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SF2822 Applied Nonlinear Optimization, 7.5hp, 2019/2020

Instructor and examiner

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Exercise leader and project leader

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Course material

- *Linear and Nonlinear Optimization*, second edition, by I. Griva, S. G. Nash och A. Sofer, SIAM, 2009. (The book can be ordered from several places. Please note that you can become a SIAM member for free and obtain a discount at the SIAM bookstore.)
- *Exercises in applied nonlinear optimization, 2019/2020*. Available via Canvas.
- *Supplementary course material in applied nonlinear optimization, 2019/2020*. Available via Canvas.
- *Lecture notes in applied nonlinear optimization, 2019/2020*. Can be downloaded from this web page, see the schedule below. Also available via Canvas.
- *GAMS, A user's guide*. Available at the GAMS web site.
- *GAMS*. GAMS is installed in the KTH linux computer rooms. It may also be downloaded from the GAMS web site for use on a personal computer.
- Two project assignments that are handed out during the course, April 2 and April 22 respectively.

Additional notes that may be handed out during the course are also included.

Course goals

After completed course, the student should be able to:

- explain fundamental concepts of nonlinear programming;
- explain how fundamental methods for nonlinear programming work;
- illustrate how these methods work by solving small problems by hand calculations;
- starting from a suitably modified real problem, formulate a nonlinear program; make a model in a modeling language and solve the problem;
- analyze the solutions of the optimization problem solved, and present the analysis in writing as well as orally;
- interact with other students when modeling and analyzing the optimization problems.

Examination

The examination is in two parts, projects and final exam. To pass the course, the following is required:

- Pass project assignment 1, with presence at compulsory presentation lecture on Wednesday April 22, and presence at the following dicussion session.
- Pass project assignment 2, with presence at compulsory presentation lecture on Wednesday May 6, and presence at the following dicussion session.

- Pass final exam. Please note that advance application for participation in examinations is compulsory according to KTH's rules.

Course registration

Due to the project based nature of this course, students must register no later than March 30. Registration is made by the students online following KTH standard procedures.

Project assignments

The project assignments are performed in groups, where the instructor determines the division of groups. This division is changed between the two assignments. Assignment 1 is carried out using the modeling language GAMS. For project 2, there is a choice between a modeling assignment, to be carried out using GAMS, or a method assignment, to be carried out using Matlab. The project assignments *must* be carried out during the duration of the course and completed by the above mentioned presentation lectures. It is the responsibility of each student to allocate time so that the project group can meet and function. Presence at the presentation lectures is compulsory. For passing the projects, the following requirements must be fulfilled:

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- No later than the night before the presentation lecture, each group must hand in a well-written report which describes the exercise and the group's suggestion for solving the exercise. Suitable word processor should be used. The report should be on a level suitable for another participant in the course who is not familiar with the group's specific problem.
- At the beginning of the presentation lecture, each student should hand in an individual sheet with a brief self-assessment of his/her contribution to the project work, quantitatively as well as qualitatively.
- At the presentation lecture, all assignments will be presented and discussed. The presentations and discussions will be made in small presentation groups, first in presentation groups where each student has worked on the same project assignment, and then in presentation groups where the students have worked on different project assignments. Each student is expected to be able to present the assignment of his/her project group, the modeling and the solution. In particular, each student is expected to take part in the discussion. The presentation and discussion should be on a level such that students having had the same assignment can discuss, and students not having had the same assignment can understand the issues that have arisen and how they have been solved. Each student should bring a copy of the project group's report to the presentation lecture, either in paper or electronically.
- Each project group should make an appointment for a discussion session with the course leaders. There is no presentation at this session, but the course leaders will ask questions and give feedback. There will be time slots available the days after the presentation session. One week prior to the presentation lecture, a list of available times for discussion sessions will be made available at Doodle, announced via Canvas. Each project group should sign up for a discussion session prior to the presentation lecture.
- Each participant in the course must contribute to the work of the group. Each group must solve their task independently. Discussion between the groups is encouraged, but each group must individually solve the assignments. It is *not* allowed to use solutions made by others in any form. If these rules are violated, disciplinary actions in accordance with the KTH regulations will be taken.

Each project assignment is awarded a grade which is either fail or pass with grading E, D, C, B and A. Here, the mathematical treatment of the problem as well as the report and the oral presentation or discussion is taken into account. The exercises are divided into basic exercises and advanced exercises. Sufficient treatment of the basic exercises gives a passing grade. Inclusion of the advanced exercises is necessary for the higher grades (typically A-C). Normally, the same grade is given to all members of a project group. A student who has not worked on the advanced exercises says so in the self assessment form.

Each project group must solve their task independently. Discussion between the project groups concerrning interpretation of statements etc. are encouraged, but each project group must work independently without making use of solutions provided by others. All project groups will not be assigned the same exercises.

