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University of Illinois at Urbana-Champaign
Department of Industrial and Enterprise Systems Engineering

Course Title: **Convex Optimization**

Course Description: This course is focused on learning to recognize, understand, analyze, and solve constrained convex optimization problems arising in engineering. The course shall cover the fundamental convexity theory and the algorithmic approaches for nondifferentiable convex problems. It shall start with the theory of convex sets and convex functions, and their properties. The exposure to this theory is tailored to the level necessary for understanding the crucial aspects of constrained convex optimization problems, including existence of solutions, primal-dual properties, and zero duality gap conditions. All of these aspects will come to play an important role in the subsequent study of the fundamental and the state-of-art algorithmic approaches for nondifferentiable convex problems, and in the analysis of the quality of the algorithmic solutions. The course shall keep strong emphasis on practical applications, by providing numerous examples of convex optimization problems such as least-squares, linear and quadratic optimization, semidefinite programming, minimax problems, and some convex problems with special structures. The application areas include image/signal processing, control, and circuit design among others. This course would be of interest to students from math, ECE, computer science, mechanical engineering, civil engineering, and economics.

Number of Credit Hours: 4 hours

Offering Level: Graduate students.

Prerequisites: Basic background in Linear Algebra and Multivariate Calculus.

Instructor: Angelia Nedich

Lecture Schedule for Convex Optimization 498 AN

L1 Introduction

L2 **Theory and Principles** Convex Sets [H1, none][1]

L3 Convex Sets (Geometry)

L4 Convex Functions [H2, H1 in]

L5 Operations Preserving Convexity

L6 Convex Problems [H3, H2 in]

L7 Existence and Characterization of Optimal Solutions

L8 Projection, Hyperplanes, Separation [H4, H3 in]

L9 Lagrangian Duality (Motivation)

L10 Lagrangian Duality (Optimality Conditions) [H5, H4 in]

L11 Lagrangian Duality (Saddle-Point Results)

L12 Lagrangian Duality (Sensitivity) [H6, H5 in]

L13 **Algorithms** Unconstrained Optimization (Gradient)

L14 Unconstrained Optimization (Newton's Method) [H7, H6 in]

L15 Interior Point Method: Barrier, Central Path

L16 Interior Point Method: Feasibility, Ph. I Methods [H8, H7 in]

L17 Interior Point Method: Complexity, Self-Conc., Primal-Dual

L18 Equality Constrained Optimization [H9, H8 in]

L19 Dual Methods

L20 Subgradient Methods [H10, H9 in]

L21 Cutting Plane

L22 Bundle Methods [H11, H10 in]

L23 Bundle Methods

L24 **Applications** Approximation and Fitting [H12, H11 in]

L25 Statistical Estimation

L26 Geometric Problems [H13, none]

L27 Semidefinite Optimization

[1] The homework assignment handed out and the homework assignment due

TEXTBOOK

The *recommended book* for the course is:
"Convex Optimization" by Boyd S. and Vandenberghe L., Cambridge University Press, 2004.
The book is available for free on at the following web-address:
http://www.stanford.edu/ boyd/cvxbook/

Some of the course material is also covered in:
"Convex Analysis and Optimization" by Bertsekas D. P., Nedić A., and Ozdaglar A. E., Athena Scientific, 2003.

HOMEWORK

The promptness of homework submittal counts. Discussing the homework problems (and solutions) in groups is encouraged. However, it is expected that everyone writes the solutions independently.

GRADES

Final grades are formed based on:

Homework (30%)

Participation in the class (10%)

Final exam (and possibly projects) (only exam 60%, exam and projects the split is 40% exam and 20% projects)[2]

OFFICE HOURS

Office hours are on Tuesdays from 3:00–4:00pm in Room 211 in TB117.

[2]Projects will be paper presentations.