ISE 406: Introduction to Mathematical Optimization Syllabus

Dr. Tamás Terlaky

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1 Miscellaneous Course Information

Instructor:	Dr. Tamás Terlaky
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Office Hours:	Thursday 2:30pm-3:30pm or by appointment
Teaching Assistant:	Liyuan (Leon) Cao (Email: lic314@lehigh.edu)
Course meeting time:	Tuesday and Thursday 13:10-14:25 in Mohler 375

2 Description of Course

This course will be an introduction to mathematical optimization, or other words into "mathematical programming", with an emphasis on algorithms for the solution and analysis of deterministic linear models. The primary types of models to be addressed will be linear optimization. However, the course will touch on more complex models, such as integer linear optimization, and convex conic optimization. Those include Second Order Conic and Semidefinite Optimization. The main emphasis will be on underlying mathematical structure of these models; on various algorithms, duality, solution techniques; and on the complexity and convergence analysis of the algorithms. Among others simplex and pivot algorithms, Ellipsoid and interior point methods are discussed. As a supporting theme, the course will also emphasize effective modeling techniques, and the assignments will requires the use of state-of-the-art optimization software.

3 Course Objectives

The goals of this course are for students to:

1. Improve their ability to rigorously prove mathematical statements.
2. Cultivate an ability to analyze the structure of and mathematically model various complex systems occurring in industrial and engineering applications.
3. Develop knowledge of the mathematical structure of the most commonly used deterministic, continuous and discrete, linear and conic linear optimization models.

4. Develop an understanding of the algorithms and techniques used to solve and analyze linear, and conic linear optimization models using their mathematical structure.

5. Develop knowledge of existing solvers for linear and conic liner optimization.

4 General Course Requirements

4.1 Prerequisites

You are expected to have a good undergraduate mathematics background, especially in linear algebra. Familiarity with logic and proof techniques, as well as basic knowledge of numerical computing is expected as well, while experience with mathematical modeling is a plus.

4.2 Recommended Primary Text

D. Bertsimas and J.N. Tsitsiklis, *Introduction to Linear Optimization*, Athena Scientific (1997).

This only the primary reference book, further literature, papers, and transparencies will be made available during the course, e.g., chapters of the book.

C. Roos, T. Terlaky, and J.-Ph. Vial, *Interior Point Methods for Linear Optimization*, Springer Science, Heidelberg/Boston, 2006,

and other papers.

4.3 Reading

There will be required readings associated with each lecture. Links to supplementary reading material will be accessible from the course WEB page.

4.4 Lectures

You are expected to attend and participate in the lectures, actively participate in, and initiate discussions. Part of the grade will be determined by overall class participation. Lecture materials will be available for reference on the course web page. This is a Ph.D. level course, the lectures also discuss material not covered by the primary text books.

4.5 Assignments

Mandatory assignments, and quick bonus home works will be given throughout the course.

4.6 Exams

There will be a midterm and a final exam. All exams will be closed book and closed notes, however you are allowed to prepare ONE sheet of letter size "cheat-sheet". The "cheat-sheet", must be hand written by you.

4.7 Course Topics

Review of modeling of linear optimization problems. Geometry of linear models. Duality, Farkas Lemma. Families of Pivot algorithms, cycling and finiteness. The Ellipsoid method. Interior Point Methods. Sensitivity analysis. Large-scale Linear Optimization. Assignment and Transportation problems. Integer and mixed integer linear optimization: Models and algorithms. Introduction to conic linear optimization, such as second order and semidefinite optimization.

5 Course Policies and Procedures

5.1 Referencing the Work of Others

You should attempt the problem sets on your own before consulting outside references. However, I encourage the use of research materials as a way to supplement your understanding of the course material, as long you heed the following common-sense ground rules. First, you may not consult my solutions or the problems sets of other students from previous offerings of this course. Second, external sources may be used only to improve your own understanding. You may not quote directly from any source and you should not write down anything that you do not understand. When you write your solutions, you should do it on your own without the direct help of any external sources. If you do use external references, discussions with your fellow students, in improving your understanding, you must cite them! Failure to cite references will be treated as cheating and will not be tolerated. If you are diligent about citing references, you will come out ahead in the end. Please ensure that you understand the spirit and the letter of these rules before beginning any class work.

