Master program in Computational Physics, Mathematics and Life Science

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May 6 2015

Master program in Computational Physics, Mathematics and Life Science (CPMLS)

We would like to propose a new Master of Science program at the School of Mathematics and Natural Sciences of the University of Oslo. This program is called **Computational Physics, Mathematics and Life Science**, with acronym **CPMLS**.
The program is a collaboration between four departments and four main disciplines,

- Department of Biosciences
- Department of Informatics
- Department of Mathematics
- Department of Physics

The Department of Physics will be the organizational unit where the program resides. The program is based on the highly successful Computational Physics direction under the present Master program in physics at the University of Oslo.
The program is multidisciplinary and all students who have

Overarching aims and strategic perspective

Numerical simulations of various systems in science are central to our basic understanding of nature. The increase in computational power, improved algorithms for solving problems in science as well as access to high-performance facilities, allows researchers nowadays to study complicated systems across many length and energy scales. Applications span from studying quantum physical systems in nanotechnology and the characteristics of new materials or subamotic physics at its smallest length scale, to simulating cancer treatment, how the brain works, modeling climate and weather, oil flow through various rock strata, simulating natural disasters, semi-conductor technology, simulating quantum computers, financial engineering etc, just to mention a few possible directions of research and study for a thesis.

Overarching aims and strategic perspective

Simulations that couple multiple physical phenomena are as old as simulations themselves. However, such simulations deserve fresh assessment, in light of steadily increasing computational capability and greater aspirations for simulation in domains of scientific prediction, engineering design, and policy making.
Of particular importance for technological advances in fields as varied as materials science and life science, or subatomic physics, is the capability to study and model physical phenomena across scales, what is normally called multiscale science. Today's problems, unlike traditional science and engineering, do not involve physical processes covered by the single traditional discipline of say physics or the associated mathematics. Complex and real systems encountered in virtually all applications of interest involve many distinct physical processes. The issue of coupling models of different events at different scales (length or energy) and governed by different physical laws is largely wide open and represents an enormously challenging area for future research and technological advances. Tackling problems from multiscale science requires multi

Overarching aims and strategic perspective

This program aims at preparing the next generation of scientists enabling them to tackle the many challenges posed by understanding physical processes across many scales.
Since this requires cooperations between many disciplines, a program which involves several departments is needed.
Furthermore, this program aims at developing a master's program in Computational Life Science in order to meet the coming needs of the scientific community. If successful, it will position the University of Oslo as the leading institution nationally in computational life science and computational science in general.
In addition to collaborations across disciplines at the University of Oslo, this program will also link to the Norwegian University of Life Sciences in order to build a strong basis in computational science via collaborations with other universities.

Overarching aims and strategic perspective

The initiative has its roots in the highly successful direction called Computational Physics under the Master program in Physics at the University of Oslo.

This program has educated almost 60 Master of Science students during the last ten years. Over 50% of these students have continued with PhD studies in Physics, Chemistry, Mathematics and now recently Biology connected with the CINPLA projects.

Seen the popularity and versatility of the Computational Physics program and the abovementioned coming needs for multi-disciplinarity in science, we would thus like to propose a new Master of Science program which includes computational physics, computational mathematics and computational life science. As stated above, it will be a collaboration between four departments, with the admistrative responsibility residing with the department of Physics.

This program will also take a leading responsibility in further developments of the highly successful Computing in Science Education initiative at UiO.

Learning outcomes

Students of this program learn to use the computer as a laboratory for solving problems in science and engineering. The program offers exciting thesis projects from several disciplines; biology and life science, chemistry, mathematics, informatics, physics, geophysics, mechanics, geology – you choose your field according to your own interests.

In addition to this, a Master's degree from this program gives you a methodical training in planning and carrying out large research projects, often together with other students and university teachers. Projects usually emphasise finding practical solutions, developing an intuitive understanding of the science and the scientific methods needed to solve complicated problems, use of many tools, and not least developing your own creativity and independent thinking. Your thesis work is a scientific project and during your work you will learn to plan and conduct large-scale projects logically and efficiently, as well as to report and present results in a professional manner.

Structure and courses

The table here is an example of a suggested path for a Master of Science project, with course work the first year and thesis work the last year.

4th semester	Master thesis	Master Thesis	Master Thesis
3rd semester	Master thesis	Master Thesis	Master Thesis
2nd semester	Master courses	Master courses	Master courses
1st semester	Master courses	Master courses	Master courses
	10 ECTS	10 ECTS	10 ECTS

The program is very flexible in its structure and students may opt for starting with their thesis work from the first semester and scatter the respective course load across all four semesters. Depending on interests and specializations, there are many courses on computational science which can make up the required curriculum of course work. Furthermore, courses may be broken up in smaller modules, avoding thereby the limitation of 10 ECTS per course only. Some of these courses are listed below.

Structure

Here follows a list of suggested courses that students may include in their required course load.

- FYS4150 Computational Physics I
- FYS4411 Computational Physics II
- FYS4460 Computational Physics III
- INF5620 Numerical Methods for Partial Differential Equations
- FYS388 Computational Neuroscience
- STK4520 Laboratory for Finance and Insurance Mathematics
- STK4021 Applied Bayesian Analysis and Numerical Methods
- MAT-INF4130 Numerical Linear Algebra
- MAT-INF4110 Mathematical Optimization
- ECON4240 Equilibrium, welfare and information
- MEK4470 Computational Fluid Mechanics
- MEK4250 Finite Element Methods in Computational Mechanics

Admission

The following higher education entrance qualifications are needed

- A completed bachelor's degree (undergraduate) comparable to a Norwegian bachelor's degree in one of the following disciplines
  1. Biology, molecular biology, biochemistry or any life science degree
  2. Physics, astrophysics, astronomy, geophysics and meteorology
  3. Mathematics, mechanics, statistics and computational mathematics
  4. Computer science and electronics
  5. Chemistry
  6. Materials Science and nanotechnology
  7. Any undergraduate degree in engineering
  8. Mathematical finance and economy
- The language of instruction is English. An internationally recognised English language proficiency test is required.

Study abroad and international collaborators

As a student at the University of Oslo you may choose to take part of your degree at a university abroad.
Students in this program have a number of interesting international exchange possibilities. The involved researchers have extensive collaborations with other researchers worldwide. These exchange possibility range from top universities in the USA, Asia and Europe as well as leading National Laboratories in the USA. Students may select to take all or part of their degree abroad.

Career prospects

Candidates who are capable of modeling and understanding complicated systems in natural science, are in short supply in society. The methods and approaches to scientific problems you learn when working on your thesis project are very similar to the methods you will use in later stages of your career. To handle large numerical projects demands structured thinking and good analytical skills and a thorough understanding of the problems to be solved. This makes you unique on the labor market.

Career opportunities are many, from research institutes, universities and university colleges and a multitude number of companies. Examples like IBM, Hydro, Statoil and Telenor. The program gives you an excellent background for further studies, with a PhD as an eventual goal. One of two students with a Master of Science from this program choose to continue with PhD studies.

The program has also a strong international element which allows you gain important experiences from international collaborations in science, with the opportunity to spend parts of the time spent on your thesis work at research institutions abroad.