IE 521 – Convex Optimization

Spring 2021

MW: 1:00PM – 2:20PM, 112 Transportation Building

Course Info

Instructor: **Xin Chen** (xinchen@illinois.edu)
Office: Transportation Building 201D
Office Hour: TBD
Teaching Assistants: Xingyu Bai (xingyub3@illinois.edu)
TA Office Hours: TBD

Course Description

This course is focused on learning to recognize, understand, develop, analyze, and solve unconstrained and constrained convex optimization problems arising in engineering fields. The course shall keep strong emphasis on in-depth understanding of classical convex analysis, theory and applications of disciplined convex programming, as well as efficient algorithms for solving constrained convex problems.

Prerequisites: Students are expected to have basic background in linear algebra, multivariate calculus, and real analysis.

Textbooks: There is no required textbook. Most of the course materials are covered in

- Boyd & Vandenberghe. *Convex Optimization*. Cambridge University Press. (2004)
- Ben-Tal & Nemirovski. *Lectures on Optimization III: Convex Analysis, Nonlinear Programming Theory, Nonlinear Programming Algorithms* (2021)
- Ben-Tal & Nemirovski. *Lectures on Modern Convex Optimization: analysis, algorithms, and engineering applications* (2020/2021)
- Nesterov. *Lectures on Convex Optimization*. (2018)

Here are some other useful reference books.

- Rockafellar. *Convex Analysis*, Princeton University Press. (1970)
- Bertsekas, Nedich,& Ozdaglar. *Convex Analysis and Optimization*, Athena Scientific. (2003)
- Hiriant-Urruty & Lemarechal. *Fundamentals of Convex Analysis*, Springer. (2001)

Grading Policy: Grades will be based on

Homework	35 %	approximately biweekly
Midterm Exam I	30%	Tentative Date: Wednesday, March. 17, 2021
Midterm Exam II or Project	30%	Tentative Date: Monday, May 5, 2021
Class Participation	5%	attendance is required

- [**Homework**] You are encouraged to discuss homework problems with your fellow students. But your final answers should be based on your own understanding and written in Latex. No late submission is acceptable.

- [**Exams**] Both midterm and final exams will be open-book exams. There will be no make-up exams for any reason.
- [**Project**] You can opt out of the final exam by completing a course project. The project must be related to optimization, and cannot be your own research with your advisor or your other course projects. Your grade will be evaluated based on the quality of the project and the report.

Topical Outline and Tentative Schedule

- **Part I: Classical Convex Optimization: Fundamentals** (4 weeks)
  - Convex Sets, Convex Functions, Convex Programs
  - Convex Geometry
  - Lagrangian Duality
  - Optimality Conditions
  - Polynomial Solvability of Convex Programming (center-of-gravity, Ellipsoid method)
  - Problems with Convex Structure (convex-concave saddle point problems, variational inequality with monotone operators)

- **Part II: Modern Convex Optimization** (4 weeks)
  - Conic Programming and Conic Duality (LP, SOCP, SDP)
  - Interior Point Method (barrier, central-path, primal-dual)
  - Computation Toolbox (CVX) and Applications

- **Part III: Algorithms for Constrained Convex Programming and Recent Advances** (4 weeks)
  - Subgradient Method
  - Cutting Plane Method
  - Bundle Methods
  - Dual Methods
  - Primal-Dual Methods

- **Part IV: Selective Topics Based on Request** (2 weeks, if time allows)

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 atemergency.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, or call 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.

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, e-mail 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.