1 Course description

Mathematical optimisation is one of the cornerstones of fields such as Machine Learning, Artificial Intelligence, Business Analytics, and Operations Research. Most decision support methods have, at some level, a mathematical optimisation method at its core, and it is precisely these methods that we will learn in this course.

Mathematical optimisation 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, you will learn the basic optimisation theory, how to formulate problems and how they can be solved. Linear, integer, and nonlinear optimisation will be covered in the course. At the end of this 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.

2 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 optimisation problems;
- know the main techniques for solving optimisation problems and how to apply them in practice;
- know how to use optimisation software for implementing and solving optimisation problems.

3 Teaching methods

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

- prerecorded online and in-person lectures;
- guided self-study;
- exercises;
- peer review.

4 Lectures

The prerecorded lectures will be made available via Panopto. Lecture notes on the weekly in-person lectures will be made available via MyCo. The exercise sessions will be conducted by the TAs in the preallocated times on Sisu and MyCo (H1-H7).

- Lecturer: Harri Hakula (Harri.Hakula@aalto.fi);
- Office hours: Thu 13:00h - 14:00h (M311)

Exercise sessions: there are seven groups in a week. Please check Sisu to see what sessions you have enrolled to and times. The TAs are

H01 Paula Weller (Head TA: paula.weller@aalto.fi)
H02 Joel Hakavuori
H03 Eero Ketola
H04 Jarkko Jalovaara
H05 Leevi Korkeala
H06 Afrin Hossain
H07 Jyri Mattila

5 Exercise sessions

For each lecture, the students will receive a list with two demos plus extra exercises. In the exercise sessions, the TA's will present the solution of two demos. After that, the space will be used for the students to do exercises individually or in group and ask for the help of the TA's, if needed. Solutions for these exercises will be provided, however complete demonstrations will only be provided for the demos.

The students can attend any of the seven exercise sessions for a given class. In case of space limitations, preference will be given for those enrolled in that session.

6 Assessment

The final grade is given by a final exam at the end of the course. Bonus points will be awarded for homework assignments. The exam will be graded in a scale of 0-100. The final grade will be calculated as

$$\text{Exam grade} + \text{Bonus points}$$

The tentative conversion scale for to the 1-5 scale is 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 1-5 scale

6.1 Exam

The exam will consist of questions similar to the exercises provided and solved in the exercise sessions. Full instructions concerning the exam format and a revising guide will be provided during classes. The date for the first exam is **11 April 2022**.

6.2 Quizzes and Homework assignments

There is a continuous assessment component, with a maximum of 25 bonus points. There are ten homework assignments, one per normal exercise session, and five weekly quizzes each with two problems. Each correct answer is worth **one point** leading to 20 bonus points. The remaining five points are earned via peer review activity, with every review accumulating **one half** toward the total.

7 Course material

Main study material: lecture notes, exercises, homework assignments, course book.

Main course book: *H. Taha, Operations Research, An Introduction. Pearson, 2017.* Auxiliary course book: *W. Winston, Operations Research, Applications and Algorithms. Cengage, 2004*

8 Course schedule

The course schedule is as follows:

Week	Lecture	Content
9	1	Admin./ Introduction + Formulation
9	2	Formulation + Graphical method
10	3	Simplex method
10	4	Simplex method II - special cases
11	5	Linear duality
11	6	Sensitivity analysis + Integer prog. - formulation I
12	7	Integer prog. - formulation II + Branch-and-bound method
12	8	Unconst. opt. I: optimality conditions
13	9	Unconst. opt. II: gradient and Newton method
13	10	Const. opt. I: KKT conditions
14	11	Const. opt II: Interior point methods
14	12	Closing session