Program description for doctoral program

Farkostteknik
Vehicle and Maritime Engineering

1. Program title

The doctoral program is intended as a natural continuation of the educational structures created within the Master’s program Vehicle Engineering, Naval Architecture and Engineering Mechanics (specializing in Technical Acoustics), and the title is Vehicle and Maritime Engineering (Sv Farkostteknik).

2. The subject area

Sweden has a long and successful tradition of cooperating in the field of vehicle and maritime engineering with several large international companies in both the civilian and the military sectors. The industry has a broad range, with development and manufacture of trucks, forestry and agricultural machinery, private cars, buses, ships, boats, tracked vehicles, trains, trams and aircraft. These are fitted with large quantities of equipment and auxiliary systems developed and manufactured by domestic suppliers.

KTH and engineers from KTH constitute part of the base for Swedish vehicle and maritime engineering. KTH has always offered modern education programs with a high quality vehicle engineering focus, reflected among other things in the fact that the graduate engineering degree program Vehicle Engineering (Farkostteknik) at KTH, the only one of its kind in Sweden, was granted the Swedish National Agency for Higher Education’s distinguished award Sweden’s best educational environment in 2008.

In order to meet tomorrow’s demands for reduced environmental load, today’s transport sector is undergoing major changes, and the degree of technological development is high. The need for research is thus increasing both in more traditional fields such as design and propulsion systems and in new multidisciplinary fields that arise as sustainable environment and working environment emerge as design parameters. The aim of the proposed doctoral program is to create, through its composition, a multidisciplinary research environment in which PhD students from different divisions can meet and address applications and issues in common.
The doctoral program *Vehicle and Maritime Engineering* has the aim of gathering doctoral students at KTH whose scientific basis is in subjects related to terrestrial and maritime craft, their development, design, manufacture, use and maintenance as part of a sustainable transport system. At the department of Aeronautical and Vehicle Engineering there are at six subjects for education at research level with research in the field concerned (excluding aeronautical engineering, which has its own doctoral program): *Vehicle Dynamics*, *Rail Vehicle Technology*, *Lightweight Structures*, *Technical Acoustics*, *Marine Systems* and *Vehicle Aerodynamics* with joint guidelines for curriculum and joint subject courses of study.

3. The overarching aim and goal of the doctoral program

The doctoral program is intended for doctoral students from several disciplines. Vehicle-related research, for example, deals with the dynamics, aero- and hydrodynamic properties, design, materials and acoustic properties of craft and vehicles. Together with applied mechanics and mathematics, the research comprises the important areas of systems engineering, ergonomics, ecology, behavioral science, damage prevention and logistics. The aim is to create a multidisciplinary research-level training program of the highest international class. The activities will mainly encompass the divisions which comprise the basis for the Master’s programs in *Vehicle Engineering, Naval Architecture and Engineering Mechanics/Technical Acoustics – Marcus Wallenberg Laboratory (MWL)*). Thus, the expertise of KTH in land- and sea-based vehicle engineering is collected in a doctoral program within the framework of the present organization.

A further aim is to create smoothly functioning collaboration with other divisions and departments at KTH which have activities in *vehicle and marine engineering*. For example, the creation of the doctoral program links in parts of the division for Neuronics to the subject for training at research level and thereby also research on numerical models of the human body for damage prevention, and on driver ergonomics.

The doctoral program broadens the doctoral training environment that has emerged in the Centre for ECO² Vehicle Design by adding seaborne craft and research students working in this subject area. However, the program also aims, in a similar way but on a larger scale, to create a sense of belonging, increased quality and the potential for synergy effects and interaction between the various doctoral groups and the disciplines.

4. Scope of and recruitment to the doctoral program

4.1 Target group

The primary target group are graduates from the master’s programs in *Vehicle Engineering, Naval Architecture* or *Engineering Mechanics* at KTH, or equivalent education from another university. Students with other backgrounds, from mechanical engineering or engineering physics, for example, are allowed, where necessary, to supplement their first degree with courses in Vehicle Engineering in order to achieve the same basic qualifications as the rest of the students on the doctoral program.
Master’s programs at KTH attract many bright students both from Sweden and other countries in Scandinavia and the EU, which means that an excellent recruitment base is already in place at KTH. The vehicle and marine industries are strong in Sweden. This in combination with a unique doctoral program is expected to lead to an increased influx to both master’s and doctoral programs. The long-term aim is to increase the number of applicants to the master’s programs, after which the best students can be offered the opportunity to continue their education at research level in the proposed doctoral program.

