SYLLABUS
IOE 510/Math 561/TO 518: Linear Programming I

Instructor	Prof. Ruiwei Jiang, ruiwei@umich.edu
Office hours	Fri. 10:00–11:00AM (all time in **Eastern Time**)
Zoom Link	https://tinyurl.com/510w21
GSI	Huiwen Jia, hwjia@umich.edu
Office hours	TBD
Zoom Link	https://tinyurl.com/510w21
Data Analytics Help Desk	Ziang Xu, xuziang@umich.edu
Office hours	TBD
Zoom Link	TBD

Lectures Asynchronous; recordings posted on Canvas → Media Gallery.

Textbook

- ◇ No required textbooks; all homework assignments and exams are based on my lecture notes and materials posted on Canvas.
- ◇ Optional: Bazaraa, M. S., Jarvis, J. J., and Sherali, H. D. (2010) Linear Programming and Network Flows. Wiley; 4th edition. (Available as an e-textbook at UMich library.)
- ◇ Optional: Jon Lee. A First Course in Linear Optimization; 2nd Edition. Online Available at https://github.com/jon77lee/JLee_LinearOptimizationBook/archive/master.zip.

Prerequisites Linear algebra (matrix analysis, row/column operations, solution methods for linear equation systems). Skills of writing mathematical proofs and coding.

Focus of the Course We teach **how to optimize decisions for problems in various application domains where complex situations are involved.** We will focus on formulating mathematical models for real-world problems, developing algorithms to identify optimal solutions to these models, and implementing these models in commercial/academic solvers. For implementation, we accept any programming language (e.g., C/C++, Python, AMPL) and any optimization solver (e.g., CPLEX, Gurobi, IPOPT), but we strongly encourage you to try and use **Python** and **Gurobi**.

IOE 510 is a ***graduate level*** course in optimization. In particular, we will teach:

- ◇ Modeling

- ◇ Mathematics and algorithms of linear programs
- ◇ Computation and coding
- ◇ Mathematical proofs

Software:

- ◇ LaTeX (for typing documents; required for homework and project)
- ◇ Excel (for spreadsheet functions, and solving optimization models)
- ◇ Python (for compiling and solving optimization models)
- ◇ Matlab (for linear algebra operations, solving optimization models, and other math computations)

Example Topics:

- ◇ How to formulate mathematical optimization models: Identify decision variables, problem parameters, objectives, and constraints
- ◇ A wide variety of modeling applications
- ◇ Algebraic and geometric interpretations of linear programs (LPs)
- ◇ The Primal Simplex method for solving LPs
- ◇ The relationship between primal and dual of an LP (complementary slackness) and how this relationship is useful
- ◇ Sensitivity analysis
- ◇ What an integer program (IP) is? How to formulate and solve an IP (e.g., the branch-and-bound algorithm, cutting-plane algorithms, totally unimodular structures)
- ◇ Linear optimization approaches: Decomposition, Lagrangian relaxation, column generation

Responsibility & Requirements Students are expected to read this syllabus fully and responsible for the whole content.
We will post lecture notes and necessary materials before the corresponding days of class; students are encouraged to print out the notes and fill them up during the class.

Homework There are 6–7 homework assignments planned. Homework questions will include modeling, numerical analysis, algorithm design, and coding in software to solve optimization models.

- ◇ You may work in a group of 1–3 students, and all of your submitted work should be the work of the group — NOT of uncredited others; NOT materials found on the internet; NOT getting homework solutions from students who took the course in previous semesters. Violation of this is a violation of the Honor Code, and you will not get any credit for your homework. This honor code violation will also hurt your overall grade.
- ◇ For your mental health during this difficult time, we encourage that you work in a group of size 3. To this end, we will add 5 extra credits to your HW grade if you work in a group of size 3 and submit evidence of doing so in your HW submission (e.g., a Zoom meeting screenshot with all group members). **Note**: your HW score in the course grade cannot exceed the full mark specified below.
- ◇ All work must be typed using LaTeX and submitted on time by ONE representative of your group. Please clearly write all students' names in your group in the FIRST line. Please submit LaTeX source (.tex) and a compiled pdf file. If there are coding questions, please submit all the code-related files.
- ◇ No extension of the due dates will be given for any homework or project assignments — start your work early, and try the best you can with the allotted time.
- ◇ The maximum grade for an assignment turned in on time is 100, plus the 5 extra credits if you work in a group of 3.
- ◇ An assignment turned in late, but less than 24 hours late, will have max score = 80+5; an assignment turned in more than 24 hours late, but less than 48 hours late, will have max score = 60+5; an assignment turned in more than 48 hours late, but less than 72 hours late, will have max score = 40+5; no assignments will be accepted if turned in more than 72 hours late.

Office Hours Office hours are for clarification of lecture material and for clarification of homework assignments. They are **NOT** for: (i) help in actually doing the homework, (ii) verifying your solutions and pre-grading your homework, (iii) help coding or debugging.

