Mechanical Engineering

/Maskinteknik /

The research area Mechanical Engineering includes the following specialisations:

- **Fluid and Mechatronic Systems**/ Fluida och mekatroniska system/ SCB code 20399/
- **Solid Mechanics**/ Hållfasthetslära/ SCB code 20301
- **Manufacturing Engineering**/ Industriell produktion/ SCB code 20307
- **Engineering Materials**/ Konstruktionsmaterial/ SCB code 20599
- **Machine Design**/ Maskinkonstruktion/ SCB code 20399
- **Applied Thermodynamics and Fluid Mechanics**/ Mekanisk värmeteori och strömningslära/ SCB code 20306
- **Engineering Mechanics**/ Teknisk mekanik/ SCB code 20301

General description of the research area

Mechanical Engineering is a discipline of engineering sciences based on classical mechanics. In a broader perspective, mechanical engineering embraces activities from product development, engineering design, and machine elements to manufacturing, maintenance and remanufacturing. The research area is a fundamental discipline in which the principles of engineering, physics, materials science and mathematics are applied for the design, analysis, manufacturing, and maintenance of mechanical and mechatronic systems. The research area includes central concepts in areas such as mechanics, thermodynamics and materials science combined with more applied knowledge in areas such as product development, design engineering and manufacturing. As in most engineering sciences, mathematical modelling often plays a central part, and models of mechanical systems and processes are evaluated in computer environments and are validated against experiments and observations. In mechanical engineering, these core competencies along with tools and methods for computer-aided design and product development methodology are utilized for developing and analysing products and systems during their entire life-cycle. Since the industrial revolution, mechanical engineering has been a central topic for virtually every industry from traditional manufacturing industries and energy production to vehicles, aircrafts, industrial robots and consumer products. In addition, health care has long been an application area for mechanical engineering.
The research area Mechanical Engineering comprises the areas described above, which are further detailed in the specialisations described at the end of this document.

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*.

Specific eligibility requirements

Admission to PhD Studies in the research area of Mechanical Engineering requires fulfilling the master's degree requirements with completion of at least 60 ECTS at the master level in a field relevant to the research area as well as the specialisation in PhD studies. These 60 ECTS should include an independent project of at least 30 ECTS in a field relevant to the subject of the PhD studies.

Degree

PhD studies in Mechanical Engineering leads to a Degree of Doctor or a Degree of Licentiate. The latter degree can also serve as a stage in the PhD studies. The Degree of Licentiate comprises 120 ECTS, of which courses correspond to 40 ECTS and the licentiate thesis corresponds to 80 ECTS. The Degree of Doctor comprises 240 ECTS, of which courses correspond to 60-90 ECTS and the doctoral thesis corresponds to 150-180 ECTS. The distribution of course and thesis credits will be determined in the first individual study plan.

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 the research area of Mechanical Engineering will equip the PhD student with the knowledge and skills to fulfill all the degree outcomes. The studies consist of research and thesis work, courses, participation in seminars, attendance at national and international conferences, and collaboration with the surrounding community.

The PhD studies will endow the PhD student with a broad knowledge and understanding of Mechanical Engineering through participation in seminars and courses in the research area, and, in applicable cases, teaching undergraduate courses in Mechanical Engineering. PhD students who teach their own courses must take a mandatory basic course in university pedagogy.

The PhD student will acquire deep knowledge and understanding of Mechanical Engineering and, in particular, his/her research specialisation by actively participating in in-depth courses within his/her field of specialisation, by carrying out independent research work in one or several research projects, and by participating in discussions at seminars and conferences, etc.

The PhD student will develop familiarity with scientific methodology through his/her own research and by attending the faculty's mandatory course in research methodology as well as departmental activities for PhD students.

PhD students in Mechanical Engineering acquire skills and competencies by:

- Independently planning and carrying out his/her research work.
- Conducting research in parallel with course work.
- Taking part in the department's research activities and attending seminars, workshops and guest lectures, etc. during his/her period of study.
- Reporting on results achieved and plans for continued thesis work at least once a year at a seminar.
- Participating in international conferences and presenting his/her own research in order to practise his/her ability to make presentations in front of colleagues from his/her own field of research as well as adjacent, related fields, and to critically review his/her own research as well as the other participants' research.

PhD students in Mechanical Engineering will develop judgement and approach by completing a course in research ethics, participating in seminars within the research area as well as participating in

departmental activities for PhD students. PhD students in Mechanical Engineering will demonstrate their intellectual autonomy by writing and defending a doctoral thesis.

Thesis

The subject of the thesis should be chosen in consultation with the supervisor. To receive a Degree of Licentiate, the student should write a licentiate thesis that will be defended at a public seminar. The thesis should show the student's ability to systematically elucidate a problem using scientific methods.

To receive a Degree of Doctor, the student should write a doctoral thesis that will be defended at a public defence. The thesis should have been submitted for international review either partially or in its entirety. The thesis can be either a monograph or a compilation thesis. In the latter case, the thesis will consist of a short summary of the PhD student's work as well as a number of scientific articles. The number of articles can vary depending on the PhD student's own contributions to the respective work, the scope of the articles and their scientific contributions. Normally a compilation thesis consists of 4-6 articles, of which at least 2 articles have been accepted for publication in referee-reviewed international scientific journals and/or books, plus another 2-4 articles that are of such a standard as to be suitable for international scientific publication. In a compilation thesis, it should be clearly indicated what the PhD student has contributed by him-/herself and what the other co-authors have contributed with.

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.

