ISE 496: Convex Analysis and Optimization, Spring 2014

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Description: Convexity, as it is defined for sets and functions, is of fundamental importance in the study of mathematical optimization. The purpose of this course is to provide a rigorous introduction to the rich field of convex analysis, particularly as it relates to optimization and duality theory. In addition to more formal analytical tools and concepts, emphasis is placed on developing a geometric and visually intuitive understanding of convex objects, optimization problems, and duality.

Course Objectives: The objectives of this course are for students to do the following:

- Understand the central role of convexity in optimization theory.
- Learn basic concepts related to convex sets and functions.
- Explore important special types of convexity, such as polyhedral convexity.
- Gain a fundamental understanding of duality via insights provided by geometric arguments.
- Investigate concepts related to conjugacy and the calculus of subdifferentiable functions.
- Develop a mathematically rigorous understanding of an important area of research.
- Be able to apply course concepts in other areas of scientific research.

Prerequisite Topics: Multivariable Calculus, Linear Algebra, and Real Analysis.

Lectures: Wednesdays, 5:10pm-8:00pm in Mohler 375.

Office Hours: I have reserved Thursdays, 10:00am-12:00pm, for office hours. I am also available through e-mail (always) and on Google Talk (often). If I do not respond to an e-mail within 24 hours, then please assume that I have not received it and send a follow-up e-mail. If I do not respond on Google Talk, then I am either busy or you are contacting me too late in the day, in which case you can try again the next day (during work hours) or send an e-mail instead. I am also willing to meet at other times, but in such cases please e-mail me in advance to set up a mutually convenient time.

Course Site: Lecture notes will be posted on Course Site prior to each lecture. Homework assignments, solutions, announcements, and other important material will also be posted on Course Site. Important information, corrections, and updates about the course may also be sent by e-mail (via Course Site).

Textbook: The primary textbook for the course is the following:

- Dimitri P. Bertsekas, *Convex Analysis and Optimization*, Athena Scientific, Nashua, NH, USA, 2009.

Reading the textbook is not required, but it is recommended. You are not responsible for textbook material that is not covered in lecture. Course material also will be derived from the following recommended textbooks:

- Frank H. Clarke, *Optimization and Nonsmooth Analysis*, Canadian Mathematical Society Series of Monographs and Advanced Texts, Wiley-Interscience, New York, NY, USA, 1983.
- Jean-Baptiste Hiriart-Urruty, Claude Lemaréchal, *Convex Analysis and Minimization Algorithms I*, Springer Series of Comprehensive Studies in Mathematics, Springer, New York, NY, USA, 1993.

- R. Tyrrell Rockafellar, *Convex Analysis*, Princeton University Press, Princeton, NJ, USA, 1970.
- R. Tyrrell Rockafellar, Roger J-B. Wets, *Variational Analysis*, Springer Series of Comprehensive Studies in Mathematics, Springer, New York, NY, USA, 1998.
- Andrzej Ruszczyński, *Nonlinear Optimization*, Princeton University Press, Princeton, NJ, USA, 2006.

LaTeX: All work must be submitted as documents produced with LaTeX. There are no exceptions to this requirement. Assistance for learning LaTeX will be given in the form of the source for all documents produced for the course. I will also provide templates for all homeworks. It is not required that you use the templates provided, but it is highly recommended, especially if you are unfamiliar with LaTeX.

Grading: Your grade will be calculated as follows.

Homework:	30%
Midterm Exam:	30%
Final Exam:	30%
Participation:	10%

Homeworks: There will be regular homework assignments throughout the semester, generally assigned and due every few weeks. Each homework must be submitted electronically. No credit will be given for any late assignment. You are free to consult with other students when working on homework, but the work you turn in must be your own. *Please cite any references you use, including fellow students.*

Exams: Both exams will be cumulative, closed-book, closed-notes, in-class, *written* exams.

Participation: Attendance will not be taken. However, participation will factor into your grade. If you are unable to participate in lecture, then participation entails being a presence online—via e-mail or Course Site—or in office hours. In short, if by the end of the semester I do not remember your having been in the course, then your participation grade will suffer.

Collaboration Policy: The sharing of ideas is educationally useful and you are encouraged to discuss assignments with other students. However, *plagiarism* of any kind is destructive, fraudulent, and unacceptable. You are *strictly* forbidden to copy another student's written work, whole or in part, and submit that work under your name. You are also *strictly* forbidden to make trivial or mechanical changes to another student's written work and submit that work under your name. Note that while electronic plagiarism is easier to perform (via copy-and-paste), it is also easier to detect. Plagiarized work will receive no credit and repeat offenses will result in more severe action. A sure way to avoid this issue is to discuss the assignments with fellow students, but then write your solutions individually and independently.

Emergencies: Everyone is responsible for all material covered and announcements made in lecture. If you believe you will miss a long period of time in the course due to illness, a family emergency, etc., then please contact me as early as possible. Under no circumstances will I give credit for missed work unless you have discussed your absence with me in advance.

Regrade Requests: If you disagree with a grade you receive on a homework, exam, or project component, then you may submit a regrade request. This request must be in writing and submitted no more than 48 hours after you receive the graded assignment.

Recording Devices: Voice and/or video recording devices may be used only with the approval of everyone in the classroom. Please let me know in advance if you wish to use these types of devices.

Students with Disabilities: If you have a disability for which you are or may be requesting accommodations, please contact me and the Office of Academic Support Services, University Center C212 (610.758.4152) as early as possible in the semester. You must have documentation from Academic Support Services before accommodations can be granted.

Equitable Community Principles: Lehigh University endorses The Principles of Our Equitable Community (http://www4.lehigh.edu/diversity/principles). We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.

Preliminary Schedule:

Week	Date	Lecture Topic(s)	Notes
1	1/15	Introduction	
2	1/22	Convex Sets and Functions	
3	1/29	Characterizing Convexity and Closedness	
4	2/05	Projections, Hulls, Interiors, and Closures	
5	2/12	Recession Cones and Functions	
6	2/19	Hyperplanes and Conjugacy	
7	2/26	Polyhedral Convexity	
8	3/05	(No lecture)	Spring Break
9	3/12	Midterm Review (and Exam)	Midterm Exam
10	3/19	Convex Optimization	
11	3/26	Min Common and Max Crossing Duality	
12	4/02	Weak and Strong Duality	
13	4/09	Nonlinear Farkas Lemma	
14	4/16	Subdifferential Calculus	
15	4/23	Theorems of the Alternative	
16		(No lecture)	Final Exams