LEHIGH UNIVERSITY

Course Syllabus
ISE 401: Convex Analysis, Fall 2018

Course Information:

Lectures:	Tuesdays & Thursdays, 10:45am-12:00pm, Mohler 375
Office Hours:	Tuesdays & Thursdays, 01:00pm-02:00pm, Mohler 475

Instructor Information:

Name:	Frank E. Curtis
Office:	Mohler 475
Phone:	+1 (610) 758-4879 (Office)
	+1 (646) 789-5490 (Mobile)
E-mail:	frank.e.curtis@gmail.com
	frank.e.curtis@lehigh.edu
IM:	`frank.e.curtis` (Google)
	`frank.e.curtis` (Skype)
Web:	http://coral.ise.lehigh.edu/frankecurtis

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

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

- Understand the central role of convexity in applied mathematics and optimization in particular.
- 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: Mathematical Logic, Multivariable Calculus, Linear Algebra, and Real Analysis. Please see the *Mathematical Background* document provided on Course Site.

Office Hours: Please come to office hours if you have any questions about the course. I am also available through e-mail (always) and on Google chat (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 chat, 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 [1]. 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 [2, 3, 4, 5, 6, 7].

References:

[1] D. P. Bertsekas. *Convex Optimization Theory.* Athena Scientific, Nashua, NH, USA, 2009.

[2] S. Boyd and L. Vandenberghe. *Convex Optimization.* Cambridge University Press, New York, NY, USA, 2004.

[3] F. H. Clarke. *Optimization and Nonsmooth Analysis.* Canadian Mathematical Society Series of Monographs and Advanced Texts. John Wiley & Sons, New York, NY, USA, 1983.

[4] J.-B. Hiriart-Urruty and C. Lemaréchal. *Convex Analysis and Minimization Algorithms I.* A Series of Comprehensive Studies in Mathematics. Springer-Verlag, New York, Berlin, Heidelberg, 1993.

[5] R. T. Rockafellar. *Convex Analysis.* Princeton Landmarks in Mathematics and Physics. Princeton University Press, Princeton, NJ, USA, 1970.

[6] R. T. Rockafellar and R. J.-B. Wets. *Variational Analysis.* A Series of Comprehensive Studies in Mathematics. Springer-Verlag, Berlin, Heidelberg, New York, 1998.

[7] A. Ruszczyński. *Nonlinear Optimization.* Princeton University Press, Princeton, NJ, USA, 2006.

Expected Schedule:

Week	Dates	Lecture Topic(s)	Note(s)
1	08/28, 08/30	Motivation and Background	
2	09/04, 09/06	Convex Sets	
3	09/11, 09/13	Projections, Hulls, and Relative Interiors	
4	09/18, 09/20	Recession Cones and Lineality Spaces	
5	09/25, 09/27	Hyperplanes and Separation	
6	10/02, 10/04	Polyhedral Sets	
7	10/09, 10/11	Convex Functions	
8	10/16, 10/18	Convex Set to Convex Function Theory	Pacing Break
9	10/23, 10/25	Conjugate Functions	Midterm Exam
10	10/30, 11/01	Fundamentals of Convex Optimization	
11	11/06, 11/08	Geometric Duality Framework	
12	11/13, 11/15	Convex Optimization Duality	
13	11/20, 11/22		Thanksgiving Break
14	11/27, 11/29	Subdifferential Theory	
15	12/04, 12/06	Additional Topics	
16			Final Exam

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 documents produced for the course. I will also provide a template for homework solutions. It is not required that you use the provided template, but it is recommended, especially if you are unfamiliar with LaTeX.

Grading: Your grade will be calculated as follows.

Homework:	25%
Midterm Exam:	35%
Final Exam:	35%
Participation:	5%

Homeworks: There will be regular homework assignments throughout the semester, generally assigned and due every few weeks. Each homework must be submitted electronically via Course Site. No credit will be given for any late assignment. You are free to consult with other students when working on homeworks, but the work you submit must be your own. *Please cite any references you use, including fellow students.* Your homework grade will be determined by the number of points you accumulate over the entire semester as compared to the maximum number of points that are possible to accumulate. In this manner, homeworks with more questions will effectively have a higher weight in determining your homework grade.

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 we have not had any one-on-one discussions about the course and/or course material, 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 credit be given for missed work unless you have discussed your absence with me in advance.

Regrade Requests: If you disagree with a grade you receive, then you may submit a regrade request. This request must be written and submitted no more than 48 hours after you receive the grade.

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.

Accommodations for 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, Williams Hall, Suite 301 (+1 (610) 758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

The Principles of Our Equitable Community: Lehigh University endorses The Principles of Our Equitable Community (http://www.lehigh.edu/~inprv/initiatives/PrinciplesEquity_Sheet_v2_032212.pdf). 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.