**DEPARTMENT OF MATHEMATICAL SCIENCES**

# MMG621 Nonlinear Optimization, 7.5 credits

Ickelinjär optimering, 7,5 högskolepoäng

*First Cycle*

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### Confirmation

This course syllabus was confirmed by Department of Mathematical Sciences on 2011-10-20 and was last revised on 2017-06-26 to be valid from 2017-07-10, autumn semester of 2017.

*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 main purpose of the course is to give a good theoretical grounding in some of the most important areas of optimization: convex, linear, and non-linear optimization. You will learn about the principles for analyzing the properties of a specific optimization problem, and characterization of feasible solutions which are (locally) optimal. The course is meant as a background for more applied courses, where you will get the chance to use your knowledge in solving practical optimization problems, such as *MMA511 Large-Scale Optimization*.

On successful completion of the course the student will be able to:

- describe the most important concepts of convex optimization, especially from convex analysis, as well as from the related areas of duality and optimality,
- describe the basics of necessary and sufficient optimality conditions and apply them to basic examples,
- describe the basics of linear optimization, especially duality, and use the most common method for this problem class: the simplex method,
- use the concepts of descent direction and feasible direction,
- describe the principles behind classic methods such as steepest descent, Newton's method, the Frank-Wolfe method, and sequential quadratic programming, and to have a basic knowledge about when they are expected to be convergent.

### Course content

This basic course in optimization describes the most relevant mathematical principles that are used to analyze and solve optimization problems. Practical assignments in the course are: (i) a project in which a practical optimization problem is modelled and solved with software and presented in a report, and (ii) two computer lab assignments where the student will get acquainted with some mathematical optimization methods and their properties. Perhaps the most central concept in the course is optimality, which is analyzed by means of a series of theorems about existence of optimal solutions, convex analysis, Lagrange duality, and necessary and sufficient conditions for optimality. Especially important are the Karush-Kuhn-Tucker conditions and when they are applicable. After the the theory of optimality is applied to constructing algorithms for finding optimal solutions. These are naturally divided in different types of methods for some standard types of optimization problems, such as linear optimization, optimization without constraints, and general non-linear constrained optimization. In the course their convergence properties are analyzed, and in some cases they will also be illustrated with examples, especially during the exercise sessions.

### 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