Doctoral programme — Mathematics

The programme description was approved by Fakultetsnämnden (Faculty Board) November 30, 2010. Valid from Spring 11.

Programme description (KTHMAT)

Programme name
Mathematics (Matematik)

Subject area

The doctoral programme’s overall purpose and learning outcomes

The aim for the education is to make the student well prepared for independent research assignments within the mathematics or for other assignments where requirements are set on an in-depth understanding of mathematics and mathematical research methods.

This implies that the doctoral student after the education should be able to:

- describe and explain theories, design principles and empirical results in his area of specialization,
- formulate concrete research issues within his area of specialization
- use established research methods and provide new knowledge
- analyse critically and evaluate own and others’ research results,
- present and discuss research results for colleagues public and in teaching,
- analyse and take position in ethical aspects of research within the subject and act thereafter
- identify needs of new knowledge and have knowledge of to initiate and lead research,
- participate in interdisciplinary cooperations and show knowledge of different views on the research role in the social progress and analyse and evaluate connected issues critically.

All of the above listed skills should in a natural way be developed under the supervision process. Courses should contribute to develop the skills described in 1st, 3rd, 6th and the 8th point. To participate in seminars and to teach and participate in conferences contribute to develop the skills described in 2nd, 4th, 5th and the 7th point.

The doctoral programme’s size and recruitment

The program is calculated obtain approximately 30 full time graduate students of which approximately 6 be admitted each year.

Today, there are 30 doctoral students in mathematics. The target student group is Master of Engineering engineering physics (with an emphasis on mathematics in the education) and masters students in mathematics, or with equivalent higher education qualification in a close field strong related to mathematics. Recruitment of doctoral students takes place according to KTHs regulatory framework. Notification takes place normally two times annually.

Currently, there are fifteen professors and at least ten docents in mathematics. There are also junior associates that are expected to become docents within the coming years, which give a natural renewal of the supervision capacity.
**Funding**

Doctoral studentships are financed normally through external direct government fundings and to some extent direct government fundings for research and third-cycle programmes.

**Courses**

The courses within the doctoral programme are all offered within a third-cycle subject and are therefore presented in the study plan for the subject.

**Quality enhancement activities**

The systematic quality assurance procedures are aimed more on courses on the students' progress and on the quality of the supervision.

At the KTH School of Engineering Sciences is today routines for the development of the education for third-cycle studies. Especially, there is a council of graduate students, as in front of the students' collected wishes about the development of the education. Furthermore, the doctoral students' progress in an annual process is supervised. For each doctoral student, there is a supervisor group that consists of the doctoral student's principal supervisors, assistant supervisors and at least another senior individual which is chosen in consultation with the doctoral student. The group should be met at least once a year especially in connection with the audit of the individual study plan.

The core courses in the program will be evaluated which implies that course analyses are prepared and published after each course occasion.

In both courses and supervision can improvements of the implementation of the graduate program be suggested and should I see lead through discussion in the Programme Council to a raised quality. For an individual doctoral student, the annual meeting with the supervisor group gives a natural occasion to suggest improvements. Discussion of supervision can in addition lead to audit of the supervisor group for a doctoral student.

The Programme Council led of programme co-ordinator should also follow the local and international discussion within the subject area so well as for general education for third-cycle studies and when necessary adapt the program to the development.

In addition to the program in KTHs working environment is included the above and be evaluated independent through working environment survey that gives the participants a larger anonymity protection than the discussion of supervisor group.

The doctoral thesis should contain new research results that the student has developed alone or in collaboration with others. The scientific main results should satisfy the quality requirements for publication in internationally confessed magazines and proceedings with referee system. The quality of the thesis is supervised through the above described publication norms and through review between examining committee and supervisor.

For a Degree of Licentiate, it is required that the student writes an academic paper or a qualified report on a scientific basis. One for Degree of Licentiate written academic paper may be included in a compilation thesis for Degree of Doctor.

The student's contributions to in the thesis included texts that have several authors should be able to be stated. The publication language is normally English.

**National and international network**

The doctoral students are included in the established international network that is within the subject. Exchange takes place normally on basis of the supervisors' contact network, international projects and network.
Program link to the strategic KTH network CIAM. Where is arranged normally annually workshops with presentation of results of the doctoral students and supervisor of the network and invited speaker. A certain interaction with the industry is also included in connection with joint research initiatives.

In the present time, joint cooperations lead normally to the graduate student exchange. Such can grow to joint degree and can be facilitated by EU grants or the equivalent.

A connection to Erasmus program and similar programs for third-cycle studies is desirable.

The cooperation within Stockholm's Mathematical Centres has been said earlier.