Admission to the doctoral program *Vehicle and Maritime Engineering* complies with the national requirements for admission to research studies and with KTH’s requirements for special eligibility in accordance with the admissions regulations for education at research level at KTH, internal regulation no. 3/01.

4.2 Supervisors

At present there are approximately 28 supervisors whose research in *Vehicle and Maritime Engineering* is linked to the doctoral program. About half of them have “docent” status and are therefore qualified to act as main supervisors; see Appendix 2. The existing supervisors group have long experience of education, supervision and research within most of the essential sectors of the subject.

Over the years, the proportion of women doctoral students in Vehicle and Maritime Engineering at KTH has been low. However, the proportion of women senior researchers has increased, which is predicted to lead to more women doctoral students in the field in future.

5. Funding

Research-level training in vehicle and maritime engineering at KTH is conducted almost exclusively through externally-funded research projects. The principal research funding sources are EU’s Framework Programs, government bodies such as the Swedish Armed Forces and the Swedish Transport Administration, industry-specific programs such as *Fordonsteknisk Forskning och Innovation* (FFI) [Vehicle Engineering Research and Innovation] and *Gröna tåget* [literally: the green train], and Swedish industrial companies. Several doctoral students are also funded by the strategic trust foundations Vinnova, the Swedish Energy Agency and the Swedish Research Council. Most of the doctoral students in the doctoral program are expected to be funded in this way even in the future. Coordination of vehicle and maritime engineering at research level provides a good starting point for applying for major framework programs for more basic research in the subject at KTH. Coordination with KTH’s *Transportplattform* and *TRENopS* activities further strengthens the field.

6. Courses
The preconditions for the courses in the program must fulfil KTH’s local regulations for degrees at research level: local degree regulations. By means of the individual study plan, supervisors and doctoral students specify the courses to be followed.

All doctoral students taking a degree in Vehicle and Maritime Engineering should have a basic knowledge of vehicle and maritime engineering. This requirement is automatically fulfilled by KTH students with master’s degrees in Vehicle Engineering, Naval Architecture, Engineering Mechanics or equivalent from other universities. Students with different backgrounds will be given the opportunity to study complementary courses at advanced level, particularly in mathematics, numerical methods and mechanics.

7. Quality assurance procedures

The doctoral program will be developed continuously with the aim of working at the highest international level, on a par with the best universities in the world offering this subject. Doctoral theses in Vehicle and Maritime Engineering at KTH are normally compilation theses consisting of 4-6 papers/documents, the majority of which have usually already been accepted for publication in international journals by the day of the doctoral defense/viva. This procedure automatically involves a careful and impartial review of thesis content, which ensures the quality of the theses.

For quality assurance and development of the doctoral program, a program director is installed for the day-to-day activities and a program board with representatives from the supervisors’ group for strategic development and follow-up of the program. The program board has at least one representative from each division participating in the program to ensure that it is well accepted and that information is spread. One member of the program board is appointed to be program director. It is intended that this role should function on a two-year rotation system to achieve renewal and to ensure the active participation of all of the disciplines in the program.

7.1 Educational environment

The proposed doctoral program builds on the master’s programs Vehicle Engineering, Naval Architecture and Engineering Mechanics, in which most of the supervisors listed in Appendix 2 also work as teachers. In this way, efficient and systematic quality assurance procedures can be carried out. The natural learning environment striven for in the master program courses is also well suited to courses at researcher level.

7.2 Supervisor resources

One of the aims is for all supervisors to have completed a basic course in research supervision, similar to that presently offered by Learning Lab. One supervisor in Appendix 2 is also active as a teacher of supervisor training. Having a starting point in common increases the opportunities for the doctoral program supervisors to share their experience with each other and to organize supervision in a satisfactory way.
7.3 Courses

By creating a joint doctoral program and subjects for education at research level, more doctoral students will be exposed to the research training courses that were previously only visible to smaller divisions/in-house subjects for education at research level. This places higher demands on the organization and running of the courses, which as such is expected to raise the quality. The need for courses on the program is channelled through the program board, which is expected to push forward course development and also quality follow-up.

