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Study Abroad
INTERNATIONAL PROGRAMMES
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Faculty: Sciences, Technology and Engineering

Course: **Optimization and Operational Research**

Programme: Study Abroad in Engineering

Semester: 1 - Fall

ECTS credits: 3

Duration: 22.5 hours

Language of instruction: English

Instructors: Jordi Villà-Freixa / Jing Yang

Course Description

In this course we will deal with Operations Research (OR), a scientific discipline at the interface of Applied Mathematics, Computer Science and Engineering, defined as the use of quantitative methods to assist analysts and decision-makers in designing, analyzing, and improving the performance or operation of systems. OR can be used in financial systems, scientific or engineering systems, or industrial systems. Its aim is to rationalize, simulate, optimize, model and plan the architecture and operation of complex systems that are increasingly present in industry and large organizations. We will focus on the optimization problem, and we will be following a fully practical approach, using Python/iPython, Colab and libraries like google OR, among others, as our main tools during the course to demonstrate and test what we learn from the theoretical sessions.

Prerequisites

Linear algebra, matrix analysis, basic numerical analysis, differential, and integral calculus. Basic knowledge of Python programming and jupyter notebook.

Attendance and punctuality policies

Attendance is mandatory for all classes. Any presentation or activity missed due to student absences can only be rescheduled in cases of certified medical or family emergencies. If a student misses more than three classes in any course half a letter grade will be deducted from the final grade for each additional absence. Seven absences in 6 ECTS courses or four absences in 3 ECTS courses will result in a Fail grade. Notice that there is a minimum of 80% attendance.

Students will be marked ABSENT from any class if they arrive more than 20 minutes late. Students will not be permitted to enter the class unless the professor specifically accepts it. Even if the instructor allows students to join the class, they will still be marked as absent for that lesson.

Absences can be justified in the following cases: Death of a first-degree relative, serious illness of the student/ first-degree relative or obligation to attend legal affairs. In all these cases a document or receipt must be sent via e-mail to studyabroad@uvic.cat adding your professor in

copy. Important! In case of injury/ illness of the student, a medical document issued in Vic* needs to be provided.

*Medical documents accepted: physical doctor's notes which contain the hospital's stamp and signature in handwriting OR digital doctor's notes which contain the doctor's valid digital signature (a digital signature is valid when it shows the authentication of the person who signs and prevents the pdf to be modified after being signed).

Learning outcomes

By the end of the course, students should be able to:

- identify specific problems of linear programming;
- identify and use techniques to solve an optimization or linear programming problem;
- implement specific OR algorithms.

Method of presentation

Lectures and practical training:

- Short lectures with appropriate visual support provide the theoretical content of the sessions.
- Practical training will present specific problems to be solved using computational tools and algorithms in and out of the class.

Required work and assessment methods

To pass the course, students should obtain at least an overall average grade of 5 out 10. The grade is obtained in three tasks:

- TESTS (E1-10): At least an average grade of 4 out 10 in tests. No delay is allowed for tests.
- PROGRAMMING EXERCISES (P1-4): At least a grade of 5 out of 10 in programming exercises. If delivery is delayed for a particular programming exercise, the grade for such exercise will be penalized with a maximum score of 60%.
- FINAL EXAM: A minimum grade of 5 is necessary to pass the exam.
- RETAKE EXAM: If the global OR the final exams grades are less than 5, a retake exam will take place, but it will only account for 30% of the final grade.

Contents

Unit 1: Introduction to OR and Optimization

- Introduction to systems modelling; optimality and practicality
- Introduction to the Python/colab environment; GitHub

Unit 2: Non-linear optimization

- Concepts and algorithms in non-linear optimization
- Unconstrained optimization
- Constrained optimization (Lagrange multiplier theorem, Kuhn-Tucker multiplier theorem)

Unit 3: Linear programming

The linear programming model

- Fundamental principles of linear programming
- Geometric resolution
- Basic mathematics tools

The Simplex method

- Standard form,
- Deviation variables
- Basic feasible solutions
- Artificial variables

Duality

- Primal and dual problems, economic interpretation, conditions of optimality, resolution of the dual by the primal and penalty method

Unit 4: Sensitivity analysis

- Sensitivity analysis: the effect of modifying the objective function or the constraints

Unit 5: Network analysis

- Graphs and Networks
- Maximum flow / minimal cost
- Network connectivity
- Shortest path problems
- Dynamic programming
- Project management

Unit 6: Integer programming

- Branch and bound
- Cutting planes
- Cover inequalities
- Lagrangian relaxation
- Column generation

Recommended reading

1. "Operations research. A practical Introduction (2nd Ed)" by Michael W. Carter, Camile C. Price and Ghaith Rabadi. CRC Press