Engineering Mechanics

Study plan for third-cycle subject

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

**Subject title**

Engineering Mechanics (Teknisk mekanik)

**Subject description and programme outcomes**

**Scientific field**

Mechanics is one of the four classical fields of physics (optics, electromagnetism and thermodynamics are the other) and is therefore of course an essential part of all education within natural sciences and engineering. In line with KTH's directives, the Department of Mechanics and the Marcus Wallenberg Laboratory for Sound and Vibration research introduce a doctoral programme/third-cycle subject area in Engineering Mechanics.

Specialisations

The program/the subject area has a range of courses offered with three specialisations, namely acoustics, structural mechanics and fluid mechanics. The specialisation in structural mechanics also includes courses within fields such as solid mechanics and biomechanics.

The compulsory course module consists of taking two of the specified conditionally elective courses within one of the specialisations.

**Description of possible specialisation**

1. Acoustics
2. Structural mechanics
3. Fluid Mechanics

**Specification of how the programme outcomes are to be achieved**

The aims for the education for third-cycle studies in engineering mechanics is to give the doctoral student a good general knowledge within his own field but also within related fields. It should also give the
doctoral student training to tackle difficult problems so that she/he after completed education independently will be able to initiate, run and evaluate scientific and technical research projects. Active participation in national and international research networks within the knowledge field is aimed for.

The aim with the education in engineering mechanics for third-cycle studies is that the trained Ph.D. should become an independent, excellent researcher within his subject area and be able to:

- describe and explain theories and empirical results within the field of engineering mechanics
- formulate concrete research issues in engineering mechanics
- use scientific methods and provide new knowledge through their own 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 an educational way outside the science community and in an educational context
- assess ethical aspects of research within the current field and act from these and
- identify needs of new knowledge and have the knowledge to lead and initiate research

The education for third-cycle studies in engineering mechanics should also aim that the trained researcher should be able to:

- participate in interdisciplinary cooperations within engineering mechanics and analyse the role of research in social development

The doctoral student's, so called, soft skills regarding knowledge and understanding is developed through individual oral tests in a part of the third-cycle courses, where the connection between theoretical knowledge and physical understanding of the same become particularly tested for the individual the doctoral student. The doctoral student's skills and abilities is developed through own responsibility for experimental equipment and the implementation of experiments and/or calculation programs and its application in the current case. Further regular summer schools/expertise courses are given within current research areas to complement the third-cycle courses of the departments. These courses are often led by internationally recognized guest lecturers and involves as rule a project work within the frame of the course. Then, the doctoral student's development of better skills and abilities within a special field can be hastened. The doctoral student's development of judgement and approach is supported through the communication with supervisors and other senior researchers via internal seminars and meetings. Feedback is given at recurrent meetings weekly.

**Acoustics**

**Description of the specialisation**

The number of systems that generate noise and vibration is constantly growing. Examples are vessels, machines and processes of all kinds. Engine power and other driving forces are increased in parallel with
limiting weights and material consumption. This implies that the research and development carried out must be constantly increased to come to terms with the distractions due to sound and vibrations, to manage both the competition on the market and the requirements that are set by public authorities. The concept quality of sound means that the sounds of the product should communicate impressions of efficiency, quality and reliability. Already today, but above all in the future, more and more products for consumption, industry and transportation will be "sound-designed". Numerical computational models and experimental methods are developed to provide advanced knowledge in how sounds and vibrations arise and are transmitted in vehicles, machines, buildings, environments etc to understand how the distractions from sounds and the vibrations can be decreased.

**Current research**

The involved groups carry out theoretical, numerical and experimental research that covers large parts of the field of mechanics such as acoustics, solid mechanics, structural mechanics, fluid mechanics and biomechanics. The research is of basic nature but there are strong connections to different technical applications such as vehicle engineering.

**Programme structure**

The education for third-cycle studies in engineering mechanics consists partly of a course module partly of a thesis project work that is carried out within one of the research areas in acoustics or mechanics that are represented among the groups which are linked to the program. A doctoral student is usually employed at KTH but can also be employed at another higher education institution, research institute, government agency or industrial company. The doctoral student has at least two supervisors. One is the principal supervisor with which she/he decides individual study plan and the planning of the research project work. An individual study plan should be established in connection with admission to the education for third-cycle studies. The individual study plan should be accepted by the director of third-cycle studies at the School of Engineering Sciences. The doctoral student's progress should be assessed at least once a year in connection with audit of the individual study plan.

