IE417: Nonlinear ~~Programming~~ Optimization

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Description: Our primary goal as engineers is to optimize, whether it be designs, systems, processes, or decisions. This, along with the fact that (practically) everything around us is inherently nonlinear, brings us to the need to solve *nonlinear optimization* problems. The purpose of this course is to introduce the basic theoretical principles behind nonlinear optimization and the numerical methods that are available to solve these types of problems. We begin with the central component of nearly all nonlinear optimization algorithms — Newton's method — then develop an understanding of optimality conditions and duality in the presence of nonlinear functions, and finally discuss modern numerical methods for nonlinear optimization.

Lectures: Lectures will normally be held on Tuesdays and Thursdays at 4:10pm-5:25pm in Mohler 453. However, I will be traveling the weeks of October 11-15 and November 8-12, which may require that we reschedule a few lectures around those times.

Office Hours: I have reserved Wednesdays from 9:00am-12:00pm for office hours. This should work well for most people since homeworks will normally be due and quizzes/exams will normally be scheduled on Thursdays. However, 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 send a reminder/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 either try again the next day (during work hours) or send an e-mail instead. I am also willing to schedule other times to meet in my office, but please e-mail me in advance to set up a time.

Materials: The required textbook for the course is:

- J. Nocedal and S. J. Wright, *Numerical Optimization*, Second Edition, Springer Series in Operations Research, Springer, New York, NY, USA, 2006.

Course material also will be derived from the following recommended textbooks:

- M. S. Bazaraa, H. D. Sherali, and C. M. Shetty, *Nonlinear Programming: Theory and Algorithms*, John Wiley & Sons, Hoboken, NJ, USA, 2006.
- D. P. Bertsekas, *Nonlinear Programming*, Second Edition, Athena Scientific, Belmont, MA, USA, 1999.
- R. L. Burden and J. D. Faires, *Numerical Analysis*, Seventh Edition, Brooks/Cole, Pacific Grove, CA, USA, 2001.
- J. E. Dennis, Jr. and R. B. Schnabel, *Numerical Methods for Unconstrained Optimization and Nonlinear Equations*, Classics in Applied Mathematics, SIAM, Philadelphia, PA, USA, 1996.
- R. Fletcher, *Practical Methods of Optimization*, Second Edition, John Wiley & Sons, Chichester, West Sussex, England, 1987.
- A. Ruszczyński, *Nonlinear Optimization*, Princeton University Press, Princeton, NJ, USA, 2006.

Grading: Your grade will be calculated as follows:

Homeworks:	25%
Quizzes:	25%
Project:	15%
Final Exam:	25%
Participation:	10%

Homeworks: There will be homeworks assigned (roughly) every other week throughout the semester.

- *No credit* will be given for any late assignment.
- You are free to consult with other students when working on homework. However, *the work you turn in must be your own.* Please cite any references you use, including fellow students.
- Homework must be submitted electronically through Coursesite. I *strongly* prefer assignments that are written up in LaTeX. However, scanned hand-written documents are also acceptable as long as they are written legibly. If I cannot read your work, then no credit will be given.

Quizzes: There will be two quizzes during the semester. Each will be cumulative and closed-book/notes.

Projects: The course project will not be a single assignment, but rather the accumulation of all of the coding components of homeworks that will be assigned throughout the semester. All coding must be done in Matlab. If you are not experienced in coding and/or Matlab, then I suggest you start practicing early as you will be expected to learn these things on your own. Ask me if you have any questions. The grade for the project will be based on the correctness of the code and the comments/documentation that you provide.

Final Exam: The final exam will be cumulative.

Participation: Everyone is expected to attend lecture, ask and respond to questions, and provide feedback about the lectures and assignments. My hope is that everyone will receive all of the possible credit for this part of the grade, but, if by the end of the semester I have no idea who you are, then your participation grade will suffer. In short, you are expected to communicate with me during the semester!

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

Absences: Class attendance will not be recorded. However, everyone is expected to attend lecture and so everyone will be responsible for all material covered and announcements made in lecture. *It is your responsibility to contact me about any important information you might have missed in class if you were unable to attend.* If you believe you will miss numerous lectures due to illness, family emergencies, etc., then please contact me as early as possible. *Under no circumstances will I give credit for a missed homework, quiz, or exam unless you have discussed your absence with me in advance.*

Coursesite: Lecture slides will be posted on Coursesite prior to each lecture. Homework assignments, solutions, announcements, and other important material will also be posted on Coursesite. Important information, comments, corrections, and updates about the course may also be sent via e-mail (through Coursesite). Therefore, please let me know if you do not receive mass e-mails sent through Coursesite.

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.

Tentative Schedule:

Week	Tues.	Thurs.	Topics	Exams
1	Aug. 31	Sept. 2	Newton's method, numerical analysis	
2	Sept. 7	Sept. 9	Convexity theory	
3	Sept. 14	Sept. 16	Unconstrained optimization theory	
4	Sept. 21	Sept. 23	Line search methods	
5	Sept. 28	Sept. 30	Trust region methods	
6	Oct. 5	Oct. 7	Conjugate direction methods	Quiz 1
7	Oct. 12	Oct. 14	Quasi-Newton methods	
8	Oct. 19	Oct. 21	Constrained optimization theory	
9	Oct. 26	Oct. 28	Constraint qualifications	
10	Nov. 2	Nov. 4	Duality theory	
11	Nov. 9	Nov. 11	Linear/quadratic optimization	
12	Nov. 16	Nov. 18	Penalty methods	Quiz 2
13	Nov. 23	Nov. 25	Sequential quadratic optimization	
14	Dec. 30	Dec. 2	Interior-point methods	
15	Dec. 7	Dec. 9	Review	