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:

- lectures;
- guided self-study;
- exercises.

4 Lectures

The lectures will be held on Wednesdays (14.15-16.00) and Thursdays (14.15-16.00). (Please note the break over Easter.)

The lectures will be held on campus. Please check sisu for the lecture halls as these change over the semester.

The exercise sessions will be conducted by the TAs at the preallocated times (H1-H8).

- Lecturer: Philine Schiewe (philine.schiewe@aalto.fi);

Exercise sessions: there are 8 groups in a week. The TAs are

1. Eeli Asikainen
2. Joel Hakavuori
3. Eero Ketola
4. Han Le
5. Joonatan Linkola
6. Yu Liu (Head TA: yu.2.liu@aalto.fi)
7. Iago da Silva Rossetto
8. Teemu Tasanen

5 Exercise sessions

For each lecture, the students will receive a list with 2 demos plus extra exercises. In the exercise sessions, the TAs will work together with the students to develop a 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 8 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 conversion scale for to the 1-5 scale is as follows.

1-5	0-100
Fail	0-39.99
1	40-49.99
2	50-59.99
3	60-69.99
4	70-79.99
5	80-100

Table 1: Conversion from 0-100 to 1-5 scale

6.1 Exam

The exam will be held onsite and will consists 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 **15 April 2024**.

6.2 Homework assignments (Quizzes)

Every week, the students will have the opportunity to do two exercises and submit their answers online via MyCourses. Each correct exercise is worth **one point**, totalling 10 extra points.

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 tentative 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
14	10	Const. opt. I: KKT conditions
15	11	Const. opt II: Interior point methods
15	12	Closing session