IE 507 Nonlinear Optimization Methods

Year and Semester: **2016-2017 Spring**
Credit Hour: **(3,0)3**
ECTS: **7.5**
Prerequisite(s): **Graduate standing**

Catalog Description
Linear algebra and polyhedral sets. Duality and the theorems of the alternative. Convex sets and convex functions. Line-search methods. Unconstrained optimization. Optimality conditions. Steepest descent, Newton, quasi-Newton and conjugate-gradient algorithms. Constrained optimization and optimality conditions. The reduced gradient method. Penalty and barrier methods. Interior point algorithms for nonlinear optimization.

Prerequisite by Topic
Linear algebra, convexity, linear optimization and fundamentals of operations research and modeling.

Textbook
- S.G. Nash and A. Sofer, *Linear and Nonlinear Programming*, McGraw Hill 1996.

Reference Books
- M.S. Bazaraa, H.D. Sherali, and C.M. Shetty, *Nonlinear Programming* (2nd ed.), Wiley, 1993.
- D.P. Bertsekas, *Nonlinear Programming*, Athena Scientific, 1995.
- J. Shapiro, *Mathematical Programming*, Wiley, 1979.
- R.L. Rardin, *Optimization in Operations Research*, Prentice-Hall, 1998.

Course Objectives
- To provide a vision of the theory of nonlinear optimization as well as understanding of algorithms.
- To enhance the ability of making mathematical proofs.
- To give an understanding of algorithmic complexity and convergence.
- To emphasize the application areas of nonlinear optimization.
- To teach the students implement nonlinear programming algorithms using basic software and computer programming.

Course Outline

Weeks 1—4: **Revision of the Infrastructure**
A review of linear algebra. Linear equalities and inequalities, polyhedral sets. Linear objective functions. Convexity. Convex sets, cones, extreme points and extreme directions. Separating hyperplanes and supporting hyperplanes. Convex functions. Convex optimization.

Weeks 5—6: **Optimality Conditions**
Univariate minimization and line search techniques. Unconstrained optimization problems. Constrained optimization problems. Necessary conditions of optimality. Sufficient conditions of optimality. Feasible moving directions and step size selection for primal optimization algorithms.

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Weeks 7—12: **Overview of Algorithms**

Steepest descent algorithm. Newton's algorithm and its variants. Conjugate gradients method. The Lagrangean representation of constraints. Primal methods. Penalty and barrier function methods. Nonlinear approaches to linear programming problems. Projection onto convex sets. Analytic centers, cutting plane methods and shrinking polytopes. The ellipsoid method and an overview of interior point algorithms.

Week 13: **Complementary Project Discussions**

Each student is required to conduct an assigned project work related to nonlinear optimization. After a preliminary study is made by the student progress discussion will be made in the class. Due date of project submission will be announced during the semester.

Week 14: **Issues of Convergence and Algorithmic Complexity**

Convergence of algorithms. Rates of convergence. Computational complexity of combinatorial problems. Polynomial time algorithms and the theory of *NP*-completeness.

Computer Usage

Students should be able to use packages such as *MATLAB*, *LINGO*, and GAMS which will be required for homework assignments.

Grading Policy

HW Assignments	25%
Midterm Exam	30%
Final Exam	30%
Complementary Project	15%

Lecture Hours

Wednesday 18:00—20:50 (A-201)

Lecturer

Hakan Özaktaş, Ph.D. in Industrial Engineering
Office: L-323, x1377, ozaktas@cankaya.edu.tr
Office hours: TBA