7.4 The thesis process


Doctoral students are offered the possibility of taking a licentiate degree. A licentiate degree may constitute the final degree. Even if the doctoral degree is the intended final degree, a licentiate degree is sometimes taken first. A possible licentiate thesis is presented at a licentiate seminar. The process leading to a licentiate thesis is similar to that for a doctoral thesis. The licentiate thesis normally comprises a compilation of 2-3 scientific works (published or ready for publication in peer-reviewed international journals) along with an introductory summary of the subject. If the doctoral student goes on to do the doctoral degree after the licenciate degree, the work that constitutes the licentiate thesis is normally re-used in the doctoral degree. The requirements for courses for the licentiate degree are to be found in KTH’s in-house regulations for degrees at research level, in-house degree regulations.

7.5 Infrastructure

There are extensive experimental resources for research and education within the subject area. At the divisions in the program are, among other things, a vehicle dynamics laboratory, a laboratory for acoustic testing, a structural laboratory and resources for manufacturing and testing of polymer composites and structures. Furthermore, with the rebuilding planned for 2011-2012, a new centre for Experimental Mechanics will be created at Teknikringen 8; the centre will include the laboratories for fluid mechanics and strength of materials and can be used for joint research projects. Through XPRES, a laboratory for production-related research including automated manufacture of composite materials is in the planning stage.
8. National and international contact networks

Today, the main centre for the activities within the doctoral program Vehicle and Maritime Engineering is at the School of Engineering Sciences. The doctoral students in the program are employed at (or, in the case of industrial doctoral students, linked to) a division in the same way as at present, which also applies to the teachers and supervisors in the program. The doctoral program has points of contact with ventures such as KTH’s Transportplattform and the calculation platform SeRC, along with KTH’s venture in Experimental Mechanics. Furthermore, the supervisors are connected to different Strategic Research Areas (SRAs), such as TRENop and XPRES.

Some of KTH’s doctoral students within the field have pursued parts of their research studies at a foreign university. Examples of such universities are California Institute of Technology (Caltech), Cambridge University, the University of Southampton, Virginia Tech (Virginia Polytechnic Institute and State University), the University of Illinois at Urbana-Champaign, Universidad Politécnica de Valencia, Universite du Maine, Politecnico di Milano, Technische Universität München (TUM), TU-Eindhoven and the University of Auckland. The KTH research groups have also accepted doctoral students from these universities. See also Appendix 4. It is desirable for all doctoral students to carry out at least one short stay at a foreign university or research organisation at which research is conducted in Vehicle and Maritime Engineering.

Through Global Links in the Centre for ECO² Vehicle Design there are established contacts with international companies, institutes and universities, which are expected to be useful for the doctoral program. Moreover, several of the program supervisors take part in a summer school arranged in cooperation with the Frauenhofer Institute in Darmstadt; doctoral students are also invited there to participate.

The research and training at research level have very strong links to industry and the business world since a large part of the funding comes through EU’s framework programs and national industry-specific programs. Major industrial companies such as Scania CV AB, AB Volvo, Bombardier Transportation, Volvo Car Corporation and SAAB Automobile are also involved in coordination and/or management of research projects within the EU and nationally. Since the doctoral students take part in these projects, this creates networks that lead to good opportunities for future employment in the business on completing their education.
Appendix 1:

Subject study plan

Vehicle and Maritime Engineering

School of Engineering Sciences, KTH

Joint regulations and guidelines for studies at research level at KTH are to be found in the university’s overarching regulatory framework for education at research level. This study plan for education at research level in the subject Vehicle and Maritime Engineering supplements joint regulations and guidelines with the following subject-specific requirements and rules.

Subject description and aim of education

Sweden has a long and successful tradition in the field of vehicle and maritime engineering, in both the civilian and military sectors. The industry spans a wide range, with research, development and manufacture of trucks, forestry and agricultural machinery, passenger cars, buses, ships, boats, tracked vehicles, trains, trams and aircraft. Large quantities of equipment and partial systems are developed and made for these by domestic suppliers.

The doctoral program Vehicle and Maritime Engineering aims to gather doctoral students at KTH with a scientific foundation in subjects concerning land and marine vehicles, their development, design, manufacture, use and maintenance as part of a sustainable transport system. Education at research level is conducted principally in the following six main areas, but other areas may also be possible.