Each project assignment is awarded a grade which is either fail or pass with grading E, D, C, B and A. Here, the mathematical treatment of the problem as well as the report and the oral

presentation or discussion is taken into account. Normally, the same grade is given to all members of a group.

Final exam

The final exam consists of five exercises and gives a maximum of 50 points. At the exam, the grades F, Fx, E, D, C, B and A are awarded. For a passing grade, normally at least 22 points are required. At the exam, in addidion to writing material, no other material is allowed at the exam. Normally, the grade limits are given by E (22-24), D (25-30), C (31-36), B (37-42) and A (43-50).

The grade Fx is normally given for 20 or 21 points on the final exam. An Fx grade may be converted to an E grade by a successful completion of two supplementary exercises, that the student must complete independently. One exercise among the theory exercises handed out during the course, and one exercise which is similar to one exercise of the exam. These exercises are selected by the instructor, individually for each student. Solutions have to be handed in to the instructor and also explained orally within three weeks of the date of notification of grades.

The final exam is given Thursday May 28 2020, 8.00-13.00.

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Final grade

By identitying A=7, B=6, C=5, D=4, E=3, the final grade is given as

round((grade on proj 1) + (grade on proj 2) + 2 * (grade on final exam)) / 4),

where the rounding is made to nearest larger integer in case of a tie.

Preliminary schedule

"L" means lecture, "E" means exercise session, "P" means project sesstion.

Type	Day	Date	Time	Room	Subject
L1.	Mon	Mar 16	15-17	Q21	Introduction. Nonlinear programming models.
L2.	Wed	Mar 18	10-12	Q21	Optimality conditions for linearly constrained problems.
L3.	Thu	Mar 19	8-10	Q21	Optimality conditions for nonlinearly constrained problems.
E1.	Mon	Mar 23	15-17	Q21	Optimality conditions.
L4.	Wed	Mar 25	10-12	Q21	Unconstrained optimization.
L5.	Thu	Mar 26	8-10	Q21	Unconstrained optimization, cont.
E2.	Mon	Mar 30	15-17	Q21	Unconstrained optimization.
P1.	Wed	Apr 1	10-12	Q31	Introduction to GAMS.
P2.	Thu	Apr 2	8-10	Q21	GAMS excercise session.
L6.	Fri	Apr 3	13-15	Q21	Equality-constrained quadratic programming.
E3.	Mon	Apr 6	15-17	Q21	Equality-constrained quadratic programming.
L7.	Tue	Apr 7	15-17	Q21	Inequality-constrained quadratic programming.
L8.	Wed	Apr 8	10-12	Q31	Inequality-constrained quadratic programming, cont.
E4.	Thu	Apr 9	8-10	Q21	Inequality-constrained quadratic programming.
L9.	Mon	Apr 20	15-17	Q21	Sequential quadratic programming.
P3.	Wed	Apr 22	10-12	V32	Presentation of project assignment 1.
E5.	Thu	Apr 23	8-10	V32	Sequential quadratic programming.
L10.	Mon	Apr 27	15-17	Q21	Sequential quadratic programming, cont. Interior methods for nonlinear programming.
L11.	Wed	Apr 29	10-12	Q21	Interior methods for nonlinear programming, cont.
E6.	Mon	May 4	15-17	Q21	Interior methods for nonlinear programming.
P4.	Wed	May 6	10-12	Q21	Presentation of project assignment 2.

L12.	Mon	May 11	15-17	Q21	Semidefinite programming.
E7.	Wed	May 13	10-12	Q21	Semidefinite programming.
E8.	Thu	May 14	8-10	Q21	Selected topics.

Overview of course contents

- **Unconstrained optimization**
  Fundamental theory, in particular optimality conditions.
  Linesearch algorithms, steepest descent, Newton's method.
  Conjugate directions and the conjugate gradient method.
  Quasi-Newton methods.
  (Chapters 11, 12.1-12.3 and 13.1-13.2 in Griva, Nash and Sofer.)
- **Constrained nonlinear optimization**
  Fundamental theory, optimality conditions, Lagrange multipliers and sensitivity analysis.
  Quadratic programming.
  Primal methods, in particular active-set methods.
  Penalty and barrier methods, in particular primal-dual interior methods.
  Dulal methods, local duality, separable problems.
  Lagrange methods, in particular sequential quadratic programming.
  (Chapters 3, 14.1-14.7, 14.8.2, 15.1-15.5, 16.1-16.3 and 16.7 in Griva, Nash and Sofer.)
- **Semidefinite programming**
  Fundamental theory.
  (Chapter 16.8 in Griva, Nash and Sofer. Separate article in the supplementary course material. Fundamental concepts only.)

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Support for students with disabilities

Students with disabilities may have the right to certain compensatory support for example during examination.
KTH has coordinators for students with disabilities, Funka, who deals with issues relating to functional disabilities. You should turn to Funka at funka@kth.se for information about support.

Welcome to the course!

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Teacher Anders Forsgren changed the permissions 11 December 2018

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