The thesis should result in a presentation of an independent completed scientific work within the subject area. The course module in the education for third-cycle studies in engineering mechanics consists of participation and examination in a number of courses which are either conditionally optional or optional. Courses should be chosen in consultation with the principal supervisor and see to that the chosen courses give both a good ground for the doctoral student's own thesis work and for her/his general knowledge in the area. It is also assumed that, apart from the compulsory parts that are included in the course syllabus, the doctoral student actively take part in seminars and similar activities at KTH and keeps her/himself informed about the scientific and technical development in general through participation in national and international conferences within the knowledge field.

In the schedules below, credits for each course is stated. 1.5 credits are assessed to correspond to studies during one week. A Doctoral degree/Licentiate degree in engineering mechanics requires examination in courses with a total of credit that is not less than 60/30.

**Compulsory and recommended courses**
General requirements for the course module in the education for third-cycle studies at KTH is stated in KTH's local regulations for the higher education qualifications for third-cycle studies, local Degree Ordinance.

Degree of Doctor in engineering mechanics consists of a course module comprising at least 60 credits and a thesis comprising 120-180 credits which in all gives 240 credits. Degree of Licentiate consists of a course module comprising at least 30 credits and a licentiate thesis comprising 60-90 credits so that the sum amounts to 120 credits.

The course module consists of specified conditionally elective courses and optional courses. The courses should be studied in accordance with the agreement between doctoral student and principal supervisor that has been made in the individual study plan.

The compulsory course module consists of choosing two of the specified conditionally elective courses within one of the specialisations.

Doctoral students who carry out teaching for first-cycle studies and second cycle should go through education in higher education pedagogy.

Specified conditionally elective courses with a specialisation in acoustics

Theoretical Acoustics

Structure-borne Sound

Aeroacoustics

Other optional courses

At the departments a number of courses for third-cycle studies that is optional is given regularly. Also other courses for third-cycle studies within the department than those stated below or given by other departments or universities can be taken within the course module. The principal supervisor and the doctoral student should in consultation plan the range of courses chosen so that both a depth within the field of the thesis work is obtained as well as a certain width within the scientific field. Furthermore, individual courses in scientific communication, theory of knowledge and research methodology can be included. Parts of this kind are otherwise considered to be included as a natural part of other theoretical courses given within the scope of the thesis.

A list of all current courses at the department for third-cycle studies is found on the webpage for the School for Technological sciences (SCI), KTH.

Uncertainty analysis

Specialisation in acoustics

Statistical energy analysis

Non-linear Vibration
Fluid Structure Interaction

Underwater Acoustics

Signal Analysis

Signal analysis II

Measurement and Analysis of Sound and Vibration

Ultrasonics

Computational Aeroacoustics

Green Functions and Fourier Methods in Acoustics

Specialisation in structural mechanics

Human movement analysis and simulation

Non-linear finite element methods

Survey of current literature in musculoskeletal biomechanics I

Survey of current literature in musculoskeletal biomechanics II

Scientifically writing

General and analytical mechanics

Non-linear Oscillation and Dynamical Systems

Relativistic mechanics

Current problems in the mechanics I

Current problems in mechanics II

Current problems in mechanics III

Current problems in mechanics IV

Current problems in mechanics V

Specialisation in fluid mechanics

Kinetic gas theory

Geophysical fluid dynamics
Vehicle aerodynamics

Micro fluid flows

Seminar course in engineering mechanics

Free boundary value problems

Current problems in fluid mechanics I

Current problems in fluid mechanics II

Current problems in fluid mechanics III

Current problems in fluid mechanics IV

**Thesis**

The thesis and thesis work is a compulsory part of the education for third-cycle studies. The education aims in this module that the doctoral student should develop an ability to give independent contributions to the field of research and also an ability to scientific cooperation.

**Degree of Doctor**

A doctoral thesis should contain new theoretical or empirical research results within the chosen subject area which the doctoral student has developed via theoretical or empirical research. It should also contain an overview of earlier research within the chosen subject area. The education for third-cycle studies is planned such that the thesis project work can be started already during the first semester. This implies that the course module is read underhand but the studies be planned so that it should be completed latest three years after the doctoral student has started his education for third-cycle studies. The doctoral student's research results should be presented regularly at informal seminars and should also be reported at appropriate milestones in the form of publications, conference proceedings or the like. The quality of the doctoral thesis should be such that it satisfies reasonably set requirements to enable publication in an internationally recognized scientific journal with peer reviewer. A doctoral thesis is normally a compilation thesis and in such cases, one of the parts should at least be published or accepted for publication before the thesis is placed forward.