Vehicle Engineering

In the research area of Vehicle Engineering, the mechanical and dynamic properties of terrestrial vehicles are studied. The area comprises modeling and analysis of the behavior of vehicles as well as their dynamic interaction with driver and the surrounding area. The research in the area deals above all with driving properties, comfort of driver, goods and chassis, driver-vehicle interaction, and strategies for steering, braking and propulsion of different types of vehicle on main highways and off-road. In addition, the research deals with modeling and analysis of the properties of various vehicle components, such as (logic) control systems, suspension, autonomous wheel corners, and tyres. Since vehicles are characterized by strongly non-linear properties, the research also deals with methods for analysis and control of non-linear dynamic systems. A common feature of research work in the field is the combination of theoretical analysis, numerical calculation and experimental work.
Vehicle Aerodynamics

Vehicle aerodynamics deals with the study of the air flow round terrestrial vehicles and accompanying loads and moments. The most important difference between vehicle aerodynamics and aircraft aerodynamics is that vehicle aerodynamics needs to factor in the effect of the ground. Furthermore, the flow is three-dimensional in character, which means that the two-dimensional approximations that can be used in aerodynamics are rarely applicable to terrestrial vehicles. The commonest issue in vehicle aerodynamics is reduction of air resistance, but in recent years the significance of transient aerodynamics, for example, transient loads from wind gusts, has received growing interest. The focus of research at KTH is on using large-scale calculations in which turbulence is modeled with computationally efficient but thorough methods to study transient events and on using different mode decomposition methods to analyze wake structures. Our ambition is to conduct vehicle aerodynamic research using a multidisciplinary approach, for instance by cooperating with vehicle dynamics and technical acoustics.

Rail Vehicle Technology

The research field of rail vehicles comprises the scientific basis for design, operation and maintenance of different types of rail vehicles and trains. It also includes interaction with rail traffic infrastructure. The principal focus of study is on the way in which rail vehicles interact mechanically with rail overhead lines (for electrical operation). In the former case, phenomena such as risk of derailment, ride stability, wheel-rail wear and ride comfort are studied. In the latter case, the contact forces power-takeoff-overhead wire and accompanying movements are analyzed. In both cases, higher speeds (passenger traffic) entail ever greater technical challenges and for the rail, one trend is towards higher axle loads (goods traffic). The research area also encompasses studies of rail traffic energy consumption and accompanying environmental impact. The research is consistently conducted on both theoretical and experimental bases and in close cooperation with companies and authorities in the field.

Lightweight Structures

Lightweight structures is a generic and application-specific research area based on materials technology, structural mechanics, process engineering and design. The scientific goal is to develop understanding of specific phenomena in these areas and in the interface between them. Above all, studies focus on new unconventional materials and structures and their use in applications where low weight is a requirement. Particular topics of study are polymer fiber composites, bio-based materials, foam and structural topologies, that is, materials that are all anisotropic and inhomogeneous. In this case, performance is regarded as a general concept referring both to functionality and use, expressed in terms of energy consumption, environmental impact and life-cycle cost.
Naval Architecture

Research in this field as conducted at KTH is characterized by an interdisciplinary approach to issues around ships and other marine systems along with their interaction with both water and the atmosphere and their impact on the surroundings in a broader sense. The work is carried out from a systems perspective, mainly for high-speed craft in waves, issues of dynamic stability for modern merchant ships, alternative propulsion systems and unmanned underwater systems. This involves working with analysis and modeling of performance, wave environment, loads, structure response and seakeeping, and also includes studies of operability, working environment and system monitoring. A strong link is emphasized between analysis and experiment.

Technical Acoustics

Technical Acoustics, or the understanding of how sound and vibrations are generated and propagated in solid and fluid media, is an important part of technical mechanics with applications ranging from aeronautical, vehicle and marine engineering to energy technology and medicine. Important research areas concern sound generation and sound propagation in flow systems and in complex materials with the aim of creating better models and enabling more efficient technical solutions. Trends in the research are moving towards combining advanced numerical and experimental methods and towards increased interdisciplinary collaboration. The field will have considerable significance in the development of sustainable solutions for future transport systems.