Shortly, you must follow the rules of academic integrity.

5.2 Respect for Intellectual Property

In both your classwork and your research, it is important that you be aware of and respect the intellectual property rights of others. Unless explicitly stated otherwise, all materials available on the Internet, in libraries, and elsewhere are considered intellectual property and can only be used with the permission of the owner. Please be aware of the license you are being granted when you use these materials and what you are and are not allowed to do with them.
`http://www.lehigh.edu/lts/official/Academic_Integrity_Vignettes.pdf`.

5.3 Group Work

You are encouraged to work together on problem sets, especially those designated as group work. However, unless the problem set is specifically designated as group work, you must ultimately demonstrate your understanding of the material by writing up your own solutions without the help of other students or their written work. If you consult with other students (or faculty) on a problem set, this is considered equivalent to consulting any other reference and must be cited appropriately. This policy will be strictly enforced.

5.4 Turning in Assignments

All assignments should be delivered in the class or submitted electronically by e-mailing a PDF file to the TA by the beginning of the class period in which the assignment is due. The official turn-in

time of the assignment will be the time stamp on the e-mail. The PDF file should have the name `<Network ID>-HW*.pdf` where the "*" is replaced by the assignment number and the subject of the e-mail should be "IE406 Assignment *," where "*" is replaced by the assignment number. If the assignment is a group assignment, then the mail ID of all the group participants should be listed in the file name separated by hyphens. LaTex is strongly recommended for producing your solutions, but Microsoft Word is acceptable.

5.5 Bonus Homework

Occasionally Bonus Homework problems will be given in the class. The solution of those homework problems enhance deeper understanding of the material. Bonus homework solutions must be handed at the start of the next class. You will be rewarded by one percentage point bonus of your final grade if your solution is correct.

5.6 Lateness

I will allow a total of 2 days of lateness on assignments throughout the semester. These 2 days can be split up in any way you choose. In other words, you can have one assignment late by 2 days or 2 assignments each late by one day. After that, there is a penalty of 25% off per late-day on each assignment. No assignment will be accepted more than 4 days late. Exceptions to this rule may be made on a case-by-case basis. Please let me know, with proper reasoning, if you will be turning in an assignment late.

5.7 Grading Scheme

There will be 4 assignments, 1 midterm exam, a project and 1 final exam. While students are welcome to discuss assignments in groups, everyone must hand in his/her own write-up. Your grade will be determined as follows: Assignments: 24%; Midterm: 25%; Project: 10%; Class participation: 5%; Final: 36%.

5.8 Notes, Statements

Feedback: I do appreciate of getting feedback from my students about all -let it be positive or to be improved aspects of the course. Please don't be afraid to tell me what you think. Utilize office hours, or just talk to me before or after class.

Learning Styles: There are many different styles of learning. Some people gain better understanding from listening to something being explained orally. Some get better understanding from written material. Some like a combination of both. I do my best to accommodate various styles of learning. However, feel free to let me know what your learning style is so that I can take that into account when determining the future direction of the course.

Technology improves fast: Intelligent pens and other recording devices are getting available for a reasonable price. Please keep the general privacy rules in mind: Any voice or video recording device in the classroom may be used only after gaining consent from all course participants.

5.9 Polyces

Religious Accommodation Policy:
Lehighs Religious Accommodation Policy is published in the Student Handbook. The web site for

this policy, as well as a calendar of various major religious holidays, can be found at http://www.lehigh.edu/~inch

Accommodations for Students with Disabilities

If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, Williams Hall, Suite 301 (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.There are many different styles of learning. Some people gain better understanding from listening to something being explained orally. Some get better understanding from written material. Some like a combination of both. I do my best to accommodate various styles of learning. However, feel free to let me know what your learning style is so that I can take that into account when determining the future direction of the course.