Doctoral programme — Solid Mechanics

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

Programme description (KTHHFL)

Programme name

Solid Mechanics (Hållfasthetslära)

Subject area

The doctoral programme’s overall purpose and learning outcomes

The education implies specialized studies within some of solid mechanics's research areas through balanced training in theoretical and numerical methods and experimental work. The doctoral student should acquire both expertise and width within the subject of the program. The third-cycle courses and study programmes should be at a high level in an international comparison. After completed Degree of Licentiate the doctoral student should be prepared for both research assignments and development work. After completed Doctoral Degree the doctoral student should independently be able to conduct research- or development work within industry or academia.

KTH has through the president's decision UF 0044-09 established general aims for KTH’s education for third-cycle studies. These aims are achieved through:

- fair and instructive supervision
- a regular and varied supply of courses for third-cycle studies
- a regular participation in international and national conferences
- education in presentation technique and media training
- extensive participation of the department in larger interdisciplinary research efforts and in industrially financed research projects

The doctoral programme’s size and recruitment
At the end of 2013, 24 individuals are active as doctoral students in the program. Of these 5 are industrial doctoral students. A reasonable assumption is that 20-25 doctoral students will be active at the same time within the program during the next years. The students who are admitted as doctoral students with full-time employment are offered doctoral positions.

The obvious basis for recruitment of doctoral students is the Solid Mechanics track within the Master's programme "Engineering Mechanics" with about 20-30 students annually from the engineering programmes BD, F, M, P and T. Furthermore, within the international Master's programme "Engineering Mechanics" each year about 10 students have followed many of our advanced courses and made degree project on the department. All in all, our track within "Engineering Mechanics" constitute a very good basis for recruitment of doctoral students. The department also has a relatively large and continuous inflow of doctoral students with her/his basic education carried through at other institutes of technology in Sweden and also at universities abroad. This is obviously not an insignificant part of the recruitment base for the program.

In 2013, there are 10 senior researchers (4 professors, 1 adjunct professor, 4 senior lecturers, 1 associate senior lecturers) active within the department and thereby within the program.

**Funding**

At the moment about half of the doctoral students at the department are financed by different government research funding bodies and centres (Turbokraft, VR, Vinnova) and the other half is financed directly by industry (DNV, MTU, Scania, SKF etc). This wide variety of funding sources makes the doctoral program less sensitive for sudden changes regarding the specialisation in different government research funding bodies and industry. The participation of the department in Centres like Turbokraft and different WIN Excellence centres also constitutes a long-term foundation for the research funding within the program.

**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**

Quality assessments take place continuously, for example by the fact that the doctoral students participate in regular seminar activity and also present their work at national and international conferences. It is desirable that each doctoral student should participate (and present her/his results) at at least one national or international conference a year.

Licentiate and doctoral theses should before application of thesis defence always be reviewed in detail of a senior researcher in the department (apart from the principal supervisor). It should also be stated that it is tradition at the department that each thesis is studied more or less in detail by most of the teachers.

Essentially all theses from the department are compilation theses. It is required that the scientific articles in a doctoral theses from the program should have the potential to be published in reputable international scientific journals. In the case that unpublished articles or papers are included in the thesis, the principal supervisor should decide if they satisfy the requirement above.
The department has a very well-equipped laboratory, which ensures that the experimental needs of the program are well met. An aim is that all doctoral theses that are presented within the program should contain experimental parts.

The courses in the program will be evaluated completely in accordance with the principles that apply to courses on basic and second cycle.

It should be pointed out that the infrastructure of the program corresponds completely to the department (of solid mechanics) regarding administration, computer capacity, laboratory and so on.

**National and international network**

The department is part of a large number of formal and informal network. Many of the doctoral students have their funding from national research programmes (Turbokraft) and WIN Excellence Centres (BiMaC Innovation and HERO-M) which constitute interdisciplinary networks with participants from both industry and academia and where Summer Schools are commonly occurring. The participation of the department in national organisations such as Vascular Mechanics (biomechanics) and UTMIS (fatigue) also constitutes natural networks for the doctoral students of the program. The department is also hosting the forest industrial doctoral school FPIRC.

Solid Mechanics is included as a track in the Master's programme "Engineering Mechanics". Other tracks within the Master's program are "fluid mechanics" and "sound and vibration". The Master's programme therefore constitutes an interdisciplinary network for the doctoral students of the program.

The department has an extensive international contact network that also is beneficial for the program. The doctoral students are encouraged to shorter or longer research visits at foreign universities. The department is regularly visited by international researchers. It is the policy of the department that these visiting researchers should if possible be involved in the doctoral students' research.

The above is enumerated and defined in appendix 3.

**Further instructions for registration**

**Appendixes**

Appendix 1: Study plan for third-cycle subject Solid Mechanics (HÅLLF).