Courses

Faculty course requirements

Scientific theory, methodology and ethics

All PhD students should complete mandatory courses as decided by the faculty in methodology and ethics, 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).

Accreditation

Master courses may be counted toward the degree in certain cases. At most a third of the course requirements for the degree, that do not form part of the basic or specific eligibility requirements for the specialisation, and that are relevant to the PhD studies may be counted toward the degree. The PhD student should submit an application for accreditation using the appropriate form to the department's administration for PhD studies; the application is then to be approved or rejected by the main supervisor, and a positive decision on accreditation can be made by the Director of PhD Studies at the relevant department. A decision to reject an application for accreditation may

not be made by the Director of PhD Studies at the department, rather, such a decision can only be made by the faculty's Board of PhD Studies.

Specialisations

Fluid and Mechatronic Systems

The subject Fluid and Mechatronic Systems includes modeling, simulation, optimization and condition monitoring for the development, control and diagnostics of mechanical and mechatronic systems. These systems include fluid, mechanical, electrical and sensor subsystems together with integrated software. Research are conducted within the following areas:

- Fluid power systems and components
- Mechantronics
- Aircraft design and aircraft systems
- Modeling, simulation and optimization

Keywords for the research is system efficiency and system dynamics, with strong combination of both theoretical and experimental research. The research is conducted in close cooperation with industry and other research groups. The PhD studies provide knowledge and research experience in:

- Design of efficient components and systems
- System dynamics, modeling, simulation, measurement and control

Specialisation-specific course requirements

The student should have completed a course that aims to provide good knowledge to be able to independently develop and use simulation models in research and development projects, such as:

- Modeling and simulation of technical systems, 7,5 ECTS

Solid Mechanics

Solid Mechanics concerns the mechanics of deformable solid bodies. Its theoretical bases are fundamental mechanical and thermodynamical principles together with constitutive description of material behaviour. Its applied part concerns deformation, stress and life analyses of load-carrying structures and components. Numerical simulations within solid mechanics are mainly based on the Finite Element Method, which constitutes the backbone of modern simulation based design.

Specialisation-specific course requirements

For a Degree of Doctor, 10 ECTS are required in each of the following three areas: continuum mechanics, material models and advanced FEM, where the latter includes treatment of nonlinear problems.

Manufacturing Engineering

The division of Manufacturing Engineering focuses on the following four research areas:

- Development and operation of Flexible Manufacturing Equipment and Intelligent Automation
- Development and operation of Smart Manufacturing Systems
- Product Development and Design for Manufacturing
- Development of Sustainable Manufacturing, including Product Remanufacturing and Product Service Systems (PSS)

The latter area has specific main focus towards sustainable manufacturing, but research in the other three areas can all contribute to the development of sustainable manufacturing.
Manufacturing Engineering is by nature applied and interdisciplinary. It reaches across development, modelling, simulation, programming and physical implementation/realization of equipment and systems. Some research projects are very experimental and/or empirical-based while others are more theory based.

Engineering Materials

The subject Engineering Materials focus on metallic materials but also ceramics, composites and polymers intended for engineering applications. The object of the research is to study the material properties that are of importance for the design, integrity and production of engineering components. This includes theoretical and experimental studies related to the load-bearing capacity of bulk materials as influenced by their basic properties, processing history, microstructures and operating environment. The research can also focus on surface engineering for increased performance and durability, e.g. improving fatigue resistance by controlling residual stresses or applaying high temperature coatings for applications in challenging environments.

Machine Design

The subject Machine Design is focused at the intersection of product development and design engineering. Machine design is rooted in classical applied mechanical engineering, and includes methods and tools for product development, engineering design and analysis of machines and technical systems. The object of the research can be both the development process itself, including methods and tools that support it, and / or the outcome of such a process, i.e. the machine or technical system. This is exemplified in the three areas below where a typical thesis project often comprises elements found in several areas.

- Development Methodology (inc. product development methods, design methods, integrated product and production development, etc.)
- Computer-aided design (CAD, CAE, knowledge-based engineering, design automation, optimization, multi-disciplinary design and optimization, modeling, simulation and visualization of products and production processes, etc.)
- Technical systems (dynamic physical systems, machine elements, materials, additive manufacturing, etc.).

Applied Thermodynamics and Fluid Dynamics

The subject Applied Thermodynamics and Fluid Mechanics is at the intersection of thermodynamics, fluid mechanics, heat transfer and energy technology. The subject is rooted in classical mechanical engineering, and includes methods and tools for analysis and synthesis of flow and heat transfer in and around various objects. The object of the research could be the development of new methods and tools within the area and/or the outcome of using such tools and methods. In the latter case the research normally include design and analysis of products or systems from a fluid or heat transfer perspective. Regardless of the nature of the research, the dissertation project could consider both internal and external flow. Research in Applied Thermodynamics and Fluid Mechanics is of applied nature and are conducted in close collaboration with industry to demonstrate and validate the research results.

Engineering Mechanics

Mechanics is a fundamental subject within engineering, and it is the basis for several applied subjects. It deals with the motion of macroscopic bodies and related phenomena, and spans from studies of fundamental principles to newly developed subjects such as computational mechanics and biomechanics.

Being a subject within engineering science, engineering mechanics focuses on establishing mathematical models that are in accordance with observations and experiments. These models are evaluated by their use in applications, which nowadays is exclusively done by computer based methods, where the finite element method is of crucial importance.

Specialisation-specific course requirements

For a Degree of Doctor, 10 ECTS are required in each of the following three areas, continuum mechanics, classical mechanics and mathematics, where courses in mathematics are adapted to the dissertation work.

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.