The above is enumerated and defined in appendix 3.

**Further instructions for registration**

**Appendixes**

Appendix 1: Study plan for third-cycle subject Mathematics (MATTE).

Appendix 2: List containing names and subject areas of supervisors within the programme

Appendix 3: Presentation of the programme’s national and international network
Doctoral programme — Mathematics

Appendix 1: Study plan for third-cycle subject Mathematics (MATTE).

The subject plan was approved by Fakultetsnämnden (Faculty Board) November 30, 2010. Valid from Spring 11.

Subject title
Mathematics (Matematik)

Subject description and programme outcomes

Scientific field
Mathematics studies spatial and numerical quantities and their relationship and applications. This study can be divided up in a large number fields. Many fields are represented on KTH, such as algebraic geometry, algebraic topology, differential geometry, dynamic systems, harmonic analysis, combinatorics, commutative algebra, complex analysis, mathematical physics and numerical analysis. Both theoretical and applied research is carried out.

The said fields reply be based together for a broad supply of courses and specialisations that reflect the research activities that are on KTH then the graduate program in mathematics. Other fields within the subject can also come in question, and the program are thought to dynamic be able to include new developments over the time.

The education intends to give basic knowledge within the different branches of the mathematics a good insight in research methodology, orientation in current problems and, on at least a field, knowledge and skills that are sufficient for and lead to an independent conducted research work at the enough high level. The education is completed with Degree of Doctor. It can be natural to take Degree of Licentiate first. Possibility is also only to take Degree of Licentiate. The education for third-cycle studies in mathematics is given by the section for mathematics on Department of mathematics at the school for technological sciences. The education will find a natural location within Stockholm's Mathematical Centres that KTH and SU have just formed.

Description of possible specialisation
The subject has no specialisations.

Specification of how the programme outcomes are to be achieved
The aim for the education is to make the student well prepared for independent research assignments within the mathematics or for other assignments where requirements are set on an in-depth understanding of mathematics and mathematical research methods.

This implies that the doctoral student after the education should be able to:

- describe and explain theories, design principles and empirical results in his area of specialization
- formulate concrete research issues within his area of specialization
- used established research methods and provide new knowledge
- analyse and evaluate own and others' research results critically
- present and discuss research results for colleagues public and in teaching
- analyse and take position in ethical aspects of research within the subject and act thereafter
- identify the need for new knowledge and have knowledge of how to initiate and lead research
• participate in interdisciplinary cooperations and show knowledge of different views on the research role in the social progress and analyse and evaluate connected issues critically.

All of the above listed skills should in a natural way be developed under the supervision process. Courses should contribute to develop the skills described in 1st, 3rd, 6th and the 8th point. To participate in seminars and to teach and participate in conferences contribute to develop the skills described in 2nd, 4th, 5th and the 7th point.

Current research

Programme structure

The education is carried out under the guidance of a principal supervisor together with an or several assistant supervisors. An individual study plan should be established in consultations between doctoral student and principal supervisors. The doctoral student and the principal supervisor should update the study plan at least once a year. The doctoral student's progress should be assessed at least once a year. It is natural that the assessment takes place in connection with the date of the study plan. It established or updated levels are established by the head of graduate studies at the school. About the doctoral student's progress is not near to what has been prescribed in the study plan can measures be taken in accordance with KTH's regulatory frameworks. The individual study plan should be adapted to the prior knowledge and to the specialisation of the thesis.

The education for third-cycle studies consists of a course module and an dissertation part with mutual point conditions according to the below.

Compulsory and recommended courses

The doctoral student should alone, in consultation with his supervisor (primarily the principal supervisor), take responsibility because the courses are chosen so that a sufficient specialisation within the chosen field and an appropriate broadening within the program and against possible relevant applied subjects is achieved.

All research teams at the section for mathematics (at the establishment of the graduate program, the groups are Algebra and Geometry, and Analysis and Combinatorics) gives a set of courses within his respective fields.

A selection of the courses is core courses: they are given regular (the aim is at least every second year), can be regarded as essential for a doctoral student within the specific field and is appropriate for all doctoral students in the program. These courses constitute a

joint basis for the program and each doctoral student within the program read normally a substantial number of these courses.

Other subject courses that are stated are a selection of the courses that are given by the research teams.

Additional courses can come in question.

