

University of Illinois at Urbana-Champaign  
Department of Industrial and Enterprise Systems Engineering

## **IE411 Optimization of Large-Scale Linear Systems**

Fall 2022

**Lectures:** 101 Transportation Building, T&Th 2pm-3:20pm (links to lecture material will be available on Canvas)

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**Lecturer's Website:** <http://publish.illinois.edu/lavanyam/>

**Course website:** <https://canvas.illinois.edu/courses/24954>

**Overview:** This course is about large-scale linear optimization, which is an important discipline to modeling and solving engineering and business problems. We will cover both the theory and computation of linear optimization and touch upon some important applications. Some important topics are: a variety of applications; LP geometry; the simplex method; the interior point method; the decomposition principle and column generation; numerical implementation issues; duality theory and applications; and sensitivity analysis.

**Objectives:** The main objective is for you to gain a good understanding of theory and computation of linear optimization, in particular, the theory and computational issues related to the simplex method and the interior point method.

**Textbook:** 1. Bazaraa, Jarvis and Sherali, *Linear Programming and Network Flows (fourth edition)*, John Wiley and Sons (2010). (*ebook free from the library*, required)

2. Bertsimas and Tsitsiklis, *Introduction to Linear Optimization*, Athena Scientific (1997).

3. Vanderbei, *Linear Programming: Foundations and Extensions (fourth edition)*, Springer (2014). (ebook free from the library, optional)

**Lecture Notes:** Lecture notes will be posted on Illinois Compass 2g before the lectures. Caution: Lecture notes are only used to facilitate your understanding of the lectures and will be supplemented by additional notes/explanations on blackboard.

**Software:** Excel Solver and Matlab will be the main tools used for this course.

**Grading Policies:** There will be an individual homework every other week (roughly). Most of the exercises are going to be from the textbook(s). Some homework assignments will be computational. You are encouraged to discuss homework problems in groups. However, you must write your own solutions (**You are required to follow university policies on student conduct**). Please submit your homework through Compass. *No late homework is allowed without instructor's permission.* We will selectively grade homework problems.

We will have one project on coding the simplex method and three exams.

The homework will form 40% of the final grade and the project 15%. There will be three midterms each of which comprises 15%. The details about the exams will be announced later in class.

Additional homework problems will be assigned to students registered for 4 credit hours.

**Tentative Schedule** (subject to change, Chapters based on BJS10)

Week 1 (August 23 & 25): Chapter 1.1-1.3  
Introduction, LP Models, and LP applications I  
Homework 1 Assigned on August 23

Week 2 (August 30 & September 1): Chapter 1.1-1.3  
LP applications II

Week 3 (September 6 & 8): Chapter 1.4  
Mathematical preliminaries  
Homework 1 Due on September 7  
Homework 2 Assigned on September 7

Week 4 (September 13 & 15): Chapter 2.1-2.5  
Geometry of LP I  
*Dr. Marla away for conference this week, will find substitute*

Week 5 (September 20 & 22): Chapter 2.6-2.7, Chapter 3.1-3.2  
Geometry of LP II  
Homework 2 due September 20  
Homework 3 assigned September 20

Week 6 (September 27 & 29): Chapters 3  
Simplex method, the revised simplex method  
**September 27: Midterm I**

Week 7 (October 4 & 6): Chapters 4  
Starting solution and convergence: the Big-M method/two-phase method;  
degeneracy and cycling  
Homework 3 due October 4  
Homework 4 assigned October 4

Week 8 (October 11 & 13): Chapters 5  
Special simplex implementations and optimality conditions

Week 9 (October 18 & 20): Chapter 5  
Duality Theory, and Applications of duality theory I  
Homework 4 due on October 18  
Homework 5 assigned on October 18

*Dr. Marla away for conference one day*

Week 10 (October 25 & 27): Chapter 6  
Applications of duality theory II  
Homework 5 due on October 27

Week 11 (November 1 & 3): Chapter 6  
Dual simplex method  
Homework 6 assigned on November 3  
**November 3: Midterm II**

Week 12 (November 8 & 10): Chapter 6  
Sensitivity analysis, Parametric analysis

Week 13 (November 15 & 17): Chapters 7  
Column generation method, Lagrangian relaxation  
Homework 6 due on November 17  
Homework 7 due on November 17

Week 14 (November 22 & 24): **Thanksgiving break**

Week 15 (November 29 & December 1): Chapter 8  
Computational complexity of the simplex algorithm, Ellipsoid Algorithm,  
Interior point method  
Homework 7 due on December 1

Week 16 (December 6):  
**December 7: Midterm III**

December 6: Coding project due

# Emergency Planning

In an emergency in this building, we'll have three choices: **RUN** (get out), **HIDE** (find a safe place to stay inside), or **FIGHT** (with anything available to increase our odds for survival).

First, take a few minutes this week and learn the different ways to leave this building. If there's ever a fire alarm or something like that, you'll know how to get out, and you'll be able to help others get out too.

Second, if there's severe weather and leaving isn't a good option, go to a low level in the middle of the building, away from windows.

If there's a security threat, such as an active shooter, we'll **RUN** out of the building if we can do it safely or we will **HIDE** by finding a safe place where the threat cannot see us. We will lock or barricade the door and we will be as quiet as possible, which includes placing our cell phones on silent. We will not leave our area of safety until we receive an Illini-Alert that advises us it is safe to do so. If we cannot run out of the building safely or we cannot find a place to hide, we must be prepared to fight with anything we have available in order to survive. **Remember, RUN away or HIDE if you can, FIGHT if you have no other option.**

Finally, if you sign up for emergency text messages at [emergency.illinois.edu](http://emergency.illinois.edu), you'll receive information from the police and administration during these types of situations.

If you have any questions, go to [police.illinois.edu](http://police.illinois.edu), or call [217-333-1216](tel:217-333-1216).

## **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](https://wecare.illinois.edu/resources/students/#confidential).

Other information about resources and reporting is available here: [wecare.illinois.edu](https://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, e-mail [disability@illinois.edu](mailto: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 diagnosis 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.

### **Anti-Racism and Inclusivity Statement**

The intent is to raise student and instructor awareness of the ongoing threat of bias and racism and of the need to take personal responsibility in creating an inclusive learning environment.

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (<https://bart.illinois.edu/>). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.