1 Teaching events

Lectures:

- Lecturer: Nuutti Hyvönen (nuutti.hyvonen@aalto.fi);
- Session info: Thu, 14:15–16:00, 213a (Konetekniikka 1, i.e., Otakaari 4);

Exercise sessions:

- Assistant: Anton Saukkonen (anton.saukkonen@aalto.fi);
- Session info: Thu, 16:15–18:00, U4 (Otakaari 1).

2 Course description

Mathematical optimisation (nonlinear optimisation, in its most general form) is a powerful framework in which one seeks to find variable values within a domain that maximise (or minimise) the value of a given function. Using the analogy that variables represent decisions or parameters to be defined and the function is a measure of performance, one can use that framework to support decision making in a wide range of applications, from planning industrial chemical plants to training models that learn from data.

In this course, the student will learn the basic optimisation theory behind the main numerical algorithms available and how they can be applied to solve optimisation problems. At the end of the course, it is expected that the student will be capable of analysing the main characteristics of an optimisation problem and decide what is the most suitable method to be employed for its solution.

3 Learning outcomes

Upon completing this course, the student should be able to

- understand how several important problems arising from diverse fields can be cast and solved as nonlinear optimisation problems;
- know the main techniques for solving nonlinear optimisation problems and how to apply them in practice;
- know how to use optimisation software for implementing and solving nonlinear optimisation problems.

4 Teaching methods

The course will be taught by a composition of the following methods:

- lectures;
- self-study;
- theoretical and computational exercises and homework;
- project assignments.

The lectures are given in the lecture hall 213a (Otakaari 4) on Thursdays at 14.15–16.00. Recorded lectures from the previous fall will also be available in MyCourses. The students are expected to study the corresponding lecture notes (about 10 pages per lecture) before the lectures to facilitate active discussion.

The exercise sessions are in the lecture hall U4 (Otakaari 1) on Thursdays at 16.15–18.00. During the exercise sessions, the assistant demonstrates how to solve the exercises and answers related questions. Video recordings presenting the solutions to the exercise problems are also available in MyCourses after the sessions. We strongly recommend the students to try to solve the exercise problems themselves before attending the exercise session or watching the corresponding videos. The exercise sessions work as office hours for the students to clarify questions related to content, homework and assignments.

5 Assessment

The final grade of the course is composed of three components:

H: 4 homework assignments;

$P1$: Project assignment 1;
$P2$: Project assignment 2;

Each component will be graded individually on the scale 0–100. The final grade FG will be calculated as

$$FG = 0.5 \times H + 0.25 \times P1 + 0.25 \times P2.$$

The conversion to the grade scale 0-5 works as follows.

1-5	0-100
Fail	0-50
1	51-60
2	61-70
3	71-80
4	81-90
5	91-100

Table 1: Conversion from 0-100 to the grade scale 1-5.

5.1 Homework assignments

A total of four homework assignments will be handed out; observe that these are different from the exercise problems solved in the exercise sessions by the assistant. One round of homework is worth 25 points, which adds up to a total of $4 \times 25 = 100$ points. Each homework assignment will made available on a certain Monday in MyCourses, and the corresponding deadline is the Monday evening two weeks later (see Table 2). The solutions must be submitted through MyCourses. A homework submission after a deadline will automatically have a 5 point discount plus extra 5 point deductions per each extra day (24h) after the deadline.

The homework will be composed of theoretical and computational exercises. The computational skills required to solve the exercises will be introduced via the weekly exercises, but it is expected that the students learn and practise the employed programming language on their own, for which supporting material is provided. The programming language used on this course is Julia (julialang.org).

5.2 Project assignments

The students will be requested to develop two guided projects with given topics. The specification of each project will made available on a certain Monday in MyCourses, and the corresponding deadline is the Friday evening slightly less than four weeks later (see Table 2). The objective of the projects is to use the acquired knowledge in nonlinear optimisation in practice and discuss related technical aspects.

The projects can be conducted individually or in small groups (the size of which will be specified later). Each project will comprise an implementation in Julia and a 3000–4000 word (approximately 5–7 pages) report. Each report will be graded by the lecturer or a person assigned by him.

6 Course material

Main study material: lecture notes, lecture slides, exercise tutorials, homework assignments, course book.

The lecture material is mostly based on the main course book *M. Bazaraa et al., Nonlinear Programming, Wiley-Interscience, 2006.*

7 Course schedule

A tentative schedule for the course is given below. The precise content of each lecture may be adapted according to the pace of the course.

Week	Lecture	Content
36	1	Administration and introduction
37	2	Topology – convex sets
38	3	Analysis – convex functions (Homework 1 published)
39	4	Optimality conditions I (Homework 2 published)
40	5	Unconstrained optimisation methods I (Project 1 published)
41	6	Unconstrained optimisation methods II
42	–	*Break between Periods I and II*
43	7	Optimality conditions II
44	8	Lagrangian duality (Homework 3 published)
45	9	Constrained optimisation methods I
46	10	Constrained optimisation methods II (Homework 4 and Project 2 published)
47	11	Constrained optimisation methods III
48	12	Computational and practical points

Table 2: Schedule of the course

8 Workload estimate

The table below shows an estimate of the total workload of the course. Recall that each ECT credit is equivalent to 28h of work, and thus, 5 ECTs are equivalent to 140h in total.

Activity	Hours	# Events	Total hours
Self study plus exercise sessions	3	12	36
Lectures	2	12	24
Homework	10	4	40
Project assignments	20	2	40
		Total workload:	**140**