Biological physics

Study plan for third-cycle subject

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

Subject title

Biological physics (Biologisk fysik)

Subject description and programme outcomes

Scientific field

The third level education on the subject Biological Physics is highly multi-disciplinary and includes scientific studies in physics on the boundaries between biology, chemistry and medicine. The aim of the third level education in Biological Physics is to provide deeper knowledge in some of the main areas of Physics, and further in-depth knowledge in one of the fields in Biological Physics that are represented within the Doctoral Program in Physics at KTH.

Due to the highly interdisciplinary nature of research conducted within the Doctoral Program in Physics, the third level education includes the subjects Physics and Biological Physics. For students in the field of Physics, the doctoral education in the subject Physics is recommended.

The goal is that the students after completing the doctoral education will be well prepared for their future roles in society, both nationally and internationally.

Furthermore, the goal of the doctoral level education is that the Ph.D. students will become independent and well-educated scientists and after completion of the education will be able to:

- describe and explain theories and empirical results within the area in question
- formulate specific research questions within the area in question
- use scientific methods and develop new knowledge through their own scientific studies
- produce critical analyses and evaluate methods applied and results from their own and others' scientific studies
- present and discuss research results in the scientific community
- present research in a pedagogical manner outside the scientific community and in an educational context
- assess ethical aspects of research within the area in question and act on that basis, and
• identify needs for new knowledge and have the knowledge to initiate and lead research.

Third-cycle studies must also endeavor to ensure that doctoral students will have the ability, after completing the studies, to:

• take part in multi-disciplinary scientific cooperation within the area in question, and
• analyze the role of research in the development of society.

Description of possible specialisation

The subject has no specialisations.

Specification of how the programme outcomes are to be achieved

Current research

Biological physics is an interdisciplinary research area, where activity is based on close collaboration between physicists, biologists, bio-technicians, chemists and medical professionals. The intention is to develop and use physical methods and models for understanding biological phenomena and processes in particular on the molecular and cellular level, or the development of physical methods and technologies within healthcare and medical research. The activities are in part fundamental research, but also aim to develop procedures, including diagnostics and drug development. The different research areas represented in biological physics is:

Computational Biological Physics

The area includes the study of biological problems with the analytical and computational methods from physics, as well as physical problems of immediate or potential biological interest. The research area differs from bioinformatics as emphasis is placed in the physical issues and/or dynamic models.

Biomedical and X-Ray Physics

Mainly experimental research in applied physics is carried out, aimed towards the development of relevant biomedical instrumentation. Development of new types of X-ray sources and X-ray optics and their use for microscopy, medical imaging, bio-analysis as well as materials physics. New optical and acoustic methods for biomedical applications, such as ultrasound-tweezers for cell biology and visual optics for improved peripheral vision.

Medical imaging

Research on technical and physical methods in healthcare and medical research in close collaboration between physicians, physicists and engineers. The subject is highly multidisciplinary and results from almost all physical and technical disciplines used. For successful research, a good understanding of the human biology and physiology, the physicians techniques and methods, and physical principles is required.

Biomolecular Physics
Research into the use and development of biophysical methods to study the function of biomolecules based on their occurrence, structure, dynamics and interactions. The focus is on development of fluorescence-based methods for single molecule- and fluctuation-spectroscopy and its applications for fundamental biomolecular studies, where the possibility of being able to study single molecules can be utilized, as well as for applications in ultra-sensitive medical diagnostic and screening procedures.

**Cell Physics**

Experimental and theoretical studies on the functions of biological cells, at the boundary between biology and physics. In particular technology development of microscopic methods and techniques, with a focus on studies of individual proteins and their integrated impact on the cell's interaction with the environment. Main themes of research are cellular transport mechanisms and signaling pathways.

**Theoretical Biological Physics**

Theoretical Biological Physics is the application of theoretical methods from physics to describe biological processes at the molecular level, with emphasis especially from statistical mechanics. The research involves analysis of scientific problems and the development of mathematical models within molecular and cell biology.

**Programme structure**

The education on the doctoral level consists of course-part and a thesis-part and can be completed with a doctorate or licentiate degree. Doctoral degree is equivalent to four years of study and a licentiate degree two years of study. During the education the student is supervised by one main supervisor and one or more assistant supervisors. The main supervisor is appointed in connection with admission and is, together with the student, responsible for that course studies and the dissertation work is progressing as planned. In connection with the admission an individual study plan has to be submitted according to the internal regulations and guidelines at KTH. The individual plan must be updated annually.

The coursework may consist of lectures, literature studies, problem-solving, and active participation in seminars, and must include at least 30 credits for a licentiate degree and 60 credits for a doctorate degree.

During the education, students are encouraged to actively participate in research seminars within the Doctoral Program in Physics. For international experience the doctoral student should, if given the opportunity, relocate part of their research studies abroad through international research collaboration.

If the student teach or perform other departmental duties, the licentiate degree and the doctorate degree may in normal circumstances take up to 2.5 years or 5 years, respectively. When teaching at the first- or second-level, the students must have completed introductory courses in university pedagogy, or acquired corresponding knowledge.

