DEPARTMENT OF MATHEMATICAL SCIENCES

MMG621 Nonlinear Optimization, 7.5 credits

Ickelinjär optimering, 7,5 högskolepoäng

First Cycle

Confirmation

This course syllabus was confirmed by Department of Mathematical Sciences on 2011-10-20 and was last revised on 2023-02-08 to be valid from 2023-08-28, autumn semester of 2023.

Field of education: Science 100%

Department: Department of Mathematical Sciences

Position in the educational system

The course can be part of the following programme: 1) Bachelor's Programme in Mathematics (N1MAT)

Main field of studies	*Specialization*
Mathematics	G2F, First cycle, has at least 60 credits in first-cycle course/s as entry requirements

Entry requirements

General entry requirements and the equivalent of 60 credits in mathematics, including the courses *MMG200 Mathematics 1* and *MMG300 Multivariable Analysis*.

Learning outcomes

The goal is that the student, after completing the course, should understand parts of the theory of optimality, duality, and convexity, and their interrelations. In this way, the student will be able to analyze many types of optimization problems occurring in practice and both classify them and provide guidelines as to how they should be solved. The latter is the more practical goal of an otherwise mainly theoretical course.

More precisely, on successful completion of the course the student will be able to:

- state and explain the most important concepts in convex analysis, convex optimization, and duality, and be able to apply the theory on concrete examples,
- state and explain the basics of necessary and sufficient optimality conditions, in particular the KKT conditions, and be able to utilize the theory to analyze and solve concrete examples,
- analyze linear programming problems using concepts such as duality and sensitivity; solve linear programming programs using the simplex method and explain how the method works,
- explain notions such as descent and feasible direction, and use these concepts to explain the principles behind, to analyze, and to apply classical optimization methods, e.g., steepest descent, variations of Newton's method, the Frank-Wolfe method, and penalty methods; be able to specify conditions under which these methods converge,
- formulate relevant parts of a real-world problem in terms of a mathematical optimization model, analyze the model using appropriate tools and methods, and apply appropriate solution algorithms.

Course content

This basic course in optimization describes the most relevant mathematical principles that are used to analyze and solve optimization problems in continuous variables. A rough overview of the content is as follows.

- Convex analysis: convex set, polytope, polyhedron, cone, representation theorem, extreme point, Farkas Lemma, convex function.
- Optimality conditions and duality: global/local optimum, existence and uniqueness of optimal solutions, variational inequality, Karush-Kuhn-Tucker (KKT) conditions, complementarity conditions, Lagrange multiplier, Lagrangian dual problem, global optimality conditions, weak/strong duality.
- Linear programming (LP): LP models, LP algebra and geometry, basic feasible solution (BFS), the Simplex method, LP duality, optimality conditions, strong duality, complementarity, interior point methods, sensitivity analysis.
- Nonlinear optimization methods: direction of descent, line search, (quasi-)Newton methods, Frank--Wolfe method, gradient projection, exterior and interior penalty methods.

Form of teaching

The course will be taught in English unless everyone involved speaks Swedish.

Assessment

The examination consists of a project assignment, two computer exercises, and a written examination. During the course, there may be optional assignments that give bonus points on the exam. Examples of such assignments are small written tests, labs, and oral or written presentations. Information about this is found on the course home page.

If a student, who has failed the same examined component twice, wishes to change examiner before the next examination, a written application shall be sent to the department responsible for the course and shall be granted unless there are special reasons to the contrary (Chapter 6, Section 22 of Higher Education Ordinance).

Grades

The grading scale comprises: Pass with Distinction (VG), Pass (G) and Fail (U).

Course evaluation

The course is evaluated with an anonymous questionnaire and/or a discussion with the student representatives. The results of and possible changes to the course will be shared with students who participated in the evaluation and students who are starting the course.

Additional information

The course *MMG621 Non-linear Optimization* has the same content as *MMG620*. You are not allowed to be registered or examined on more than one of these courses.

For a list of course literature, see:
https://www.chalmers.se/sv/institutioner/math/utbildning/grundutbildning-goteborgs-universitet/kurslitteratur/Sidor/Kurslitteratur-i-matematik.aspx