Objective/Learning Outcomes

The objective is for the students to be well prepared, after their research training, for their future independent roles in the community, both nationally and internationally. After completing the training, the student will be able to:

• describe and explain theories and empirical results in his/her field,
• formulate concrete research questions within the subject area,
• use scientific methods and develop new knowledge through scientific studies,
• critically analyze and evaluate applied methods and results from his/her own scientific studies and those of others,
• present and discuss research results in the scientific community,
• present research in a pedagogical manner outside the scientific community in educational contexts,
• assess ethical aspects of research in the subject area and act accordingly,
• identify needs for new research,
• participate in interdisciplinary collaborations in the problem area,
• analyze the role of research in societal development.

Design of the education
Education at researcher level consists of a course part and a thesis part, with internal credit scales defined by KTH’s in-house degree regulations for degrees at doctoral level.

According to the Swedish National Agency for Higher Education Degree Ordinance (1993:100) 6 chapter 31, the education is to be carried out under the guidance of two supervisors, a main supervisor and one or more deputy supervisors. The education must follow an approved individual study plan which is approved by the person responsible for research training at the School. The individual study plan must be adapted to the prior knowledge of the student and to the specialization of the thesis. Review of the individual study plan must be carried out by the doctoral student in consultation with the main supervisor at least once a year.

The student is assumed to pursue his/her research with the objective of subsequently writing technical documents which will later form the basis of the thesis. These reports are sent for publication to international journals within the relevant field with peer-reviewing. One or more reports may also be published as conference proceedings, in which case the student is also assumed to present his/her work orally at an international technology conference.

Courses

The course part of the research studies must consist predominantly of technological courses. The courses are selected in consultation with a supervisor in accordance with the needs regarded as existing for the actual research work in order to enable the student to acquire both depth and breadth of knowledge and skills in the subject area. Thus, some courses will be necessary for the accomplishment of the research task while others are chosen to provide greater breadth in the field. In certain cases, after agreement with the main supervisor, courses may be included from earlier education. The conditions for the course part are stipulated in KTH’s local degree regulations for degrees at research level. A list of the research skills courses of the program, advanced courses and other courses are to be found in Appendix 3.

Thesis

The thesis is a compulsory part of the training at research level. The thesis may be what is known as a compilation thesis or a monograph. Normally, a thesis in Vehicle and Maritime Engineering is of the compilation type. The thesis is written in English.

Licentiate thesis

A thesis for the Licentiate degree must contain new scientific knowledge or a new application of existing scientific knowledge. The latter means that the application is carried out in a new field and is developed through theoretical and/or experimental
research work. The thesis must also contain an overview of previous research in the chosen research field. Regardless of whether the licentiate thesis is presented as a monograph or a compilation of scientific articles, it must normally be of such quality that it is judged to correspond to two articles that can be published in international journals or presented at international conferences.

**Doctoral thesis**

A thesis for the degree of doctor must contain new scientific knowledge or a new application of existing scientific knowledge. The latter means that the application is carried out in a new field and is developed through theoretical and/or experimental research work. The thesis must also contain an overview of earlier research in the chosen research field. Regardless of whether the doctoral thesis is presented as a monograph or a compilation of scientific articles, it must normally be of such quality and originality that it is judged able to constitute the basis for at least four articles that can be published in peer-reviewed international journals. Published and accepted articles are judged equally, as are conference articles which have undergone peer review. If unpublished articles are appended to the thesis, the main supervisor must judge whether they fulfill the main requirement.

**Eligibility and selection**

**Basic and special eligibility, and prior knowledge**

Admission to training at research level in *Vehicle and Maritime Engineering* follows the basic national requirements for admission to research studies and KTH’s requirements for special eligibility according to the admissions regulations for education at research level at KTH.

Students applying for the training at research level in *Vehicle and Maritime Engineering* are selected according to the knowledge profile demanded for the specific doctoral project. Students who have shown great interest and aptitude for the subject are particularly considered at admission. Further important qualities are personal ability in communication and initiative. The assessment of these qualities is made by the intended supervisor. Good knowledge of English (both spoken and written) is a requirement and in certain cases, Swedish is also required. The ability to work experimentally may be an explicit demand.

