STOR 415 — Introduction to Optimization
Fall 2022

Time:	Tuesday and Thursday, 5:00-6:15
Location:	Hanes Hall 120
Instructor:	Michael O'Neill (mikeoneill@unc.edu)
Website:	https://tarheels.live/moneill/
Office Hours:	Tuesday and Thursday, 2:00-3:00, https://unc.zoom.us/my/mikeoneill
Instructional Assistant (IA):	Fuwei Yu (fwy@unc.edu)
Office Hours:	Monday and Wednesday, 1:00-2:00, https://unc.zoom.us/j/3331347805 ?pwd=SmdWNllSaXp6M1RGSE4rdWtRMTNaZz09

Course Overview

Optimization models and software are ubiquitous in industry and academia and arise in a plethora of applications such as engineering design, statistics, and economics. Optimization is used by most Fortune 500 companies, to manage their inventory and workforce, to optimize their cashflow and portfolios, to design efficient supply chains, to manage logistics and transportation, and to train machine learning models.

This course will teach students how to model optimization problems and solve them using modern software. It will teach the fundamentals of algorithms to solve optimization problems as well as the underlying theory and geometry.

Topics

1. Introduction to mathematical optimization
    - Mathematical optimization and fundamental concepts
    - Motivating examples and real-world applications
2. A review on linear algebra: vectors, matrices, and linear systems
3. Linear programming
    - Linear programming with two variables
    - Forms of linear programming problems, and preprocessing
    - Basic solutions and basic feasible solutions
4. Introduction to solving optimization problems with Julia/JuMP
5. Simplex methods for linear programming
    - Simplex method in matrix form
    - Simplex method with tableaux
    - Two-phase simplex method
6. Duality and sensitivity analysis in linear programming
7. Applications of linear programming
    - Classical problems
    - Engineering applications

- Blending and inventory problems
- Transportation problems
- Minimum cost network flow problems

8. Introduction to nonlinear programming
    - Quadratic programming and its applications
    - Convex programming
9. Introduction to integer programming
    - Set covering and assignment problems
    - Logical modeling tricks
    - Solving integer programs

Course Material

This class will be based on course notes. Students do not need to buy a book. A series of lecture notes will be provided to students that have been specifically prepared for this course. Please note that these lecture notes are internally used for this course, and they must not be distributed without permission of the Instructor in any way and any form. Slides and coding examples will be used in this course and provided on the course website (both on my home page (`https://tarheels.live/moneill/teaching/stor-415/`) as well as on Canvas). For students interested in additional resources, a list of relevant texts is provided at the end of this syllabus.

Exams

Two midterm exams (held during class) and a final exam. Midterm 1: October 4th. Midterm 2: November 15th. Final exam: December 9th, 4pm.

Exams and quizzes will be closed notes.

Quizzes

There will be 4 in-class quizzes of about 20 minutes in length, on September 1st, September 22nd, October 18th, and November 3rd. The quizzes will be based off of the last 2-3 homeworks.

Homework

Homework will be assigned most weeks. Each homework will be posted as an assignment on Canvas and will be submitted through Gradescope (see `https://edtech.unc.edu/service/gradescope/` for more information on submitting through Gradescope). Please make sure to upload the homework in the manner instructed on the assignment. Homeworks will be due on Tuesday or Thursday. Late homeworks will not be accepted and will receive zero credit. For questions about homework grading, please first discuss with the Instrucational Assistant (IA).

Grading

Homework 20%, Midterm Exams 18% each, Final Exam 34%, Quizzes 10%. The lowest homework grade (may be a 0) will be dropped.

Honor Code

All students must be familiar with and abide by the Honor Code, which covers issues such as plagiarism, falsification, unauthorized assistance, cheating, and other acts of academic dishonesty. In particular, students are permitted to work together on homework assignments, but the final writeup must be generated alone by the student who submits the homework.

