

Introduction

Operational Research Complements

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The focus

Mathematical programming: algorithms to compute optimal solutions to mathematical optimization problems.

The **Operations Research** course deals with:

- How to define **mathematical optimization models** (data, variables, constraints, objective function(s))
- Algorithms: in particular, the simplex algorithm for **linear programming**.

The **Operational Research Complements** course deals with:

- Algorithms for **Mixed-Integer Linear Programming** (some variables are discrete)
- Algorithms for **Non-Linear Programming** (some constraints or the objective are non-linear).

The *Analytics and Optimization* stream

The course is part of the **Analytics and Optimization** stream.

It can be well complemented with...

- **Combinatorial optimization**: algorithms for graph optimization problems solvable in polynomial-time.
- **Heuristic algorithms for C.O.**: *NP*-hard problems, but one strives for efficiency, not for optimality.
- **Decision models and methods**: two or more objectives, two or more decision-makers, uncertainty in data...

Courses like **Simulation** and **Logistics** are also consistent with this stream.

Prerequisites and exams

Prerequisites:

- basic concepts in mathematical optimization and **linear programming**;
- **computer programming**.

The **exam** consists of

- **a project**: designing, coding and testing a mathematical optimization algorithm and reporting about the experiments;
- **an oral exam** on the topics not covered by the project.

The course is well-suited for developing a **master degree thesis**.

Why should I attend this course?

You may want to attend this course because...

- you are interested in optimization techniques to solve computationally difficult problems;
- you want to develop distinctive skills, not to be confused with the many “data scientists” and “analytics experts”;
- you are looking for a career in some sector where optimization techniques are (or will be) in high demand;
- you want to become an operations research professional;
- you like applying mathematics and you can't resist curiosity about this branch of math called Operations Research / Management Science.

Weak reasons for taking this course:

- *“I am a foreign student and this course is in English”*
- *“I need some credits with MAT label”*

The O.R. analyst

O.R. analysts in the US (2019):

- N. of positions: 109700
- Median annual salary: USD 84810 (+41% w.r.t. US median)
- Forecasted growth 2018-2028: +26% (US: +5%)

(Data from U.S. Bureau of Labor Statistics)

See also www.careercast.com.

**Certified
Analytics
Professional**



Mathematical programming

Mathematical programming problems are characterized by

- only one objective (otherwise: multi-objective programming)
- only one decision-maker (otherwise: game theory, multi-level programming,...)
- no uncertainty in data (otherwise: stochastic programming, robust optimization,...).

They can be classified as follows:

- Linear Programming (LP): linear constraints and objective, continuous variables
- **Mixed-Integer Linear Programming (MILP)**: linear constraints and objective, but some variables are discrete
- **Non-linear Programming (NLP)**: continuous variables but some constraints or the objective are not linear
- Mixed-Integer Non-Linear Programming (MINLP): some variables are discrete and some constraints or the objective are not linear.