Selection is made among the applicants based on the knowledge profile sought for the specific doctoral project as formulated in conjunction with the advertisement of vacant study places. Particularly interesting in this assessment are previous study results in courses of an advanced nature taken as part of a first academic degree or independently conducted scientific work. Apart from eligibility, the basis for the selection is degree of maturity and ability to make independent judgments and to carry out critical analyses. For admission to training in the doctoral program in *Vehicle and Maritime Engineering*, it is furthermore required that:
• supervisors are available,
• funding can be secured,
• a place can be provided in a research group, and
• access is available to other resources and infrastructure necessary for the education.

Decisions on admission to and selection of applicants for the education at research level are made by the head of the School, or by someone delegated by the head of the School, in consultation with the main supervisor.

**Degrees and examinations in the education**

Courses at research level must include an oral or written test of knowledge. The design of the examination must in individual cases be such that the examiner can be satisfied that the student has fulfilled the learning outcomes of the course. Decisions to include courses taken prior to admission to the education at research level are taken in accordance with the in-house regulations and guidelines specified for doctoral degrees and for licentiate degrees in KTH's overarching regulatory framework.
### Appendix 2: Supervisor capacity

**Name, School/Unit**

Zuheir Barsoum, SCI/Lightweight Structures  
Mats Berg*, SCI/Rail Vehicles  
Hans Boden*, SCI/Technical Acoustics  
Susann Boij, SCI/ Technical Acoustics  
Karl Bolin, SCI/ Technical Acoustics  
Magnus Burman, SCI/ Lightweight Structures  
Krister Dovström, SCI/ Technical Acoustics  
Lars Druge, SCI/Vehicle Dynamics  
Gunilla Efraimsson*, SCI/ Vehicle Aerodynamics  
Leping Feng*, SCI/ Technical Acoustics  
Svante Finnvelden*, SCI/ Technical Acoustics  
Karl Garme, SCI/Marina System  
Ragnar Glav, Scania/ Technical Acoustics  
Peter Göransson*, SCI/ Technical Acoustics  
Peter Halldin, STH/Neuronics  
Stefan Hallström, SCI/ Lightweight Structures  
Nils-Erik Hörlin, SCI/ Technical Acoustics  
Jenny Jerrelind, SCI/ Vehicle Dynamics  
Ilkka Karasalo*, SCI/ Technical Acoustics  
Leif Kari*, SCI/ Technical Acoustics  
Svein Kleiven, STH/Neuronics  
Jakob Kuttenkeuler*, SCI/Marina System  
Anders Rosen, SCI/Marine Systems  
Annika Stensson Trigell*, SCI/ Vehicle Dynamics  
Sebastian Stichel*, SCI/ Rail Vehicles  
Per Wennhage, SCI/ Lightweight Structures  
Dan Zenkert*, SCI/ Lightweight Structures  
Mats Åbom*, SCI/ Technical Acoustics  
Malin Åkermo, SCI/ Lightweight Structures

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Table 1: Supervisors in the doctoral program Vehicle and Maritime Engineering  
* main supervisor
Appendix 3: List of courses

Research skills courses

Doctoral students are given the opportunity to develop general skills in communication and scientific theory. Analysis and communication of risks is also a skill which is very relevant to the work in Vehicle and Maritime Engineering.

<table>
<thead>
<tr>
<th>Course code</th>
<th>Name</th>
<th>ECTS credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AK3024</td>
<td>Introduction to scientific theory and research methodology</td>
<td>4.5</td>
</tr>
<tr>
<td>1N5105</td>
<td>Presentation of popular science</td>
<td>3</td>
</tr>
<tr>
<td>1N5110</td>
<td>Advanced course in presentation of popular science</td>
<td>4.5</td>
</tr>
<tr>
<td>1N5125</td>
<td>Risk philosophy</td>
<td>7.5</td>
</tr>
<tr>
<td>1N5126</td>
<td>Risk communication – theory and practice</td>
<td>7.5</td>
</tr>
<tr>
<td>1N5504</td>
<td>Communicating research</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Advanced courses

A considerable number of advanced courses are offered to doctoral students in Vehicle and Maritime Engineering. A large proportion of these courses are given regularly in organised form with lectures and seminars.