Posting homework assignments, exam problems, or any part of them on the internet, or copying solutions from internet resources is a violation of the honor code. Honor code violations will be taken seriously.

Emergencies

If you get sick, or have any other emergency, and this interferes with completing a homework, please let me know before the hw is due. We cannot give extensions on completing a homework, due to limited resources, but then we may drop an additional homework. This is decided on a case by case basis.

Syllabus changes

I reserve the right to make changes to the syllabus, when unforeseen circumstances occur. These changes will be announced as early as possible so that students can adjust their schedules.

Counseling and psychological services

CAPS is strongly committed to addressing the mental health needs of a diverse student body through timely access to consultation and connection to clinically appropriate services, whether for short or long-term needs. Go to their website: https://caps.unc.edu/ or visit their facilities on the third floor of the Campus Health Services building for a walk-in evaluation to learn more. (source: Student Safety and Wellness Proposal for EPC, Sep 2018)

Acessibility resources and services

The University of North Carolina at Chapel Hill facilitates the implementation of reasonable accommodations, including resources and services, for students with disabilities, chronic medical conditions, a temporary disability or pregnancy complications resulting in barriers to fully accessing University courses, programs and activities.

Accommodations are determined through the Office of Accessibility Resources and Service (ARS) for individuals with documented qualifying disabilities in accordance with applicable state and federal laws. See the ARS Website for contact information: https://ars.unc.edu or email ars@unc.edu.

Tests for ARS students

If you have an ARS accommodation, then please let me know as soon as possible.

1. For quizzes, you get extended time at the end of the class. (Unless the accommodations say that you need a separate room too.)

2. You take exams at ARS. The exam at ARS must be scheduled at the same time as the regular exam.

Title IX resources

Any student who is impacted by discrimination, harassment, interpersonal (relationship) violence, sexual violence, sexual exploitation, or stalking is encouraged to seek resources on campus or in the community. Reports can be made online to the EOC at https://eoc.unc.edu/report-an-incident/. Please contact the University's Title IX Coordinator (Elizabeth Hall, interim – titleixcoordinator@unc.edu), Report and Response Coordinators in the Equal Opportunity and Compliance Office (reportandresponse@unc.edu), Counseling and Psychological Services (confidential), or the Gender Violence Services Coordinators (gvsc@unc.edu; confidential) to discuss your specific needs. Additional resources are available at safe.unc.edu.

Additional Material for Reading

Students who want to learn more about optimization can check out the following textbooks. These are not mandatory for this course. Many of these are about advanced topics that will be introduced during the course and go beyond the content of this class. For a general reference related to the entire course, consider reading "A gentle introduction to optimization" by Guenin, Könemann, and Tuncel.

References

[1] Aharon Ben-Tal and Arkadi Nemirovski. *Lectures on modern convex optimization: analysis, algorithms, and engineering applications*. SIAM, 2001.

[2] Dimitris Bertsimas and John N Tsitsiklis. *Introduction to linear optimization*, volume 6. Athena Scientific Belmont, MA, 1997.

[3] Stephen P Boyd and Lieven Vandenberghe. *Convex optimization*. Cambridge university press, 2004.

[4] Michael C Ferris, Olvi L Mangasarian, and Stephen J Wright. *Linear programming with MATLAB*. SIAM, 2007.

[5] Bertrand Guenin, Jochen Könemann, and Levent Tuncel. *A gentle introduction to optimization*. Cambridge University Press, 2014.

[6] Yurii Nesterov. *Introductory lectures on convex optimization: A basic course*, volume 87. Springer Science & Business Media, 2003.

[7] Jorge Nocedal and Stephen J Wright. *Numerical optimization*. Springer, 1999.

[8] J Vanderbei Robert. *Linear programming: Foundations and extensions*. Springer, 2021.

[9] Laurence A Wolsey. *Integer programming*. John Wiley & Sons, 2020.

[10] Stephen J Wright. *Primal-dual interior-point methods*. SIAM, 1997.