GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2024-2025

Selected Topics in Mathematical Optimization (C003701)

Course size *(nominal values; actual values may depend on programme)*

Credits 3.0 **Study time 75 h**

Course offerings and teaching methods in academic year 2024-2025

A (semester 1)	English	Gent	lecture
			seminar

Lecturers in academic year 2024-2025

Van Liedekerke, Paul	LA26	lecturer-in-charge

Offered in the following programmes in 2024-2025

	crdts	offering
Master of Science in Bioinformatics(main subject Bioscience Engineering)	3	A
Master of Science in Bioinformatics(main subject Systems Biology)	3	A
Master of Science in Bioscience Engineering: Cell and Gene Biotechnology	3	A
Master of Science in Bioscience Engineering: Land, Water and Climate	3	A
Master of Science in Pharmaceutical Engineering	3	A
Exchange Programme in Bioinformatics (master's level)	3	A

Teaching languages

English

Keywords

Convex optimization, gradient-based methods, constrained optimization, multi-objective optimization,heuristical methods, shortest path methods, Bayesian optimization

Position of the course

As a more advanced course within the field of applied mathematics, this course focuses on traditional methodologies and more recent developments in the area of mathematical optimization. This course presents mathematical optimization as a flexible methodology that extends the students' problem-solving abilities. Students are taught how to translate (real-life) problems of substantial complexity into formal mathematical optimization problems. Moreover, students will learn how 'to select, apply and/or create efficient optimization procedures to solve these optimization problems efficiently. The general philosophy behind this course is application-oriented. Driven by a variety of applications in bioengineering (including but not limited to bioinformatics), several theoretical concepts on mathematical optimization will be introduced and studied up to a level that allows these concepts to be applicable in practice. Consequently, the main focus will be on the application and implementation (in a programming language) of these concepts.

Contents

The main objective of this course is to teach students how to use mathematical optimization techniques to solve a variety of real-life problems. The course consists of three main modules, of which the exact topics can vary from year to year:

1 Continuous convex optimization problems
2 Discrete optimization problems solvable in polynomial time
3 'Hard problems', NP hard problems and complex problems with no guarantees on optimality and performance
4 Optimization problems with uncertainty

Every part consists of several theory lectures, written and implementation

exercises and a project. Throughout the lectures, several applications of bioinformatics are touched upon, including logistic regression, signal recovery, modelling protein oligomerization, cell tracking, single cell analysis, microfluidics design etc.
All concepts are illustrated with Python implementations and exercises, available through the course Github repository: **STMO**

Initial competences

- **Basic knowledge of scientific programming** (knowledge of Python is an advantage, but is not a strict prerequisite if the student is willing to acquire the required skills independently).
- Basic knowledge of mathematics (in particular calculus and linear algebra, some notions of probability theory cfr. Mathematics 1 & 2, bachelor of bioscience engineering).
- A general overview of the kinds of problems in bioinformatics as to be able to place the methods and algorithms in their broader context.

Final competences

1 The student understands and has insight into the main principles of mathematical optimization.
2 The student is able to recognize traditional optimization problems that are often encountered in the field of bioscience engineering.
3 The student is able to translate real-life problems into formal mathematical optimization problems.
4 The student is able to understand and judge the quality of the numerical optimization techniques underlying a variety of (bioinformatics) tools.
5 The student is able to select, apply and/or develop proper numerical optimization schemes to solve mathematical optimization problems.
6 The student is willing to routinely assess the impact of both the translation of a real-life problem into a formal optimization problem, and the optimization technique that is used to solve the resulting problem, on the solution that is found for a given problem in the field of bioengineering in general and bioinformatics in particular.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Seminar, Lecture

Extra information on the teaching methods

e-books, python notebooks
Cost of this course : 0€

Study material

Type: Laptop

Name: Python notebooks
Indicative price: Free or paid by faculty
Optional: no

References

- H. Bockenhauer and D. Bongartz (2007). Algorithmic Aspects of Bioinformatics. Springer, 397p.
- M. Kochenderfer and T. Wheeler (2019). Algorithms for Optimization. The MIT Press
- S. Boyd and L. Vandenberghe (2004).Convex Optmization. Cambridge University Press, 716p
- J. Nocedal and S.J. Wright (1999). Numerical Optimization. Springer, 634p.
- D.E. Goldberg (1989). Genetic algorithms in Search Optimization and Machine Learning. Addison-Wesley, 412p.
- R. Sedgewick (2002). Algorithms in C: Graph Algorithms. Princeton University

Course content-related study coaching

- Contact hours: 30h (of which 12u theory and 18h seminar)

- Additional information can be provided using Ufora.
- Computer exercises are guided by assistants

Assessment moments

end-of-term and continuous assessment

Examination methods in case of periodic assessment during the first examination period

Written assessment, Assignment

Examination methods in case of periodic assessment during the second examination period

Oral assessment, Written assessment, Assignment

Examination methods in case of permanent assessment

Assignment

Possibilities of retake in case of permanent assessment

examination during the second examination period is not possible

Extra information on the examination methods

- Periodic examination: oral exam
- Permanent evaluation: evaluation of assignments

Calculation of the examination mark

- 50% periodic evaluation
- 50% permanent evaluation