

DM872
Mathematical Optimization at Work

Introduction

Marco Chiarandini

Department of Mathematics & Computer Science
University of Southern Denmark

1. Course Organization

1. Course Organization

Who is here?

22 registered in BlackBoard

Prerequisites

- Programming
- Linear Algebra
- Linear and Integer Programming (DM545/DM871)

from DM545 (5 ECTS)

who??

- Math-economy
- Others?

from DM871 (5 ECTS)

who??

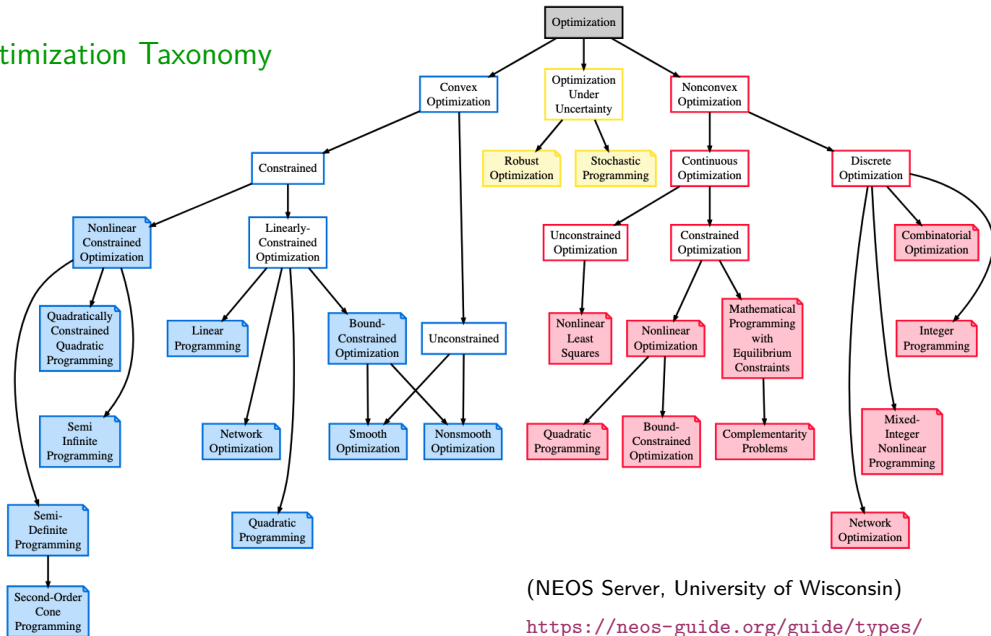
- Computer Science (Master)
- Applied Mathematics
- Others?

Learn about solving large scale, real-life problems with mixed integer linear programming:

- **advanced techniques** for integer linear programming
- applications
- implementations

→ You will see the theory and apply the tools learned to solve real life problems using computer software

Optimization Taxonomy



(NEOS Server, University of Wisconsin)

<https://neos-guide.org/guide/types/>

<https://docs.mosek.com/modeling-cookbook/index.html>

Contents of the Course (aka Pensum)

Advanced mixed integer linear programming techniques

- 0 LP and ILP Recap
- 1 More on Modeling
- 2 Cutting Planes
- 3 Dantzig-Wolfe decomposition
- 4 (Delayed) Column generation
- 5 Branch and price
- 6 Lagrangian relaxation
- 7 Matheuristics

Applications

- 7 TSP
- 8 Vehicle Routing
- 9 Vehicle Scheduling
- 10 Crew Scheduling
- 11 Machine Learning
- 12 Educational Timetabling

Practical Information

Teachers: Marco Chiarandini (imada.sdu.dk/u/march/)

Konstantin Pavlikov (<https://portal.findresearcher.sdu.dk/en/persons/kop/>)

Instructor: None

Teachers: Marco Chiarandini (imada.sdu.dk/u/march/)

Konstantin Pavlikov (<https://portal.findresearcher.sdu.dk/en/persons/kop/>)

Instructor: None

Alternative views of the schedule:

- mitsdu.sdu.dk, SDU Mobile
- Official course description (skemaplan)
- <https://github.com/DM872/Resources/>
- <https://imada.sdu.dk/u/march/Timetables/Semesters/F26/html/DM872.html>

Teachers: Marco Chiarandini (imada.sdu.dk/u/march/)

Konstantin Pavlikov (<https://portal.findresearcher.sdu.dk/en/persons/kop/>)

Instructor: None

Alternative views of the schedule:

- mitsdu.sdu.dk, SDU Mobile
- Official course description (skemaplan)
- <https://github.com/DM872/Resources/>
- <https://imada.sdu.dk/u/march/Timetables/Semesters/F26/html/DM872.html>

Schedule:

- Scheduled $16 \times 4 = 64$ hours (~ 32 classes)
- Officially joint classes: 48 hours (~ 24 classes)
- We try to finish at the beginning of May, 3,4 weeks earlier than scheduled.