**Degree of Licentiate**

Within the third-cycle subject area of engineering mechanics, there is possibility to take a Degree of Licentiate. For this degree is required that the doctoral student has acquired courses under the same condition as applies to Degree of Doctor however the difference being that the required total credit is reduced to 30 credits where specified conditionally elective courses are counted as optional. Further, it is required that the doctoral student has carried out and in writing have presented a qualified work on a scientific basis, the licentiate thesis, that either can constitute a first completed part of a doctoral thesis or that may be included as a part in a compilation thesis.

**Structural mechanics**
Description of the specialisation

Load bearing structures are found within all fields: buildings, vessels, people and animals. Bridges and skyscrapers define the more large-scale load bearing structures where geometry and materials are optimised to stand against the influence of nature. In the weightlessness and vacuum in space, the external loads are almost negligible but the mass of the structures must be minimised and their ability to be folded out, such as an umbrella, must be optimised. Within biomechanics mainly man movement patterns in different everyday movements and movement at maximum capacity of the human musculoskeletal system are studied. Numerical computational models and experimental methods are developed to better understand mechanical movement, as a dynamic action mode at land and in space structures to the muscles behaviour at human movement pattern in everyday life and in different sports.

Current research

The involved research groups carry out theoretical, numerical and experimental research that covers large parts of the field of mechanics such as acoustics, solid mechanics, structural mechanics, fluid mechanics and biomechanics. The research is of basic nature but there are strong connections to different technical applications such as vehicle engineering.

Programme structure

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Compulsory and recommended courses

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The course module consists of specified conditionally elective courses and optional courses. The courses should be studied in accordance with the agreement between doctoral student and principal supervisor that has been made in the individual study plan.

The compulsory course module consists of choosing two of the specified conditionally the elective courses within one of the specialisations.

Doctoral students who carry out teaching for first-cycle studies and second cycle should go through education in higher education pedagogy.

Specified conditionally elective courses with specialisation in acoustics
Theoretical Acoustics

Structure-borne Sound

Aeroacoustics

Other optional courses

At the departments a number of courses for third-cycle studies that is optional is given regularly. Also other courses for third-cycle studies within the department than those stated below or given by other departments or universities can be taken within the course module. The principal supervisor and the doctoral student should in consultation plan the range of courses chosen so that both a depth within the field of the thesis work is obtained as well as a certain width within the scientific field. Furthermore, individual courses in scientific communication, theory of knowledge and research methodology can be included. Parts of this kind are otherwise considered to be included as a natural part of other theoretical courses given within the scope of the thesis.

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Uncertainty analysis

Specialisation in acoustics

Statistical energy analysis

Non-linear Vibration

Fluid Structure Interaction

Underwater Acoustics

Signal Analysis

Signal analysis II

Measurement and Analysis of Sound and Vibration

Ultrasonics

Computational Aeroacoustics

Green Functions and Fourier Methods in Acoustics

Specialisation in structural mechanics

Human movement analysis and simulation
Non-linear finite element methods
Survey of current literature in musculoskeletal biomechanics I
Survey of current literature in musculoskeletal biomechanics II
Scientifically writing
General and analytical mechanics
Non-linear Oscillation and Dynamical Systems
Relativistic mechanics
Current problems in the mechanics I
Current problems in the mechanics II
Current problems in the mechanics III
Current problems in the mechanics IV
Current problems in the mechanics V
Specialisation in fluid mechanics
Kinetic gas theory
Geophysical fluid dynamics
Vehicle aerodynamics
Micro fluid flows
Seminar course in engineering mechanics
Free boundary value problems
Current problems in fluid mechanics I
Current problems in fluid mechanics II
Current problems in fluid mechanics III
Current problems in fluid mechanics IV

**Thesis**
The thesis and thesis work is a compulsory part in the education for third-cycle studies. The education aims in this module that the doctoral student should develop an ability to give independent contributions to the field of research and also an ability to scientific cooperation.