Quiz We will have 10 quizzes to encourage students to maintain a routine of learning. Each quiz will be due at the end of the week and will be about the materials taught in that week. You need to answer at least 5/10 quizzes correctly in order to receive a full mark for quiz in the course grade.

Project We require you work in a group of 1–3, and complete a project that uses modeling, computational, and coding techniques learnt in class for a real-world optimization problem. I will post a list of topics from which you can choose one as your project. Each team will record a 10-min presentation and write a report for your project. The presentation recording is due by April 21 and the report is due by April 28.

The project team group does not need to be the same as your homework group, but we highly recommend that you start early to organize the team, think about project ideas, and identify individuals' responsibilities. Moreover, we require:

- ◇ Using techniques that are relevant to what we teach in this course;
- ◇ Having sections of relevant literature review, model(s), algorithm(s), and numerical results in your project report. For conducting numerical studies, the default programming language/solver to use is Python/Gurobi, which we will use for homework assignments. You can use other coding languages and/or solvers (e.g., C/C++ with CPLEX or Matlab) if you are more comfortable using those. But the results should be clearly presented and reproducible, and each team needs to submit their code together with the pdf report.
- ◇ The report needs to be typed in LaTeX , and should use A4 size letter papers, 6–10 pages, 12pt font size, 1 inch margins on all sides, single space between lines, and in pdf format. References will not be counted into the pages, but is necessary as a part of the report submission. The correctness of citation format will affect the project grade.
- ◇ Each team needs to prepare 6–10 slides that describe their projects and presents them for 10 minutes.
- ◇ After each presentation, we will ask individual team members questions to ensure that the project is done collaboratively, and everyone understands all parts of their projects.
- ◇ Each team member needs to specify their contribution by using 2–3 sentences at the end of the report, and we anticipate equal workload distribution. We reserve the right of differentiating the grades among members from the same team, based on our judgement of individual contribution from the above statement in the report and Q&A.

To grade the project, we will mainly consider the quality of technical reports, but will also use the presentation and Q&A to assist our decision making. Each team will receive our feedback on how to revise their reports after their presentations.

For your mental health during this difficult time, we encourage that you work in a group of size 3. To this end, we will add 5 extra credits to your project grade if you work in a group of size 3. **Note**: your project score in the course grade cannot exceed the full mark specified below.

Final Grade

- ◇ Homework (30%);
- ◇ Quizzes (5%);
- ◇ Project (25% **Report + Final Presentation**);
- ◇ Exam 1 (20%; **Mar. 3 (Wed.), take home, 9:00am, 24 hours**);
- ◇ Exam 2 (20%; **Apr. 14 (Wed.), take home, 9:00am, 24 hours**).
  (We do not offer alternative exam dates for either exam.)

Letter Grade Ranges:

- ◇ A: $[93, \infty)$; A$-$: $[88, 93)$
- ◇ B$+$: $[83, 88)$; B: $[75, 83)$; B$-$: $[70, 75)$
- ◇ C$+$: $[65, 70)$; C or below: < 65; letter grades will be determined individually

Exam & Regrading Policies Any student requiring special accommodations during exam time should contact the instructor at the beginning of the semester so that adequate arrangements can be made. After grades being returned,

- ◇ If you believe that there is an error in the grading of your exam or homework submissions, you must submit a written request **within one week** of the submissions being returned, explaining why you feel points were unfairly deducted. Note that any submitted requests for re-grading will be **fully re-graded** – all questions will be reviewed for accurate grading, and the new grades could be higher or lower.
- ◇ Office hours are only for discussions related to learning, but not for regrading. Regrading request is only accepted in a written format.

Honor Code Policy We take the Engineering Honor Code **very seriously**. All students are expected to be familiar with it and are bound by its requirements. In particular, we emphasize the importance of individual student write-ups for problem sets, no collaborative work during exams, and full contribution by all members of student teams. Each student needs to independently work on quizzes and submits the work. **Do not submit for others, which will be considered as serious honor code violation.** Furthermore, respect in the classroom will be given utmost priority. Students are expected to treat the instructors and each other with respect, and have the right to be treated respectfully in return. Disrespect at any level will not be tolerated.

University of Michigan Disability Statement The University of Michigan is committed to providing equal opportunity for participation in all programs, services and activities. Request for accommodations by persons with disabilities may be made by contacting the Services for Students with Disabilities (SSD) Office located at G 664 Haven Hall. The SSD phone number is 734-763-3000. Once your eligibility for an accommodation has been determined you will be issued a verified individual services accommodation (VISA) form. Please present this form to me at the beginning of the semester to allow processing time for special accommodation for the lectures, projects, tests, and exams.

Important Links

- The Engineering Honor Council: `https://ecas.engin.umich.edu/honor-council/`
- Honor Code: `https://ecas.engin.umich.edu/wp-content/uploads/sites/19/2019/03/Honor-Code-Pamphlet-2018.pdf`