



# LTH

FACULTY OF  
ENGINEERING

*Course syllabus*

## Optimization for Learning Optimering för maskininlärning

**FRTN50, 7.5 credits, A (Second Cycle)**

**Valid for:** 2024/25

**Faculty:** Faculty of Engineering LTH

**Decided by:** PLED F/Pi

**Date of Decision:** 2024-04-15

**Effective:** 2024-05-08

### General Information

**Depth of study relative to the degree requirements:** Second cycle, in-depth level of the course cannot be classified

**Elective for:** D5-mai, E4, F5, F5-r, F5-mai, I4-fir, M4, MMSR2, Pi5-ssr

**Language of instruction:** The course will be given in English

### Aim

Learning from data is becoming increasingly important in many different engineering fields. Models for learning often rely heavily on optimization; training a machine is often equivalent solving a specific optimization problem. These problems are typically of large-scale. In this course, we will learn how to solve such problems efficiently. The large-scale nature of the problems renders traditional methods inapplicable. We will provide a unified view of algorithms for large-scale convex optimization and treat algorithms for the nonconvex problem of training deep neural networks.

### Learning outcomes

*Knowledge and understanding*

For a passing grade the student must

- know basic convex analysis
- understand the connection between machine learning and optimization
- have an understanding on the role of regularization in learning from an optimization point of view
- understand unifying framework for large-scale convex optimization

- understand concepts such as nonexpansiveness, and averagedness and their relation to monotone operators and their role for convergence of algorithms
- understand how to derive specific algorithms from the few general ones
- understand methods for avoiding numerical issues in deep neural network training.

#### *Competences and skills*

For a passing grade the student must

- be able to describe optimality conditions that are useful for large-scale methods
- be able to describe the building blocks that are the foundations of large-scale optimization algorithms and why they are used
- be able to analyze performance of optimization algorithms
- be able to solve optimization problems numerically using software and own implementations
- be able to present results in writing.

#### *Judgement and approach*

For a passing grade the student must

- understand what algorithm that should be used for different machine learning training problems
- be able to participate in the team-work needed to solve the hand-in assignments.

## Contents

The course has lectures, exercises, and four hand-in assignments.

The lectures will cover:

convexity, models for learning, unified convex optimization algorithm view, fixed-point iterations, monotone operators, nonexpansive mappings, stochastic methods, reduced variance methods, block-coordinate methods, nonconvex stochastic gradient descent and variations for for deep learning training.

## Examination details

**Grading scale:** TH - (U, 3, 4, 5) - (Fail, Three, Four, Five)

**Assessment:** Written exam (5 hours), 3 hand-in exercises. In case of less than 5 registered students, the exam may be given in oral form.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

#### **Modules**

**Code:** 0121. **Name:** Exam.

**Credits:** 7.5. **Grading scale:** TH - (U, 3, 4, 5). **Assessment:** Passed exam

**Code:** 0221. **Name:** Hand-in 1.

**Credits:** 0.0. **Grading scale:** UG - (U, G). **Assessment:** Passed hand-in

**Code:** 0321. **Name:** Hand-in 2.

**Credits:** 0.0. **Grading scale:** UG - (U, G). **Assessment:** Passed hand-in

**Code:** 0421. **Name:** Hand-in 3.

**Credits:** 0.0. **Grading scale:** UG - (U, G). **Assessment:** Passed hand-in

## Admission

**Assumed prior knowledge:** FMAN61 Optimization

**The number of participants is limited to:** 90

**Selection:** Completed university credits within the programme. Priority is given to students enrolled on programmes that include the course in their curriculum.

## Reading list

- Lecture slides and notes.

## Contact

**Course coordinator:** Pontus Giselsson, [pontusg@control.lth.se](mailto:pontusg@control.lth.se)

**Director of studies:** Björn Olofsson, [bjorn.olofsson@control.lth.se](mailto:bjorn.olofsson@control.lth.se)

**Course homepage:** <http://www.control.lth.se/course/FRTN50>

## Further information

A student who has been offered a seat in the course must confirm his/her participation within a week, or else the seat will be offered to the next student according to the selection criteria.