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 — Solid Mechanics

Appendix 1: Study plan for third-cycle subject Solid Mechanics (HÅLLF).

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

Subject title

Solid Mechanics (Hållfasthetslära)

Subject description and programme outcomes

Scientific field

Solid Mechanics is a science of technology, with issues that often are of fundamental character. The applied part of the research be characterised by large width and often takes place in the interface with other technological sciences. Research in solid mechanics includes all situations where a deformable solid body is involved. The deformation can depend on mechanical strain but can also have other causes. Often, the research intends to formulate limits, criteria for design or conditions for the validity of a theory and point at the need of more advanced theories. The research methods consist of experimental studies, theoretical modelling and numerical analysis. Also development of analytical, experimental or numerical methods are a part of the solid mechanics.

Solid Mechanics is a research discipline where new fields are developed concurrently with the need of the society and new discoveries both within and outside the subject. At the Department of solid mechanics, the research programme is broad, but most of the research projects belong normally one of the fields biomechanics, fracture mechanics, contact mechanics, material mechanics, paper mechanics or fatigue. In common of the different fields in solid mechanics is that the research often deals with the consequences on the macro level due to deformation- and/or failure processes on the micro level.

Description of possible specialisation

The subject has no specialisations.

Specification of how the programme outcomes are to be achieved

The education implies in-depth studies within some of solid mechanics's research areas through balanced training in theoretical and numerical methods as well as experimental work. The doctoral student should
acquire both expertise and width within the subject. The third-cycle studies at the department should hold a high level in an international comparison. After achieving the Licentiate Degree, the doctoral student should be prepared for both research assignments and development work. After achieving the Doctor's degree, the doctoral students should independently be able to conduct research- or development work within industry or academia.

KTH has through the presidents decision UF 0044-09 established general aims for KTH's education for third-cycle studies. According to these aims, the doctoral student should after completed studies be able to:

- describe and explain theories within her/his field
- formulate concrete research issues within her/his subject area
- use scientific methods to provide new knowledge through scientific studies
- critically analyse and evaluate applied methods and results from own and others' scientific studies
- present and discuss research results within the scientific community
- present research in a pedagogical way outside the scientific community in an educational context
- assess ethical aspects within the research area and act from these and identify needs of new research and have knowledge of how to initiate and lead research

The education should also aim against that the doctoral student after completed studies should be able to participate in interdisciplinary cooperations within the subject area and analyse the role of research in the society.

These aims are achieved through:

- fair and instructive supervision
- a regular and varied supply of courses for third-cycle studies
- a regular participation in international and national conferences
- education in presentation technique and communication training
- the extensive participation of the department in larger interdisciplinary research efforts and in industrially funded research projects

**Current research**

The current research at the Department of solid mechanics treats the following fields:

- development of material models and design criteria for materials that can be characterised as biological, metallic, polymers, composites, paper, fibre based or compacted
- development and verification of criteria and models for brittle and ductile fracture as well as fatigue failure in materials
- development of methods and algorithms for the analysis different of phenomena in solid mechanics and the implementation of these into numerical software

**Programme structure**

The third-cycle studies consists of a course module and a thesis part and are carried out under the guidance of a principal supervisor. The extent of the Degree of Licentiate is 120 credits, where the essay part should correspond to 90 credits and the course module to 30 credits. The extent of the Degree of Doctor is 240 credits, where the thesis part should correspond to 180 credits and the course module to 60 credits. The course module in both the Degree of Licentiate and the Degree of Doctor may, apart from third-cycle courses, also contain courses from the basic education. The minimum allowed part of third-cycle courses

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are decided by the KTH's regulatory frameworks for "taking of Degree of Licentiate" respective "taking of Degree of Doctor". For both licentiate and doctoral degree, courses from the basic education may be included. The number of credits that may be included is limited: (i) to the part of the education for basic studies that exceeds the exam requirements for basic or special (if specified) entry requirements for admittance to doctoral studies; (ii) to the part of basic courses that may be included in the Degree of Licentiate and the Degree of Doctor course module limited according to KTH's regulatory frameworks for "taking of Degree of Licentiate" respective "taking of Degree of Doctor". The master's degree project may not be included in the course module. The courses that are included in the education for third-cycle studies are established in an individual study plan according to KTH's regulations. The principal supervisor, in consultation with the doctoral student, delivers in connection with the admission to the education for third-cycle studies a suggestion for an individual study plan that must be approved by the director for doctoral studies at the School of Engineering Sciences, KTH. The courses, including courses from the basic education given credit for, should be chosen so that width is received within the subject and with regard to the current research specialisation.

