Fall 2019

IE 650-101: Advanced Topics in Operations Research

Cai

IE 650 Advanced Topics in Operations Research

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It is the responsibility of the student to read and understand the course syllabus.

Instructor:
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Office Hours:
Wed 3:30 - 4:30 pm,
or by appointment

Course Website on Canvas: `https://njit.instructure.com/courses/5693`

Course Description: This is a graduate level course on mathematical programming. We will study how to formulate mathematical models, develop solutions using classical optimization techniques and interpret optimal solutions. Topics covered in this course include Linear Programming (LP) Formulation, Simplex Method, Two-Phase Method, Sensitivity Analysis, Duality, Unconstraint and Constraint Nonlinear Programming (NLP), Optimality Conditions, and Lagrange Methods. The overall learning outcomes include formulating mathematical models, developing solutions using classical optimization techniques, applying algorithms to find optimal solutions, interpreting optimal solutions, and performing sensitivity analysis.

Recommended Textbooks:

- *Introduction to Operations Research* by Frederick Hillier and Gerald Lieberman. McGraw-Hill, 2014. ISBN: 9780073523453. 10th Edition.
- *Nonlinear Programming: Theory and Algorithms* by M.S. Bazaraa, H.D. Sherali, and C.M. Shetty. Wiley, 2006. ISBN:978047148608.

Required Background: You are expected to be able to do the following prior to taking this class:

- Apply Gaussian elimination method for solving the systems of linear equations
- Add and multiply matrices
- Compute the transpose and determinant for a given matrix

Communication Method: Important information, comments, corrections, and updates about the course will be posted on Canvas. Students are responsible to check the course webpage on Canvas regularly. Note: lecture notes posted on Canvas are outlines of the class. They are NOT designed to replace lecture notes as most derivations are presented on whiteboard. You are responsible to take your own notes.

Communication Etiquette: Communication via email or online discussions with the instructor and with each other is expected to be professional. The instructor will NOT answer emails or questions posted on online discussions that are not professionally formatted and stated. The following links provide examples of professional email etiquette: `https://www.math.uh.edu/~tomforde/Email-Etiquette.html` and `https://www.wikihow.com/Email-a-Professor`.

Academic Integrity: Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is the responsibility of students to protect their educational investment by knowing and following the academic code of integrity policy, which can be found at: `https://www.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf`.

Please note that it is the instructor's professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university. Students who have questions about the code of Academic Integrity should contact the Dean of Students Office at dos@njit.edu.

In-class Participation and Exercises: You are expected to attend classes, take notes, and participate in discussions. During classes you are asked to work on problems. The goal of these in-class exercises is to get you started on a problem but not necessarily finish. By the end of the class, you must submit your work via Canvas. Late submissions via Canvas or submissions via email will NOT be graded and will receive zero points. The lowest two in-class exercise/attendance scores will be dropped in the calculation of the course grade.

Homework Assignments: Homework assignments are intended to help students learn the topics and keep up with the pace of the course. Deadlines are set so feedbacks, such as homework solutions and grades, can be provided in a timely manner. Homework assignments and deadlines will be posted on Canvas.

- **Submission Policy**: Students may choose to either type up their answers to the homework problems or scan their hand-written answers. All students must submit homework assignments via Canvas. Only two file formats are accepted: pdf and excel spreadsheets. A maximum of two files, one in pdf and another in xlsx (excel spreadsheet), are allowed. The cutoff submission time is set to be 6 p.m. on the due date. Late submissions via Canvas or submissions via email will NOT be graded and will receive zero points.

- **Solutions:** Homework solutions will be posted on Canvas after the submission deadline. In order to receive full points, students must meet the criteria specified in each homework assignment. The instructor will check whether the criteria specified are

met. The instructor will NOT grade the assignments based on the accuracy of students' work. Students are responsible to compare their work to the homework solutions and ask questions during office hours or via email.

