LEHIGH UNIVERSITY

Course Syllabus
ISE 401: Convex Analysis
Fall 2020

Course Information:

Lectures:	Tuesdays & Thursdays, 1:35pm-2:50pm, Mohler 375
Zoom:	Mondays & Thursdays, 9:00am-10:00am, https://lehigh.zoom.us/my/frank.e.curtis
Office Hours:	Thursdays, 1:00pm-3:00pm (or by appointment), https://lehigh.zoom.us/my/frank.e.curtis

Instructor Information:

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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.

Blended Course Model: This course will be run using a blended model. Lectures will be prerecorded. It is expected that you will watch these lectures prior to the Zoom sessions in which they will be discussed, keeping up with the schedule of the course (see next page). Regular Zoom sessions will be scheduled to discuss lecture topics and other matters. All Zoom sessions will be held using https://lehigh.zoom.us/my/frank.e.curtis. A Slack workspace has been created to communicate about the course.

Zoom: Zoom sessions work best when all students join, are ready to participate, and follow the same guidelines regarding use of video. I will be asking all students to turn on their cameras during active

learning sessions in Zoom. If you have a strong preference not to do so, then please let them know. Students should respect everyone's privacy by not taking screenshots or recording the live sessions. I do *not* plan to record the Zoom sessions myself, although if requested it is something that we could consider as a class. If recordings are ever made, then they would only be shared with students in the class and will be deleted at the end of the semester.

Course Site: Lecture notes and recordings will be posted on Course Site. Homework assignments, solutions, announcements, and other important material will also be posted on Course Site and on Slack. Important information, corrections, and updates about the course may also be sent by e-mail and on Slack.

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	08/25, 08/27	Motivation and Background	
2	09/01, 09/03	Convex Sets	
3	09/08, 09/10	Projections, Hulls, and Relative Interiors	
4	09/15, 09/17	Recession Cones and Lineality Spaces	
5	09/22, 09/24	Hyperplanes, Separation, and Polyhedral Sets	
6	09/29, 10/01	Convex Functions	
7	10/06, 10/08	Conjugate Functions	Midterm
8	10/13, 10/15	Fundamentals of Convex Optimization	
9	10/20, 10/22	Geometric Duality Framework	
10	10/27, 10/29	Convex Optimization Duality	
11	11/03, 11/05	Subdifferential Theory	
12	11/10, 11/12	First-Order Algorithms	
13	11/17, 11/19	Second-Order Algorithms	
14	11/24, 11/26	Constrained Optimization Algorithms	Thanksgiving Break
15	12/01, 12/03	Review	
16			Final

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:	40%
Midterm Exam:	25%
Final Exam:	25%
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 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.

Participation: Attendance will not be taken. However, participation will factor into your grade. If you are unable to participate in Zoom sessions, then participation entails being a presence in other ways, such as over e-mail or on Slack. 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.

Accommodations for Students with Disabilities: Lehigh University is committed to maintaining an equitable and inclusive community and welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact Disability Support Services (DSS), provide documentation, and participate in an interactive review process. If the documentation supports a request for reasonable accommodations, DSS will provide students with a Letter of Accommodations. Students who are approved for accommodations at Lehigh should share this letter and discuss their accommodations and learning needs with instructors as early in the semester as possible. For more information or to request services, please contact Disability Support Services in person in Williams Hall, Suite 301, via phone at 610-758-4152, via email at indss@lehigh.edu, or online at https://studentaffairs.lehigh.edu/disabilities.

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.