ORIE 5380, CS 5727: Optimization Methods
Fall 2024
August 8, 2024

Optimization is one of the core technologies used to provide business intelligence. Online retailers use optimization models to decide where to position their fulfillment centers, which fulfillment center to use to satisfy each customer order and how much inventory to store for each product in each fulfillment center. Ad exchanges use optimization models to match publishers with users. Airlines use optimization models to construct their flight schedules, to plan routes for their crews and to price their tickets. On-demand transportation companies use optimization models to figure out how to incentivize their drivers when excess capacity is needed and how to price their services in response to surges in demand. In this course, we study algorithmic and computational tools for solving optimization problems with the goal of providing decision support for business intelligence. We will cover the fundamental theory of linear and integer optimization. We will emphasize optimization as a large-scale computational tool and show how to link programming languages with optimization software to develop industrial-strength decision support systems.

Staff

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Office hours: Tuesday 10:00 – 11:00

TAs to be announced.

Course Website

To reach the course website, you can log in at https://canvas.cornell.edu with your net ID. All the materials related to the course, including slides used in the lectures, source code, homework assignments and the project, will be posted on the course website. Please make sure you are enrolled in the course website. In addition, if you have any questions regarding the homework, then please use the discussion forum on the course website. In this way, everyone in class can see the questions and the answers. We will monitor the discussion forum closely and answer the questions as soon as possible.

Prerequisites

The course requires background in linear algebra and calculus. At minimum, you should be comfortable with multiplying and inverting matrices, carrying out Gaussian elimination and plotting functions. If you feel comfortable with the material during the first three weeks of the course, then it is likely that your background is adequate. Also, you need some familiarity with a programming language, such as Julia, or Python. All the necessary programming tools will be covered in the lectures, but familiarity with a programming language allows you to focus on optimization, rather than fundamentals of programming.

Resources

Our main resource will be the course packet by Dr. Huseyin Topaloglu, which will be posted on the course website (under the "Files" section). The course packet has some parts that are intentionally left blank, and we will fill those parts during lectures. You could print a hard copy of the course packet and bring it to every lecture or, green option, use a tablet.

There are several good textbooks on optimization. In the order of increasing mathematical sophistication, three good textbooks are as follows.

- F. S. Hillier and G. J. Lieberman, *Introduction to Operations Research*, McGraw Hill, 2009, 2012, 2014. (There are many editions. Any edition will work.)
- R. J. Vanderbei, *Linear Programming: Foundations and Extensions*, Springer, International Series in Operations Research and Management Science, 2014, 2007, 1998.
- M. Fischetti, *Introduction to Mathematical Optimization*, Kindle Direct Publishing, 2019.

You can get through the course without using a textbook, but you are encouraged to purchase one of the textbooks and read it to see a different angle on the topics covered in the lectures. Throughout the semester, we will suggest readings from those books and / or others. The textbook by Hiller and Lieberman is rather comprehensive, but it is introductory. If you have never taken a serious course on optimization before, then you should consider purchasing that textbook. The other two textbooks are less comprehensive, but they go deeper into the theory of optimization.

In addition to the course packet and a textbook, we will use computational tools for building and solving optimization models. Almost all the computational tools that we will use are freely available and we will provide the necessary directions to access them at appropriate points during the semester. The only computational tool that is not free is Microsoft Excel and its optimization solver, which we will use as an example only at the very beginning of the course.

Assignments

There will be weekly homework assignments in the first part of the course. In the second part, a project requiring modeling and coding will be assigned. The assignments will be posted on the course website by Wednesday 7:00 pm and will be due the following Tuesday 7:00 pm. Please pay attention to the organization of the assignments (including the project) you turn in. If you include computer outputs, clearly label them, and mark your answers. Unless otherwise stated, all homework assignments / project should be your own work. You can discuss the problems on the assignment at the level of a corridor discussion, but you should make sure that you are on your own when you write your assignment / project.

If you would like your homework / project to be re-graded, then you should contact us within one week after you get your homework / project back. You can skip one homework assignment without any penalty (but not the project).

Grading

Your grade will be based on homework assignments, a project and one exam. The project is essentially a larger homework assignment, but you will be asked to write a report for the project. Please plan accordingly. Different items will be weighed according to the following scale:

Homework	30%
Project	35%
Final	35%

Policy of Academic Conduct

Every student is expected to abide by the Cornell University Code of Academic Integrity. In particular, everybody has to turn in his or her own work, unless otherwise stated. You may discuss the homework assignments with the other students, but only at the level of a discussion in a corridor. When you are writing down or typing your homework assignment, please make sure you are by yourself. Sharing computer code or spreadsheet calculations is not allowed. You cannot get help in any way from other people that are in or outside Cornell Tech. We believe that homework is a learning experience, and will grade as easily as possible, as long as you put an honest effort. If you violate this policy, you risk having your entire homework grade set to zero or even failing the course. If you have hesitations as to whether certain actions violate the policy, please contact the instructor beforehand. Please see http://cuinfo.cornell.edu/aic.cfm for more information on the university code of academic integrity.

The use of ChatGPT or similar AI technologies to assist with assignment-writing tasks is allowed but **must be acknowledged.** The output of whatever writing process is your responsibility, regardless of whether AI helped or not. You should be able to justify every single word, sentence, or argument, 100%, no excuses, at any time.

Topics Covered

Below is a chronological list of topics that we will cover throughout the course of the semester, along with the approximate number of lectures we will spend on each topic.

Topic	N. of lectures
Introduction to linear programming, MS Excel solver	2
Geometry of linear programming	1
Linear algebra concepts	1
Fundamentals of simplex method	4
Finding initial feasible solutions	1
Unbounded problems, alternative optima, degeneracy	1
Network models	3
Gurobi, Julia and Python	2
Weak duality	2
Strong duality	1
Economic interpretation of duality	2
Modeling power of integer programming	1
Branch and bound	1
Models in logistics (time permitting)	3
Designing heuristics (time permitting)	1
Optimization under uncertainty (time permitting)	2