EPFL

MATH-329 **Continuous optimization**

Boumal Nicolas

Cursus	Sem.	Type
Mathematics	BA5	Opt.

Language of teaching	English
Credits	5
Session	Winter
Semester	Fall
Exam	Written
Workload	150h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	2 weekly
Number of positions	

Summary

This course introduces students to continuous, nonlinear optimization. We study the theory of optimization with continuous variables (with full proofs), and we analyze and implement important algorithms to solve constrained and unconstrained problems.

Content

Unconstrained optimization of differentiable functions

- Necessary optimality conditions
- The role of Lipschitz assumptions
- Gradient descent and Newton's method
- Convexity
- The trust-regions method, CG, truncated CG
- Nonlinear least-squares

Constrained optimization of differentiable functions

- Necessary optimality conditions, cones
- Convexity
- Projected gradient descent
- Notions of duality
- The quadratic penalty method
- The augmented Lagrangian method

Related topics and extensions may be included in lectures or though exercises / homework.
Note: precise contents may change during the semester, and from year to year.

Learning Prerequisites

Required courses

Students are expected to be comfortable with linear algebra, analysis and mathematical proofs. Lectures, homework and the final exam are proof heavy.
Students are expected to be (or become) comfortable writing code in Matlab. They may be allowed to write some of their work in Python or Julia upon request. Homework requires a substantial amount of coding. We will not teach Matlab but there are a lot of resources online to help you.

Learning Outcomes

By the end of the course, the student must be able to:

- Recognize and formulate a mathematical optimization problem
- Analyze and implement the gradient descent method, Newton's method, the trust-region method and the augmented Lagrangian method, among others.
- Establish and discuss local and global convergence guarantees for iterative algorithms.
- Exploit elementary notions of convexity and duality in optimization.
- Apply the general theory to particular cases.
- Prove some of the most important theorems studied in class.

Teaching methods

Lectures + exercise sessions + extensive homework (in groups)

Expected student activities

Students are expected to attend lectures and participate actively in class and exercises. Exercises include both theoretical work and programming assignments. Students also complete homework assignments that include theoretical and numerical work. The homework assignments require a substantial amount of work throughout the semester, and accordingly account for a substantial part of the final grade. They are done in groups.

Assessment methods

Final exam (40%) + homework (60%) -- the split may change depending on how many TAs are available for the course. This will be fixed during the first week.

The overall grade (computed as above) is rounded up or down to the closest quarter of a point: up if the (individual) exam grade is a passing grade, down if not.

Supervision

Office hours	No
Assistants	Yes

Resources

Bibliography

Book "Numerical Optimization", J. Nocedal and S. Wright, Springer 2006: https://link.springer.com/book/10.1007/978-0-387-40065-5

Ressources en bibliothèque

- Numerical Optimization / Nocedal

Notes/Handbook

Lecture notes provided by the lecturer: https://www.nicolasboumal.net/papers/MATH329-Lecture_notes_Boumal_2023.htm

Moodle Link

- https://go.epfl.ch/MATH-329