Degree of Doctor

A doctoral thesis should contain new theoretical or empirical research results within the chosen subject area which the doctoral student has developed via theoretical or empirical research. It should also contain an overview of earlier research within the chosen subject area. The education for third-cycle studies is planned such that the thesis project work can be started already during the first semester. This implies that the course module is read underhand but the studies be planned so that it should be completed latest three years after the doctoral student has started his education for third-cycle studies. The doctoral student's research results should be presented regularly at informal seminars and should also be reported at appropriate milestones in the form of publications, conference proceedings or the like. The quality of the doctoral thesis should be such that it satisfies reasonably set requirements to enable publication in an internationally recognized scientific journal with peer reviewer. A doctoral thesis is normally a compilation thesis and in such cases, one of the parts should at least be published or accepted for publication before the thesis is placed forward.

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Fluid Mechanics

Description of the specialisation

Within the field of fluid mechanics is studied a fluids (gas or liquid) movement and influence on other fluids or solids. The movement of the fluid (flow) are either laminar or turbulent and since turbulent flow is most common in nature current research is focused on understanding turbulent flow. Within the aero- and the hydrodynamics is studied the turbulent flow around e.g. cars, aircrafts and ships, since it increases the drag which increases the fuel consumption in turn. Within fluid machinery, the flow in fans, pumps, turbines and separators are studied to make them as efficient as possible. In papermaking, the pulp is analyzed from a fluid mechanical perspective to ensure that the paper-fibres oriente themselves in the intended direction. Within meteorology are studied air currents to be able to make weather forecasts, which is quite difficult since small changes in the turbulent air currents create large changes. Fluid mechanics is also used to explain different wave phenomena, e.g. Tsunamis, how sound is spread and melted metals behaviour at e.g. welding. Within the medicine, fluid mechanics is used to study e.g. the blood flow in the human body. In fluid mechanic research numerical computational models and
experimental methods are developed to understand fluids flow around different bodies and at different states and speeds. They computationally heavy fluid dynamical calculations are made on supercomputers and the experiments in wind tunnels.

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**Current research**

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**Programme structure**

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Structure-borne Sound
Aeroacoustics

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Free boundary value problems

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**Entry requirements and selection**

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

Entry requirements for education in engineering mechanics for third-cycle studies consist of academic degree from second-cycle studies at an institute of technology, or other academic degree from second-cycle studies, or completed course requirements of at least 240 credits of which at least 60 credits for
second-cycle studies, or acquired equivalent knowledge in a different way as a good preparation for the third-cycle courses and study programmes in engineering mechanics. Doctoral students are expected to be able to read and write academic English, and be able to speak English fluently.

**Selection rules and procedures**

Admission to studies for third-cycle studies is determined by the head of the school of engineering sciences after preparation by the principal supervisors and where appropriate by the Director of third-cycle education (at assessment of qualifications).

Apart from that the applicant has been tested to be eligible, it is the grade of maturity and ability to independently assess and critically analyse information which is the basis for selections Of great interest in this assessment is earlier study results in courses of specialisation in academic first-cycle and second-cycle courses and study programmes or independently performed scientific work. The applicants are interviewed by the principal supervisor sometimes together with intended additional supervisor or other senior experienced doctoral supervisor at the department. Contact is normally taken with teachers at the education that the applicant has earlier gone through. Selections among applicants to third-cycle study programmes are made by the department in connection with the admission. At notification of doctoral studentships, more detailed selection criteria can also be formulated which reflects the special requirements on a doctoral student that can be necessary for the person concerned to be able to carry out a specific thesis project work.

**The programme’s degrees and examinations**

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

Degree of Doctor consists of a course module comprising at least 60 credits and a thesis project work comprising 120-180 credits. The doctoral thesis should be submitted and defended in accordance with KTH's general regulations. Courses and thesis that are included in Degree of Licentiate may also be included in a Degree of Doctor.

Degree of Licentiate consists of a course module comprising at least 30 credits and a licentiate thesis project work comprising 60-90 credits. In the course module for Degree of Licentiate, the specified conditionally elective courses stated above are optional. The licentiate thesis should be submitted and defended in accordance with KTH's general regulations.

**The programme’s examinations**

In courses for third-cycle studies a written examination should be included. In certain cases, this can be substituted by an oral test. The design of the examination should in individual case be such that examiner can convince oneself about that the doctoral student has acquired all course content.