The following selections give a good image:

Core courses:
Commutative algebra and algebraic geometry
Homological algebra and algebraic topology.

subject course:
Applied topology
Topology
Prime number
Clifford algebras, geometric algebra and applications
Matrix groups
Toric geometry
Algebraic geometry: calculations and applications
Algebraic spaces
Elliptic bends
Computational number theory
Lie algebras
Vector bundles and characteristic classes
Commutative algebra
Scheme theory II.
Courses at SU:
Algebra IV
Galois theory
Representation theory
Number theory
Differential geometry for algebraists
Algebraic geometry (surfaces, Ā‰tale cohomology)
Algebraic geometry (Hartshorne, parts of chapter. II, III)
Introduction to the theory of spectral sequences
Young tableaux.
Courses within Analysis
The following selections give a good image:
Core courses:
Functional Analysis
Integration theory
Chaotic dynamic systems
Topology
Elementary differential geometry
Fourier analysis
Differential geometry
Mathematical analysis for doctoral students.

subject course:
Mathematical theory of option pricing
Potential theory
Wavelets
Mathematical hydrodynamics
Random matrices
Partial Differential Equations
Methods in elliptic and parabolic PDE
Dynamics of strings and membranes
Obstacle problems in mathematical physics and industry
Inverse problems
Operator theory: a simple introduction
Spectral theory and usages
Semi-riemannian geometry 2
Non-linear wave equations
Homogenisation, oscillation and chance in PDE and FRP
Semi-riemannian geometry 1
Fractal geometry and measurement theory
Stochastic analysis
Fourier analysis
Viscosity solutions left fully non-linear PDE
Integrable systems
Several complex variables.
Courses at SU:
Topics in advanced analysis
Partial Differential Equations
Geometric multilinear analysis
Analytical functions 2.
Courses within Combinatorics

The following selections give a good image:

Core courses:

Applied combinatorics
Combinatorics
Graph theory

subject course:

Topology
Commutative algebra and algebraic geometry
Homological algebra and algebraic topology
Topological combinatorics
Coxeter groups
Algebraic combinatorics
Graph theory for doctoral students
The hyperplane arrangement
Polytope theory

Chosen subjects in combinatorics

Broadening courses

Certain relevant courses on advanced level and third cycle are appropriate broadening courses within the program. Examples of such courses:

Computational methods left micro and macro scales
Algebraic statistics
Projects within industrial and applied mathematics.

Other courses

In the coursework can also be included courses on teaching and learning in higher education. University pedagogical education is a requirement, if teaching should take place for first-cycle studies or second cycle under the education time.

Seminar activity

The student for third-cycle studies should under his education take part in and contribute to the scientific activity that is carried out within his field by often attending seminars and give a seminar a year about his work in the area normally.

Own seminar is evaluated to 1 credit (however in all no more than 5 credits). A regular participation in the general mathematical colloquium and relevant seminars and guest lectures outside the field be expected also. This also applies to seminars and guest lectures on the Department of Mathematics SU, Institutes Mittag-Leffler and NADA.
**Thesis**

The work with the thesis or the licentiate thesis should be started as soon as possible after the third cycle studies have been started. The subject for the thesis should be chosen in consultation with the principal supervisor and should connect to the research that is at the section for mathematics.

The thesis or the licentiate thesis is a compulsory part of the education for third-cycle studies. This part of the education aims at developing the student's ability to give independent contributions to research and cooperating to scientific studies within and outside his/her own subject. The thesis or the licentiate thesis should contain new research results that the student has developed alone or in collaboration with others. The scientific main results should satisfy the quality requirements for publication in internationally confessed magazines and proceedings with referee system. The student's contributions to in the thesis included texts that have several authors should be able to be stated.

The thesis or the licentiate thesis should normally be written in English. It can either be designed as a compilation of scientific articles or as a monograph thesis. In the previous the case should it be a particularly written summary.

Irrespective of if the thesis is intended become monograph or compilation thesis should international publication of achieved results be sought under the graduate student period.

**Entry requirements and selection**

**General and special admission requirements and prior knowledge**

General entry requirements are defined by general rules according to Higher Education Ordinance and KTHs internal regulations for education for third-cycle studies.

For specific entry requirements, it is required that the applicant's education has a specialisation in mathematics for second cycle studies or a close field strong related to mathematics. Furthermore, good knowledge in English is required, both in numbers and in writing.

**Selection rules and procedures**

The selection is made among the applicants who satisfy the entry requirements. At the selection, the grade of the applicant's maturity and ability to independent assessment and the important aspects of critical analysis constitute. Strong emphasis is placed at learning outcomes in courses of deeper character or in the form of degree projects as the degree project.

**The programme’s degrees and examinations**

**Degree of Licentiate and Degree of Doctor (PhD)**

Licentiate and Degree of Doctor been taken in accordance with KTHs general rules.

**The programme’s examinations**

No other compulsory tests are included in the education.
Doctoral programme — Mathematics

Appendix 2: List containing names and subject areas of supervisors within the programme

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