**Compulsory and recommended courses**

The choice of courses to be included in the education should be based on student's prior knowledge, and the knowledge and skills considered necessary for the realization of the theses and dissertation work, and in order to achieve the program objectives.
Due to the range of research topics within the program, the inter- and multi-disciplinary nature of research activities, and that the third level education is highly individualized depending on the student's knowledge and required skills, there are no mandatory courses within the program. Consequently, within the Doctoral Program in Physics, the student's and supervisor's planning, design and monitoring of the individual study plan is of central importance for the education.

A large number of courses are offered within the Doctoral Program in Physics, but the student may, in consultation with their main supervisor also select other courses within or outside KTH in order to acquire the knowledge considered necessary for completing the thesis work and in order to reach the goals of the program.

The following courses are a selection of the courses taught within the program and can be seen as representative for Biological Physics within the Doctoral Program in Physics.

**Recommended in-depth courses**

- FSK3500 Physics of Biomedical Microscopy 6.0 hp.
- FSH3212 Photon Counting Systems in Medicine 12.0 hp.
- FSI3420 Membranes and Soft Matter 7.5 hp.
- SK2800 Laser Spectroscopy 8.0 hp.
- FSK3410 Laser Physics 10.5 hp.
- FSK3511 Cellular Biophysics II 6.0 hp.
- SH2312 Medical 3D-imaging, Supplementary Course 1 3.0 hp.
- SK2521 Fluorescence Spectroscopy for Biomolecular Studies 6.0 hp.
- SH2313 Medical 3D-imaging, Supplementary Course 2 3.0 hp.
- FSK3501 Physics of Biomedical Microscopy, Extended Course 7.5 hp.
- DD2398 Quantitative Systems Biology 7.5 hp.
- FSK3400 Laser Physics 7.5 hp.
- FSK3520 Experimental Methods in Molecular Biophysics 8.0 hp.
- FSI3430 Protein Physics 7.5 hp.

**Recommended research proficiency courses**

- FSK3740 Introduction to Scanning Probe Microscopy 6.0 hp.
- SH2007 Research Methodology in Physics 3.0 hp.
- FSK3330 Optical Design 6.0 hp.

**Recommended broad-based courses**

- FSK3540 Physics and Applications of Ultrasound 6.0 hp.
- FSH3211 Image Quality in Medicine 12.0 hp.
- FSK3531 Biomedicine for Engineers 12.0 hp.
- FSK3550 X-ray Physics and Applications 6.0 hp.
- FSK3510 Cellular Biophysics I 8.0 hp.

**Other recommended courses**

- LH200V Basic Communication and Teaching 3.0 hp.
- FSI3000 History of Physics and Epistemology 5.0 hp.
Thesis

The aim of the education during the thesis-part is for the student to develop an ability to make independent contributions to research, as well as a capability for scientific collaboration, within as well as outside their own subject of study.

The thesis should include new research results which the student has prepared independently or in collaboration with others. The main scientific results should meet the quality requirements for publication in internationally recognized journals with peer review. The thesis is typically written as a collection of scientific articles with a specific written summary, a so-called compilation thesis. During the thesis work the student should therefore strive for international publication of the achieved research results. A licentiate thesis should include scientific results corresponding to at least two for the research area representative articles publishable in internationally recognized journals with peer review, and include research results that have been presented at at least one international conference. A doctorate thesis should include scientific results corresponding to at least four for the research area representative articles publishable in internationally recognized journals with peer review, and include research results that have been presented at at least two international conferences. The doctoral thesis and licentiate thesis should be written in English.

This thesis work is a mandatory part of the doctoral education to be defended at a public defense in accordance with internal regulations and guidelines that are specified for doctoral and licentiate degrees at KTH.

Entry requirements and selection

General and special admission requirements and prior knowledge

The general entry requirements follow the regulations specified by the Higher Education Ordinance, and local rules and regulations at KTH.

For special entry requirements to third level education within the Doctoral Program in Physics, the applicant must have:

1. fulfilled the general entry requirements within the area of Biology, Biomedicine or Chemistry, or
2. obtained a medical degree, or
3. otherwise acquired largely equivalent knowledge, either in or outside Sweden, within areas appropriate for the research area.

Doctoral students are expected to be able to read and write scientific English and to be able to speak English without difficulty. Higher eligibility requirements may apply, depending on the type of research and specialization, and will be outlined in the announcement of the vacant position.

Selection rules and procedures

Selection of applicants is based on the skills profile that is being sought for in the specific projects described in the announcement of the vacant position. Of great interest in the assessment are previous results from advanced courses at second-level, or independently conducted scientific work. Besides
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For final admission to the Doctoral Program in Physics it is also required that:

- a supervisor is available and can be appointed to the student,
- there is funding for the student,
- an opening can be prepared within a research group, and
- equipment and infrastructure required for the completion education is available.

The programme’s degrees and examinations

Degree of Licentiate and Degree of Doctor (PhD)

The programme’s examinations

The courses at the doctoral level should include an oral examination or written knowledge test. The design of the examination should in special cases be such that the examiner can be satisfied that the student meets the learning outcomes. Decisions regarding accreditation of courses taken prior to admission to doctoral level education are made in accordance with internal regulations and guidelines that are specified for doctorate and licentiate degree at KTH.