IE411 Optimization of Large-Scale Linear Systems
Fall 2025

Lectures: 101 Transportation Building, T&Th 2:00-3:20 PM (In person; lecture materials posted on Canvas)

Instructor: Prof. Grani A. Hanasusanto
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- **Office hours:** T&Th 3:30-4:30 PM
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Overview: This course is about **large-scale linear optimization**, an important discipline for modeling and solving engineering and business problems. We will cover both theory and computation of linear optimization, with applications across diverse domains.
Key topics include: applications of linear optimization, geometry of linear programs, the simplex method and its variants, duality theory and sensitivity analysis, decomposition principles and column generation, and computational implementations

Objectives: Students will gain a **deep understanding of the theoretical and computational foundations** of linear optimization. Emphasis will be placed on the simplex method and its variants, covering both mathematical underpinnings and computational aspects.

Prerequisites:
- IE 310 (Deterministic Models in Optimization)
- MATH 257 or MATH 415 (Linear Algebra)

Didactic Approach: The course will be taught in a formal, lecture-based style at a modern research level. The main results will be rigorously proved. Students are expected to be comfortable with advanced mathematical reasoning and formality.

Textbooks:
1. **Required:** Bertsimas & Tsitsiklis, *Introduction to Linear Optimization*, Athena Scientific (1997).
2. **Required (free ebook via library):** Bazaraa, Jarvis & Sherali, *Linear Programming and Network Flows* (4th ed.), Wiley (2010).
3. **Optional (free ebook via library):** Vanderbei, *Linear Programming: Foundations and Extensions* (4th ed.), Springer (2014).

Lecture Notes:
Lecture notes will be posted on Canvas before class. ***Caution:*** Notes are intended to supplement lectures, not replace them. Additional explanations will be provided on the blackboard.

Software:
Python will be the primary tool used for this course, with Gurobi as the linear optimization solver.

Grading Policy:

- **Homework (40%)**
  - Assigned biweekly; includes both theoretical and computational exercises.
  - Group discussion encouraged, but solutions must be written individually.
  - Submission via Canvas only; no late homework without prior approval.
  - Selected problems will be graded.
  - Additional problems assigned to students enrolled for 4 credit hours.
- **Project (15%)**
  - Implementation of algorithms using Python + Gurobi.
- **Exams (45%; 15% each)**
  - Three midterm exams.
  - All exams must be taken to pass the course.
  - No early exams. Make-up exams require valid medical documentation.

Re-Grade Policy:

If you believe an exam, quiz, or homework was graded incorrectly, you must request a re-grade **within one week** of the grade announcement. Send an email with a clear explanation of the issue and justification for the re-grade request.

Attendance:

I will not take attendance or formally penalize you for missing lectures. You are responsible for mastering all course material and are ultimately free to decide whether to attend lectures in person or learn the material independently.

That said, I strongly believe that attending and participating in lectures is **immensely valuable**. Being present allows you to fully engage with the material, interact with your classmates, and ask questions to deepen your understanding. In addition, I am more likely to consider positive grade adjustments at the end of the semester for students who regularly attend and participate in class.

Academic Integrity:

Students are expected to uphold the highest standards of academic integrity in this course. Violations of the Student Code will be referred to the administration and may result in severe disciplinary action, including failure in the course, probation, suspension, or expulsion from the University. Dishonesty undermines your own education, disadvantages your classmates, and erodes the integrity of the University. Violations carry serious consequences and should be avoided at all costs.

Prohibited Actions:

The following actions are considered violations of the Student Code in this course and will be treated accordingly:

- Copying solutions from manuals, websites, or online repositories.
- Using solutions from students who previously took the course.
- Submitting work copied from classmates without having fully participated in solving the problems.
- Discussing or collaborating on exams in any form, with anyone inside or outside the class, until the exam period has ended (zero exceptions).
- Sharing course materials (lecture notes, assignments, exams, review sheets, etc.) with anyone outside this class, including uploading to public sites (e.g., CourseHero, Chegg). Such actions violate academic integrity and may also constitute copyright infringement.

If you witness or become aware of academic integrity violations, you are encouraged to report them to me or to the administration.

Homework Policy:
You are welcome to discuss homework problems with classmates. However, you must write up your own solutions **individually** and ensure you fully understand them.
If I suspect that your submission relies excessively on another student's work or external sources, you may be asked to meet with me and explain your solutions in detail. If you cannot adequately explain your own work, you will not receive credit for that assignment.

Updates to the Syllabus:
The contents of the syllabus and the policies described are subject to change. If that happens, all changes will be announced and described on the course website. A summary of the changes will also be provided on this page.

Tentative Schedule (subject to change)

Week 1 (August 26 & 28): BT 1, BJS 1.1-1.3
Introduction; LP Models; LP Applications I

Week 2 (September 2 & 4): BT 1, BJS 1.1-1.3
LP applications II
Homework 1 due on September 2

Week 3 (September 9 & 11): BJS 1.4
Mathematical preliminaries
Homework 2 due on September 11

Week 4 (September 16 & 18): BT 2, BJS 2.1-2.5
Geometry of LP I

Week 5 (September 23 & 25): BT 2, BJS 2.6-2.7, BJS 3.1-3.2
Geometry of LP II
Homework 3 due September 25

Week 6 (September 30 & October 2): BT 3, BJS 3
Simplex method; Revised simplex method
September 30: Midterm I

Week 7 (October 7 & 9): BT 3, BJS 4
Starting solution and convergence: the Big-M method/two-phase method; Degeneracy and cycling

Week 8 (October 14 & 16): BJS 5
Special simplex implementations and optimality conditions
Homework 4 due on October 14

Week 9 (October 21 & 23): BT 4, BJS 5
Duality theory; Applications of duality theory I

Week 10 (October 28 & 30): BT 4, BJS 6
Applications of duality theory II
Homework 5 due on October 30
Dr. Hanasusanto is away for conference one day

Week 11 (November 4 & November 6): BT 4.5, BJS 6
Dual simplex method
November 6: Midterm II

Week 12 (November 11 & 13): BT 5, BJS 6
Sensitivity analysis; Parametric analysis

Week 13 (November 18 & 20): BT 6, BJS 7
Column generation method; Lagrangian relaxation
Homework 6 due on November 18

Week 14 (November 25 & 27): Thanksgiving break

Week 15 (December 2 & 4): BT 8, BJS 8
Computational complexity of the simplex algorithm; Ellipsoid algorithm; Interior point method
Homework 7 due on December 2

Week 16 (December 9):
December 9: Midterm III

December 5: Coding project due

Sexual Misconduct Reporting Obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: wecare.illinois.edu.

Academic Integrity

The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: http://studentcode.illinois.edu/.

Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: https://studentcode.illinois.edu/article1/part4/1-401/. Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

Religious Observances

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at https://odos.illinois.edu/community-of-care/resources/students/religious-observances/ to request appropriate accommodations. This should be done in the first two weeks of classes.

Disability-Related Accommodations

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603, email disability@illinois.edu or go to https://www.disability.illinois.edu. If you are concerned you have a disability-related condition that is impacting your academic progress, there are academic screening appointments available that can help diagnose a previously undiagnosed disability. You may access these by visiting the DRES website and selecting "Request an Academic Screening" at the bottom of the page.

Family Educational Rights and Privacy Act (FERPA)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa/ for more information on FERPA.