynamical systems, combinatorics, logic, number theory, and differential equations, among others.
The area is broad and covers both pure mathematics—where the focus lies on conceptual structure and logical deduction—and areas where the research is motivated by scientific or engineering applications.

5.2.1 Subject-specific course requirements

Courses should provide both breadth in Mathematics and depth in the research specialization. The requirements include:

- Courses in analysis, algebra, geometry/topology, or discrete mathematics
- Courses relevant to the thesis subject
- Participation in advanced reading courses or seminar series may also be included.

5.3 Mathematical Statistics

Mathematical Statistics includes mathematical methods for analyzing and drawing conclusions from data subject to randomness. It encompasses probability theory, statistical inference, stochastic processes, machine learning, and statistical modeling.
The subject area covers both theoretical development and applications such as data analysis, life science modeling, industrial statistics, risk analysis, and statistical methods used in technology and natural sciences.

5.3.1 Subject-specific course requirements

Courses should provide both breadth in Mathematical Statistics and depth within the chosen specialization. The requirements include:

- Courses in theoretical statistics and probability theory
- Courses in stochastic processes
- Courses relevant to the thesis subject (e.g., statistical learning theory, Bayesian methods, advanced inference, time series).

5.4 Optimization

Optimization includes research focused on finding optimal solutions to mathematical problems, formulated either as deterministic or stochastic optimization problems. The area covers linear, nonlinear, discrete, and convex optimization, as well as optimization algorithms. Research questions may be theoretical, such as analyzing algorithmic complexity or convergence, or application-oriented, such as optimization in data science, engineering, economics, or logistics.

5.4.1 Accreditation Subject-specific course requirements

Courses should provide both breadth and depth in Optimization. The requirements include:

- Courses in linear and nonlinear optimization
- Courses in discrete or convex optimization
- Courses relevant to the thesis subject (e.g., variational analysis, numerical optimization methods, stochastic optimization).

5.5 Interdisciplinary Mathematics

Interdisciplinary Mathematics focuses on mathematical research arising from interactions with other scientific fields. This may include areas such as mathematical biology, data science, physics, engineering sciences, economics, and environmental sciences.
Research typically involves formulating and analyzing mathematical models, combining methods from various branches of mathematics, and collaborating with researchers in other disciplines.

5.5.1 Subject-specific course requirements

Courses should provide breadth in Mathematical Sciences as a whole and depth in the interdisciplinary specialization. The requirements include:

- Courses in mathematical modeling
- Courses relevant to the thesis subject (e.g., dynamical systems, applied probability, partial differential equations, computational methods)
- Courses from the collaborating discipline may also be included when relevant to the mathematical research.

6 Other information

6.1 Transitional provisions

Changes to the general study syllabus do not apply to those who have already been admitted to PhD studies in the research area. A change to the new general study syllabus may however be approved if both the main supervisor and the PhD student agree. In such a case, this should be documented in the individual study plan.

7 Commencement

1. The General study plan comes into force 01 07 2024.