IEOR E4004 Optimization models and methods

Raghav Singal
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Columbia University

E-mail: rs3566@columbia.edu
Web: Canvas
Office hours: After lectures/e-mail
Lectures: Tue & Th 5:40 to 6:55pm in Mudd 303

Course description

An introductory level course in mathematical optimization. We first introduce the idea of optimization and then discuss how to formulate decision-making problems as *optimization models*. We then shed light on *methods/algorithms* used to solve these optimization models. We cover basics of linear optimization (module 1), network optimization (module 2), integer optimization (module 3), dynamic optimization (module 4), and non-linear optimization (module 5). Each module in itself is deep enough to be taught for an entire semester (perhaps more) and hence, our coverage is not exhaustive.

Required materials

The course will be based on the notes written on the blackboard, which will be mostly based on *Introduction to Mathematical Programming: Operations Research, Volume 1* by Wayne L. Winston. It will be useful to have this textbook.

Pre-requisites

Linear algebra and calculus (both at the undergraduate level) is a must. Proficiency in a computer programming langauage (python or matlab) is a plus but not necessary.

Course objectives

There are five main objectives:

- Show students that optimization is central to decision-making in the real-world
- Enable students to *see* and *model* decision-making problems as optimization problems
- Teach students to use basic software to solve optimization problems
- Expose students to some elementary theory of optimization
- Make students realize there's much more in the world of optimization than what we cover

Teaching and course assistants

TBD

Course structure

Lectures We will have two lectures per week and each lecture will be 75 minutes long. I will be mostly writing on the blackboard. Most of the content will be based on the textbook mentioned above. I have provided a detailed schedule of this course (at the end of this document), which states the sections of the textbook that will be covered in each lecture[1]. Accordingly, if you miss a lecture, please ensure you understand the contents of the corresponding sections and ask a friend to see what I covered.

Recitations We will have occassional recitations (around 3 in total). Most of them will cover basics of optimization software.

Homeworks There will be around 7 homeworks in total. The "zeroeth" homework will cover basics of linear algebra and will be optional. The goal of homeworks is to let you practice some concepts introduced in class in addition to giving you a chance to learn new (but related) concepts[2]. It might be tempting to use the solutions available on the web (or from previous years) but I strongly encourage you to give the problems a shot first (else, you might struggle on the midterm/exam). It is usually a good idea to discuss among your peers but only after you have thought about the problems in your own time.

Midterm We will have an in-class midterm on March 7th (Thursday) during normal lecture hours (5:40pm to 6:55pm). You are allowed to bring *one* A4 sized cheat sheet (both sides). Any other aid (notes, books, electronics, calculators, etc.) is not allowed. The location is TBD.

Final exam We will have an in-class final exam sometime between May 10th and May 17th. You are allowed to bring *two* A4 sized cheat sheets (both sides). Any other aid (notes, books, electronics, calculators, etc.) is not allowed. The time and location are TBD.

Grading scheme Homeworks (20%), midterm (30%), final exam (35%), class participation (15%)

Piazza We will be using Piazza to allow students to discuss amongst themselves. I will be monitoring the threads and will reply if required. Please check Piazza (or announcements on Canvas) before sending me an e-mail. Things will be more efficient and uniform this way.

[1] I might deviate a little. Moreover, I might cover a few things that are not in the textbook.

[2] Note that homeworks do not cover all the concepts taught in class but this does **not** mean that only the concepts covered in homeworks are testable. Covering all the concepts in homeworks would make the homeworks too long and hence, I did not do so. I recommend you to practice additional problems from the textbook (or other resources) if you have time. This will strengthen your understanding and help you score a higher grade.

Course policies

During class Computers will be allowed. However, if you are using a computer, please sit towards the end of the classroom so that you do not distract others. Please refrain from using computers for anything but activities related to the class. Phones are prohibited. Eating and drinking are allowed in class but please refrain from it affecting the course. As a general courtesy, you should not be talking when I am and I will not be talking when you are.