- **Grading**: Due to various (health, work, religion, etc.) reasons, students may need to miss a homework submission. The lowest homework score will be dropped in the calculation of the course grade. As a result, missing one homework assignment will NOT negatively impact students' course grades.

- **Collaboration:** Group learning is an effective learning strategy even in an online learning environment. Students are strongly encouraged to collaborate with (at most two) of their classmates. However, every student must type/write up the solution or create his/her own Excel spreadsheet. Be sure to include the following sentences at the top of the homework: "*I collaborated with (Student's name) and (Student's name) on this homework.*" or "*I worked alone on this homework.*" Students will receive a zero if they (1) fail to include one of the previous two sentences, or (2) copy their classmates' work or electronic file.

Exams: Two midterm exams and a final exam will be given. They are comprehensive (or cumulative), closed books and closed notes. Electronics, such as calculators, computers, smart phones, smart watches, are NOT permitted. The exams will have multiple versions. During the exam, you will be assigned a seat and a a version of the exam. **Make-up exams will not be administered**.

Course Grade Calculation: A weighted average grade will be calculated using the following weights:

In-class Participation*	HW Assignments**	Midterm Exam 1	Midterm Exam 2	Final Exam***	Total Weights
15	10	20	25	30	100

**The lowest two in-class participations scores will be dropped.
**The lowest homework assignment score will be dropped.
*** Mandatory NLP component: 22.5 points, Optional LP component: 7.5 points.

Mapping from the course grade to Letter Grade:

Course Grade	85%-100%	75%-84%	65%-74%	55%-64%	45%-54%	Below 44%
Letter Grade	A	B+	B	C+	C	F

Tentative Schedule and Learning Outcomes

Date	Topic	Learning Outcomes/Learning Objectives
9/4	Overview of Operations Research (OR) and LPFormulation	Formulate a LP problem with four components: (1) variable definitions; (2) objective function in linear terms; (3) linear constraints; and (4) variable restrictions.
9/11	The Simplex Method	Convert an LP model to its Standard Form; Identify when Simplex is used; Perform Simplex iterations using tableau.
9/18	Two-Phase Method	Identify when Two-Phase is necessary; Setup initial simplex tableaus in both phases; Perform Simplex iterations using tableau.
9/25	Midterm Exam 1 Review	
10/2	Midterm Exam 1	Topics covered: LP Formulation, Simplex Method, and Two-Phase Method.
10/9	Sensitivity Analysis	Revise the initial and the final Simplex tableau when one of the following of the original LP is changed: (1) RHS; (2) coefficients of a non-basic variable; 3) coefficients of a basic variable; (4) adding a new constraint.
10/16	Duality	Create the Dual LP for a given Primal LP; Find the Dual solution using Complementary Slackness Conditions; Evaluate whether a given solution to the Primal LP is optimal.
10/23	Unconstrained Optimization: Optimality Conditions	Find stationary points of unconstrained NLP; Check first-order and second-order necessary conditions to determine which (if any) is an optimal solution.
10/30	Unconstrained Optimization II: Solution Methods	Apply algorithms to find optimal solutions; Determine when to stop these algorithms.
11/6	Midterm Exam 2 Review	
11/13	Midterm Exam 2	Topics covered: LP Formulation, Simplex and Two-Phase Methods, Sensitivity Analysis, Duality, Unconstrained NLP
11/20	Constrained Optimization: Optimality Conditions	Determine whether a function is convex or concave; Classify a given solution as a local or a global optimal solution.
11/27	Friday classes meet	
12/4	Constrained Optimization: Lagrange Methods	Find candidate solutions using the KKT necessary conditions; Evaluate whether these solutions are optimal by investigating the structure of the objective function and constraints.
12/11	Final Exam Review	
12/18	Final Exam	NLP component topics: Optimality Conditions of Non-linear Programs; Apply algorithms or KKT conditions to find optimal solutions; LP component topics: LP Formulation, Simplex and Two-Phase Methods, Sensitivity Analysis, Duality.