No distinction between classes, they are all common and with possible hands on activities.

- ItsLearning (LMS) \Leftrightarrow Git Repository
(link <https://github.com/DM872/Resources/>)
- **Announcements + Discussion Board + Submissions** in ItsLearning
- Ask peers
- Write to Marco (marco@imada.sdu.dk)
- Visit Marco in his office in working hours (9-17)

- ItsLearning (LMS) \Leftrightarrow Git Repository
(link <https://github.com/DM872/Resources/>)
- **Announcements + Discussion Board + Submissions** in ItsLearning
- Ask peers
- Write to Marco (marco@imada.sdu.dk)
- Visit Marco in his office in working hours (9-17)

Git Repository is the main reference for list of contents

It contains:

- list of topics and references
- slides
- tutorials
- reading materials
- exercise sheets
- assignments

Updated daily.

- Goal: Moderate course/track material and guide learning
 - main material is the literature and exercises
 - no lecture notes beyond the slides
- Questions and discussions welcome and encouraged at any time
 - if you have questions, ideas, or disagreement: **interrupt and ask!**
 - **discussing** and **questioning** what you read/hear is part of the lecture

- We start them in class, in groups of two
- You continue and finish them as self study
- Try to occasionally gather in different groups
- Prepared tasks are starting point for **engaged** and **self-responsible learning**
- We discuss any question or idea in plenum in the class after or you ask for personal feedback in the classes

- Two obligatory medium size projects, evaluation by examiner and internal censor (ie, Marco and Konstantin)
- First is individual and second is in group of at most two persons
- Learning goals:
 - first, understand and apply knowledge gained in a similar context, narrow scope
 - second, analyze, select and apply an appropriate method studied to a new context, open scope. Discuss and reflect.
- (language: Danish and/or English)

- Two obligatory medium size projects, evaluation by examiner and internal censor (ie, Marco and Konstantin)
- First is individual and second is in group of at most two persons
- Learning goals:
 - first, understand and apply knowledge gained in a similar context, narrow scope
 - second, analyze, select and apply an appropriate method studied to a new context, open scope. Discuss and reflect.
- (language: Danish and/or English)
- Gen AI: we follow SDU regulations <https://mitsdu.dk/en/aiatsdu>.
Report in Appendix if you have used and if so share the entire chat. If the Appendix is missing the submission is not valid and you fail the exam.

- Two obligatory medium size projects, evaluation by examiner and internal censor (ie, Marco and Konstantin)
- First is individual and second is in group of at most two persons
- Learning goals:
 - first, understand and apply knowledge gained in a similar context, narrow scope
 - second, analyze, select and apply an appropriate method studied to a new context, open scope. Discuss and reflect.
- (language: Danish and/or English)
- Gen AI: we follow SDU regulations <https://mitsdu.dk/en/aiatsdu>.
Report in Appendix if you have used and if so share the entire chat. If the Appendix is missing the submission is not valid and you fail the exam.
- Final grade: overall evaluation but as starting point the average grade rounded up

- Python 3.10+ (check pyenv)
- MILP specific:
 - gurobipy, Gurobi 13+ (commercial 100 000 DKK, alternatives: Cplex, Xpress)
 - SCIP Optimization Suite + PyScipOpt (Commercial alternative Gurobi or Cplex \approx 100 000 Dkk)
 - Python-MIP + CBC or Gurobi 13+
 - Pyomo + Ipopt, CBC, HiGHS, Gurobi 13+, Cplex
- jupyter, jupyterLab (= interactive python) or Google CoLab
- VS Code

Expected 135 working hours for 5 ECTS

- Preparations (before/after lecture): $[24 \text{ classes} \times 4h]$
Read up on non-optional material (at least the slides)
Use optional material or own research to close gaps in understanding
- Exercises: $[10 \times 1h]$
Go through the weekly sheets (github)
Solve tasks left from classes
Discuss with peers
- Project work: $[24h + 24h]$
Research literature, Implement, Analyse

150 hours in total. 8.2 hours per week.