Attendance Attendance is optional. However, you will be responsible for any material covered in the lectures. If you plan to attend, please arrive on time and show enthusiasm during class. (You will be rewarded[3] for doing so.)

Homework submission All submissions should be written/typed neatly and uploaded on Canvas. You can scan hand-written solutions. You should turn in only *one* pdf file containing your homework solutions (no other format will be accepted). You are not requried to submit any code. After submitting the pdf, download it and ensure it is okay.

Late submissions will be accepted for no penalty if a valid excuse is communicated before the deadline. After the deadline, each minute will result in a 0.1% deduction in grade. For example, if you submit 15 minutes late and received 90%, then your actual grade will be 88.5%.

Grading policy It is usually a hard task to assign grades to complete accuracy and therefore, I will employ the following 5-step grading policy while grading each question to ensure uniformity:

- if everything is correct, you will receive 100%
- if most of the things are correct, you will receive 80%
- if parts are correct, you will receive 50%
- if most of the things are incorrect or you do not write anything[4], you will receive 20%
- if everything is incorrect, you will receive 0%.

Solutions that are hard to understand (due to poor handwriting, low quality scan, being too long, etc.) will be penalized.

E-mailing me Feel free to e-mail me with any question you have. However, I encourage you to ask me questions that I can answer using one word (yes/no) or a short sentence. Moreover, if something is relevant to the whole class, post it on Piazza instead of e-mailing me.

Academic integrity I will be strict if I catch someone violating academic integrity. Examples include copying homework solutions, cheating on exams, continuing writing in an exam once the time is over, talking inside the exam room before/after handing in your answer book, etc.

Accommodations for disabilities I encourage students with disabilities, including invisible disabilities such as chronic diseases and learning disabilities, to discuss with me any appropriate accommodations that I might make on their behalf.

[3] In the form of class participation grade and occassional candy bars.

[4] Yes, leaving a question empty will earn you 20% credit! Recognizing that you do not know something and acknowledging this fact is an important skill to learn. In other words, trying to write nonsense in the hope of partial credit will cost you 20%.

Schedule

date	lecture	reference	module
22-Jan	introduction	chapter 1	introduction and linear algebra
24-Jan	linear algebra (review)	chapter 2	
29-Jan	what is linear programming?	section 3.1	linear programming
31-Jan	formulating LP models	sections 3.4 to 3.12	
5-Feb	solving linear programs graphically	sections 3.2 and 3.3	
7-Feb	simplex	sections 4.1 to 4.3	
12-Feb	simplex	sections 4.4 to 4.5	
14-Feb	simplex	sections 4.6 to 4.8	
19-Feb	simplex	sections 4.11 and 4.12	
21-Feb	duality	sections 6.5 and 6.6	
26-Feb	duality	sections 6.7 and 6.8	
28-Feb	duality	sections 6.9 and 6.10	
5-Mar	review		midterm
7-Mar	**midterm**	one A4 sized cheat sheet (both sides)	
12-Mar	basics and shortest path	sections 8.1 and 8.2	networks
14-Mar	max flow and min-cut	section 8.3 and notes	
19-Mar	spring break	spring break	
21-Mar	spring break	spring break	
26-Mar	mcnf and modeling	sections 8.5 and 8.6	
28-Mar	modeling	lecture notes	
2-Apr	introduction and modeling	sections 9.1 and 9.2	integer programming
4-Apr	modeling	section 9.2	
9-Apr	branch and bound	section 9.3	
11-Apr	examples	sections 18.1 to 18.3	dynamic programming
16-Apr	examples and general idea	sections 18.4 to 18.6	
18-Apr	applications and modeling	lecture notes	non-linear programming
23-Apr	characterizing the optimal solution		
25-Apr	convex optimization - basics		
30-Apr	convex optimization - optimality conditions and algorithms		
2-May	review		final exam
[May 10, May 17]	**final exam**	two A4 sized cheat sheet (both sides)	