<table>
<thead>
<tr>
<th>Course code</th>
<th>Name</th>
<th>ECTS credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD315V</td>
<td>Vehicle Acoustics Focusing on Combustion-related Sound</td>
<td>5</td>
</tr>
<tr>
<td>5B5106</td>
<td>Theoretical Acoustics</td>
<td>7.5-15</td>
</tr>
<tr>
<td>4B5108</td>
<td>Structure-borne Sound</td>
<td>6-12</td>
</tr>
<tr>
<td>4B5104</td>
<td>Aero-acoustics</td>
<td>6-12</td>
</tr>
<tr>
<td>4B5109</td>
<td>Statistical Energy Analysis</td>
<td>6</td>
</tr>
<tr>
<td>4B5113</td>
<td>Non-linear Vibrations</td>
<td>7.5</td>
</tr>
<tr>
<td>4B5110</td>
<td>Fluid Structure Interaction</td>
<td>6-12</td>
</tr>
<tr>
<td>4B5103</td>
<td>Signal Analysis</td>
<td></td>
</tr>
<tr>
<td>4B5112</td>
<td>Measurements and Analysis for Sound and Vibration</td>
<td></td>
</tr>
<tr>
<td>SD3601</td>
<td>Computational Aero-acoustics</td>
<td></td>
</tr>
<tr>
<td>4B5313</td>
<td>Rail Vehicle Dynamics</td>
<td>7.5</td>
</tr>
<tr>
<td>4B5307</td>
<td>Wheel-rail Contact</td>
<td>9</td>
</tr>
<tr>
<td>4B5303</td>
<td>Railway Systems and Rail Vehicles</td>
<td>9</td>
</tr>
<tr>
<td>4B5400</td>
<td>Vehicle Dynamics in Several Degrees of Freedom</td>
<td>6</td>
</tr>
<tr>
<td>4B5401</td>
<td>Vehicle Dynamics</td>
<td>9</td>
</tr>
<tr>
<td>4B5402</td>
<td>Vehicle Engineering</td>
<td>6</td>
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<tr>
<td>SD3411</td>
<td>Finite Element Analysis</td>
<td>6-12</td>
</tr>
<tr>
<td>SD3413</td>
<td>Composite Mechanics</td>
<td>6-12</td>
</tr>
<tr>
<td>SD3415</td>
<td>Analysis of Processes for Manufacturing of Composites</td>
<td>6-12</td>
</tr>
<tr>
<td>SD3416</td>
<td>Analysis and Dimensioning of Sandwich Structures</td>
<td>6-12</td>
</tr>
<tr>
<td>SD3422</td>
<td>Properties of Cellular Materials</td>
<td>6-12</td>
</tr>
<tr>
<td>SD3705</td>
<td>High-Speed Craft</td>
<td></td>
</tr>
<tr>
<td>SD3601</td>
<td>Computational Aero-acoustics</td>
<td>4-8</td>
</tr>
<tr>
<td>6L5006</td>
<td>Applied Dynamic Finite Element Analysis</td>
<td>6</td>
</tr>
<tr>
<td>HN3002</td>
<td>Load ergonomics – theory, methods and intervention</td>
<td>7.5</td>
</tr>
</tbody>
</table>
Other courses

Research students conducting some form of teaching within the framework of their employment or as departmental duties must complete teacher training. Course credits for such training may be included in the degree.

<table>
<thead>
<tr>
<th>Course code</th>
<th>Name</th>
<th>ECTS credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>LH200V</td>
<td>Basic Communication and Teaching</td>
<td>3</td>
</tr>
<tr>
<td>LH201V</td>
<td>Learning and Teaching</td>
<td>7.5</td>
</tr>
<tr>
<td>SD3420</td>
<td>Literature Studies</td>
<td>4-8</td>
</tr>
<tr>
<td>SD3421</td>
<td>Design and Construction Assignments</td>
<td>4-12</td>
</tr>
</tbody>
</table>
Appendix 4: National and international networks

See point 8, which exemplifies the doctoral program network.

Agreements concerning double degrees, at KTH and foreign universities, exist for individual students. For Technical Acoustics, there are two agreements, with CNAM, Paris, and with Katholieke Universiteit Leuven. It is likely that several such agreements will be drawn up in order to promote cooperation within various European networks, such as Marie-Curie ITN.

In the Centre for ECO²Vehicle Design, KTH Transport Platform, TRENop, XPRES, and an association of the Swedish marine industry, the entire Swedish vehicle and maritime industry is represented. Through participation in several EU projects, the list is extended to include a large number of international players. Moreover, there are a large number of collaborations in acoustic applications with companies and universities.