Master program in Computational Science at the University of Oslo

Program Structure

Planned start: Fall 2018

Thesis directions

The program has the following study directions/options

- Computational Science: Applied Mathematics and Risk Analysis
- Computational Science: Astrophysics
- Computational Science: Bioinformatics
- Computational Science: Bioscience
- Computational Science: Chemistry
- Computational Science: Geoscience
- Computational Science: Imaging and Biomedical Computing
- Computational Science: Materials science
- Computational Science: Mechanics
- Computational Science: Physics

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.

	10 ECTS	10 ECTS	10 ECTS
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

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.

Presently available courses at UiO

The University of Oslo offers the following courses in Computational Science, split here according to main disciplines/fields. All Master of Science courses will require a revision of their descriptions. This revision will include the addition of professional competences. In this process, one could think of reshaping some of the existing courses below and rename them in order to align them closely with the present program.

Mathematics and Computer Science, including Mechanics and Statistics
MAT-INF3360 Introduction to Partial Differential Equations
MAT-INF4110 Mathematical Optimization
MAT-INF4130 Numerical Linear Algebra
MAT-INF4140 Numerical Analysis
MAT-INF4160 Topics in Geometric Modelling
MAT-INF4300 Partial differential equations and Sobolev spaces I
MAT-INF4310 Partial differential equations and Sobolev spaces II
MEK4250 Finite Element Methods in Computational Mechanics
MEK4470 Computational Fluid Mechanics
INF4300 Digital image analysis
INF4331 Problem solving with high level languages
INF4820 Algorithms for artificial intelligence and natural language processing
INF5620 Numerical Methods for Partial Differential Equations
INF5631 Project on Numerical Methods for Partial Differential Equations
INF5670 Numerical methods for Navier-Stokes equations
INF5840 Computability theory
INF5850 Machine Learning for Image Analysis
STK4021 Applied Bayesian Analysis and Numerical Methods
STK4520 Laboratory for Finance and Insurance Mathematics

Physical Sciences: Physics, Astrophysics, Geosciences and Chemistry
FYS4150 Computational Physics I
FYS4411 Computational Physics II
FYS4460 Computational Physics III
GEO4310 Stochastic methods in hydrology
GEO4510 Atmosphere and Oceans on Computers: Fundamentals
GEO4450 Geophysical Fluid Dynamics
AST5210 Stellar Atmospheres I
AST9110 Numerical Modeling

Bioscience including Bioinformatics
INF4490 Biologically inspired computing
INF4350 Introductory Course in Bioinformatics
INF-BIO5121 High Throughput Sequencing technologies and bioinformatics analysis
INF5380 High-performance computing in bioinformatics
INF5560 Computational Physiology
MBV-INF4410 Bioinformatics for Molecular Biology
MBV3070 Bioinformatics

New Courses

In order to build a common study program and identity as a Computational Science student, the students will have to choose two out of three compulsory courses that aim at providing topics of common and broad interest. Both courses have a workload of 10 ECTS each. These three **new courses** (final label to be determined, only tentative name here) are

- **CS-MATH1**: *Data analysis and machine learning*, 10 ECTS)
    1. Monte Carlo methods and statistical data analysis
    2. Optimization of data and handling of large data sets
    3. Machine learning, including genetic algorithms and neural networks
- **CS-MATH2**: *Mathematical modeling in Science*, 10 ECTS)
    1. Central algorithms in mathematics applied to various fields in the Sciences
    2. Applications to physical systems
- **CS-INF1**: *High-Performance Computing and Numerical projects*, 10 ECTS
    1. This course teaches you to develop and structure large numerical projects, from code writing to finalizing a report
    2. Topics which are included are parallelization and vectorization
    3. Machine architecture and GPU-CPU programming
    4. Optimization of code and benchmarking
    5. Numerical methods from linear algebra will be discussed as well as examples from life science.

Revising existing courses

Some of these courses could incorporate (or base themselves upon) existing ones. The courses here are organized according to their corresponding disciplines. NOTE: These are suggestions for the discussions within each working group.

- Mathematics
    1. **CS-MATH1**: Data analysis and machine learning (new)
    2. **CS-MATH2**: Mathematical modeling in Science (new)
    3. **CS-MATH3**: Mathematical Foundations of data science (MAT-INF4110 and STK4021?)
    4. **CS-MATH4**: Computational Linear Algebra (MAT-INF4130)
    5. **CS-MATH5**: Computational differential equations (INF5620+INF5631)
    6. **CS-MATH6**: Computational finance (based on STK4520)
    7. **CS-MATH7**: Computational Fluid Mechanics and Navier Stokes equations (INF5670)

- Physical sciences (Astrophysics, geoscience, physics, chemistry and materials science)
    1. **CS-PHYS1**: Computational Physics (FYS3150/4150)
    2. **CS-PHYS2**: Computational Molecular dynamics in life science and materials science (new)
    3. **CS-PHYS3**: Computational Astrophysics (AST9110 and perhaps AST5210?))
    4. **CS-PHYS4**: Computational quantum mechanics (FYS4411)
    5. **CS-PHYS5**: Computational statistical mechanics (FYS4460)
    6. **CS-PHYS6**: Computational Materials Science (new, perhaps use elements from FYS-MENA4111)
    7. **CS-PHYS7**: Computational GeoScience (GEO4510 and GEO4450?)
    8. **CS-PHYS8**: Advanced Computational GeoScience (new or mix of GEO4510 and GEO4450?)

- Bioscience
    1. **CS-BIO1-INF**: Computing for biosciences (INF4490?)
    2. **CS-BIO2-INF**: Introductory bioinformatics (INF4350+MBV3070?)
    3. **CS-BIO3-INF**: Computational Bioinformatics (INF5380?)
    4. **CS-BIO4-INF**: Computational Physiology (INF5560?)
    5. **CS-PHYS2**: Computational Molecular dynamics in life science and materials science (new)

- Computer science
    1. **CS-INF1**: High-Performance Computing and Numerical projects (new)
    2. **CS-INF2**: Problem solving with high level languages (INF4331)
    3. **CS-INF3**: Machine Learning for Image Analysis (NF5850?)
    4. **CS-INF4**: Digital Image Analysis (INF4300?)
    5. **CS-INF5**: Artifical intelligence (INF4820)
- Mechanics
    1. **CS-MECH1**: Computational Mechanics (MEK4250?)
    2. **CS-MECH2**: Advanced Computational Mechanics (MEK4470)

Graduate Certificates

The program plans to offer graduate certificates in

- Three of the courses with label CS-MATH gives a certificate in Computational Mathematics
- Three of the courses with label CS-PHYS gives a certificate in Computational Physics, Astrophysics, Chemistry, Materials Science and Geoscience
- Three of the courses with label CS-BIO gives a certificate in Computational life science.
- Three of the courses with label CS-INF gives a certificate in High-performance computing.

Dual Degrees

The program plans to offer dual degrees (more text to come)