With the starting point from the research that should be carried out, the development and maturation process of a student, up to a completed Degree of Doctor, can be described as a process in three stages: In stage one a problem, well formulated by the supervisor, is solved; in stage two a research assignment, that has been formulated by the doctoral student and the supervisor together, is solved; in stage three an assignment that the doctoral student essentially alone have formulated, is solved. For a Degree of Licentiate, the doctoral student is only expected to reach the first two the stages. The doctoral student is assumed to carry out his research with the aim to step by step write scientific articles that taken together should constitute the thesis. These articles should have such a scientific level that they can be sent for publication in relevant refereed international scientific journals. The doctoral student should present his research results regularly at national and international conferences.

**Compulsory and recommended courses**

Compulsory courses

The course F4C5008 Continuum mechanics, 12 credits, or an equivalent course, is compulsory for both the Degree of Licentiate and the Degree of Doctor.

The course SE2123 Testing Techniques in Solid Mechanics, 6 credits, or an equivalent course, is compulsory for the Degree of Doctor.

Elements of theory of knowledge and research methodology should be included in the doctoral education. Furthermore, doctoral students who carry out teaching of courses in the basic education should acquire pedagogical education.

Recommended courses

Regarding recommended fields for third-cycle courses, see the webpage of solid mechanics for current range of courses offered within the doctoral education. Example of subject areas for courses in the third-cycle studies are: biomechanics, fracture mechanics, dynamics, elasticity theory, experimental methods, finite element method, contact mechanics, paper mechanics, plasticity theory, stability theory and fatigue.

Regarding recommended fields for courses for basic studies, see the webpage for current range of courses offered within the basic education in solid mechanics.
Apart from the courses that are offered by the Department of solid mechanics, there are a large number of courses at other departments, both on the basic and doctoral level, that also may be included in the individual study plan, for example courses in vehicle and aeronautical engineering, physics, machine design, mathematics, material science, mechanics and numerical analysis and computer science.

**Thesis**

With thesis, licentiate thesis or doctoral thesis are intended. A thesis in the solid mechanics is usually a compilation thesis consisting of articles published or intended for publication in international scientific journals, and an introduction summarising the thesis. A thesis can also be designed as a monograph. A thesis should reach such quality that the contents of the thesis can be published in international scientific journals of high quality.

**Entry requirements and selection**

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

General entry requirements, to be admitted as doctoral students in solid mechanics, are completed courses corresponding to at least 240 credits, of which at least 60 credits at second-cycle studies, within one of the engineering programmes F, T, M, P, BD, I or V, or equivalent documented prior knowledge acquired at a Swedish or a foreign university. Master's programme at KTH, within the above mentioned engineering programmes, is regarded in the same way as an engineering programme when it comes to length and extent of an education.

**Selection rules and procedures**

Students applying for doctoral studies in solid mechanics are chosen based on criterion relevant for the specific postgraduate project. The intended principal supervisor has the principal responsibility for the assessment of applicants to the employment.

**The programme’s degrees and examinations**

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

The education in third-cycle studies consists of a course module and a thesis part and are carried out under the guidance of a principal supervisor. The extent of the Degree of Licentiate is 120 credits, where the thesis part should correspond to 90 credits and the course module to 30 credits. The extent of the Degree of Doctor is 240 credits, where the thesis part should correspond to 180 credits and the course module to 60 credits. The course module in both Degree of Licentiate and Degree of Doctor may, apart from third-cycle courses, also contain courses the basic education. The minimum allowed number of third-cycle courses are decided by the KTH's regulatory frameworks for "taking of Degree of Licentiate" respective "taking of Degree of Doctor". For both the Degree of Licentiate and the Degree of Doctor, courses from the basic education can be included. The number of credits that may be included is limited: (i) to the part of the education for basic studies that exceeds the exam requirements for basic or special (if specified) entry requirements for admittance to doctoral studies; (ii) to the part of basic courses that may be included in the Degree of Licentiate and the Degree of Doctor course module limited according to KTH's regulatory
frameworks for "taking of Degree of Licentiate" respective "taking of Degree of Doctor". The Master's degree project may not be included in the course module. The courses that should be included in the third-cycle studies are established in an individual study plan according to KTH's regulations.

Licentiate theses are presented at a public seminar and are reviewed by an external reviewer appointed by the director of doctoral studies at the School of Engineering Sciences, KTH. The licentiate thesis is graded (passed or failed) by an examiner appointed by the director of doctoral studies at the School of Engineering Sciences, KTH.

Doctoral theses are defended at public dissertations according to instructions from the School of Engineering Sciences, KTH. The thesis is reviewed by an opponent and are assessed of an examining committee. Both opponent and examining committee are appointed by the director of doctoral studies at the School of Engineering Sciences, KTH.

It is recommended that students with the intention to take a Degree of Doctor first take a Degree of Licentiate.

**The programme’s examinations**

Second-cycle and third cycle courses have written and/or oral examinations and normally also approved written assignments and laboratory sessions are required.
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