1 Course implementation

This edition of the course will be exclusively remote. We will meet weekly in Online sessions via Zoom, to have an interactive discussion about the week's topics and do some practical exercises together.

All lectures will be delivered via pre-recorded videos, which are expected to be watched **before** the online sessions on Thursday.

Online sessions details:

- Lecturer: Fabricio Oliveira (fabricio.oliveira@aalto.fi);
- Teaching assistant: Olli Herrala (head TA), Helmi Hankimaa, Tuukka Mattlar.
- Session info: Thursdays, 14:15h - 16:00h, via Zoom (please check MyCourses Forum for link);

2 Course description

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

Linear Optimization is a powerful framework in which one seeks to represent systems by means of linear objective functions and constraints. Using the analogy that variables represent decisions or parameters to be defined, constraints represent rules that a valid configuration or a plan of action for the system, 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 students will learn the basics of linear optimisation theory as well as advanced algorithms available and how they can be applied to solve challenging real-world inspired optimisation problems. Throughout the course, we will also look into practical and research applications of linear optimisation.

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

4 Teaching methods

This course uses a **flipped classroom approach**. This means that the students learning depends on their own initiative in terms of watching the video lectures, formulating questions and discussing with colleagues.

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

- online sessions;
- guided self-study;
- theoretical and practical exercises;
- homework assignments and feedback.

All lectures will be delivered via pre-recorded videos. As preparation for the lectures, the students will be requested to watch the video material beforehand and formulate questions to be submitted before the online sessions.

The online sessions will take place as Zoom sessions. In these, the lecturer will go over the questions raised by the students, referring to the material covered in the week. Students can also use this time to clarify questions related to content, homework and assignments.

The second part of the online sessions will consist of practical exercises that will be done in small groups using breakout rooms in Zoom. These will focus on illustrating and developing concepts using computational tools.

5 Assessment

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

H: 6 homework assignments, each worth 15 points;
P: Participation component, worth 10 points;

The 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

5.1 Homework assignments

A total of 6 homework assignments will be handed out. Each homework is worth 15 points, adding to a total of 90 points. The homework for each fortnight (fortnight = two weeks) will be available on Monday from MyCourses and will have as deadline the Friday evening of the second week after the release. The submission of the solutions must be made through the course MyCourses website. Homework submissions after the deadlines will be penalised by 5 points per day after the deadline.

The homework will be composed by theoretical and computational exercises. The computational skills required to solve the exercises will be introduced in the online sessions, but it is expected that the students learn and practise the language on their own. Supporting material for that will be provided. The programming language that will be used in this course is Julia (julialang.org).

5.2 Participation component

Students that have an attendance to online sessions greater or equal than 80% (10/12 sessions) earn 10 points in the participation component. Otherwise, points will be given proportionally to attendance.

6 Course material

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

The lecture material is mostly based on the main course book *D. Bertsimas, J. Tsitsiklis, Introduction to Linear Optimization, Athena Scientific, 1997.*

7 Course schedule

A tentative schedule for the course is given. Content of each class may be adapted according to the pace of the classes.

Week	Lecture	Content
2	1	Introduction - modelling linear problems
3	2	Linear algebra, polyhedral sets
4	3	Basis, extreme points and optimality of LP
5	4	The simplex method
6	5	Duality I - the dual simplex
7	6	Duality II - other applications
8	–	*Break between Periods III and IV*
9	7	Decomposition methods: Benders and Column generation
10	8	Mixed-integer programming formulations
11	9	Branch-and-bound
12	10	Cutting planes method
13	11	Branch-and-cut: additional methods
14	12	Computational and practical points

Table 2: Schedule of classes