IE 650-101 Advanced Topics in Operations Research

Fall 2025

It is the responsibility of students to read and understand the course syllabus. Students enrolled in this course agree to all terms specified in the syllabus.

Contents

1 Course Overview

This is a graduate level course on mathematical programming, a discipline that facilitates managerial decision making by applying a scientific approach to problems with quantitative factors. 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 creating mathematical models, applying classical optimization techniques to solve problems, analyzing and evaluating solutions generated by *Excel Solver*,

and interpreting solutions to facilitate decision making. These learning outcomes are appropriate to the rigor and breadth of the IE graduate program. Further, students are required to meet high standards and requirements of the program, regardless of the method of instruction.

1.1 Instructor

Dr. Cai is the instructor of this course. See Table 1 for her contact information. She is an Associate Professor in the Department of Mechanical and Industrial Engineering at the Newark College of Engineering. She received a B.S. in both Electrical and Computer Engineering and Operations Research & Industrial Engineering at Cornell University and an M.S. and a Ph.D. from Industrial Engineering & Operations Research at University of California, Berkeley.

She joined NJIT as an Assistant Professor in Fall 2012 and has been teaching a number of courses, including IE 706 Queuing Theory and Applications, IE 650 Advance Topics in Operations Research, EM 602 Management Science, IE 459 Production Planning and Control, IE 439 Deterministic Models in Operations Research. Her research interest is in Operations Management, focusing on theoretical advancement of OR methodologies and economic models as well as their applications in managing sustainable energy systems and designing incentives to foster public-private partnership in improving environmental sustainability.

Table 1: Instructor's Contact Information

Email address: cai@njit.edu	Phone: 973-596-3338	Office: MEC 308

1.2 Course Delivery

Classes meet in person in GITC 2305 on Tuesdays 6:00-8:50 pm while office hours are held virtually on Wednesdays 8:30-9:30 pm via Zoom. Directions on how to join these meetings are posted on *Canvas*.

Canvas, NJIT's Learning Management System (LMS), will be used to collect in-class exercises and exams as well as to pose lecture notes, announcements, and grades. The course website is

https://njit.instructure.com/courses/53348.

See *Canvas* Student Guides for instructions on how to use the various features of *Canvas*.

1.3 Required Background

Students are expected to have mastered the following topics prior to taking this course:

- Apply Gaussian elimination (or row manipulation);
- Add and multiply matrices; Compute the transpose and determinant for a given matrix;
- Take derivatives of polynomial functions and solve a set of equations.

1.4 Recommended Textbooks

The following books are recommended, but not required. Practice questions will be posted on *Canvas*.

- *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.

1.5 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 your degree. As members of the NJIT community, it is the responsibility of students to protect their educational investment by knowing and following the NJIT's Policy on Academic Integrity.

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 lead to 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.

1.6 Communications

The instructor post important information, including lecture notes, announcements, and updates on *Canvas*. Students are responsible to check the course webpage regularly.

All emails and online posts should be professional in tone. See the following resources for guidance:
`https://www.wikihow.com/Email-a-Professor` and
`https://marktomforde.com/academic/undergraduates/Email-Etiquette.html`.

Expect responses within 48 hours during business hours, Monday-Friday, 8 am to 5 pm. Questions submitted on weekends will be addressed the following Monday.

2 Learning Activities and Assessments

This is a three-credit, semester-long course. Students should expect to spend at least 6 hours per week on coursework and assignments. To facilitate student learning and assess learning outcomes, the instructor includes the following types of learning activities and assessments: in-class participation and exams.

2.1 In-class Participation

Students are expected to attend classes, take notes, and participate in discussions. During classes students are asked to work on problems in groups. The goal of these in-class exercises is to get you started on a problem but not necessarily finish. **Students must submit their work via *Canvas* at the end of each class. Neither late submissions or email submissions will be accepted, and zero points will be assigned.**

2.2 Exams

Two midterm exams and one final exam are scheduled, see Table 2 for exam dates.

- All exams are administered online.
- To ensure academic integrity, all students are required to use the *Respondus LockDown Browser*.
- Multiple versions of the exams will be used.
- The exams are cumulative, closed books, and closed notes.
- Students may be provided with blank sheets of paper.
- No electronics (calculators, cell phones, tablets, computers, smart devices, etc.) other than the computer used to take the exam are permitted.
- Students found cheating on the exams, as defined in the NJIT's Policy on Academic Integrity, will receive a grade of F for the course, and be reported to the Dean of Students.

2.2.1 Make-up Exam Policy

No make-up exams will be administered without formal approval from the Dean of Students. Typical reasons that will **NOT** grant a make-up exam include, but not limited to, (1) work matters, (2) planned vacations and other events, (3) lack of preparation, (4) lack of equipment or internet, or (5) misinformation.

Procedure to Request a Make-up Exam: To properly report absence of a midterm or a final exam, students must do the following:

1. Contact the Dean of Students (DOS) at dos@njit.edu **before** the exam. Provide necessary documentation to support the student's reason for missing an exam. To protect students' privacy*, do **not** copy the instructor on the email.

   Note: Students who have incapacitating illness or emergencies that prevent them from contacting the Dean of Students before or during the exams must notify the Dean of Students within 72 hours of the missed exams.

2. If circumstances warrant a makeup exam, the Office of DOS will email a formal notice to the instructor. The instructor will then notify the student the date and time of the makeup exam. Students cannot pick the date.

2.2.2 Technical Issues during Exams

Students who cannot start or complete the exams because of poor internet connects, failure to install/launch the *Respondus LockDown Browser*, automatic updates of personal computers, etc. will **not** receive time extensions or make-up exams. Students **cannot** submit answers after the exams.

To minimize technical failure during exams, a practice exam gives students an opportunity to make sure that they have the proper equipment and internet connections.

*NJIT Academic Policies and Procedures states the following: The university continues to make every effort to protect students' academic and personal information. Moreover, maintaining the confidentiality of students' medical information is a legal and ethical duty, as defined by federal and state laws and regulations, and by the courts. Whenever students have a situation that affects their academic standing, it should be brought to the Dean of Students. This includes medical or psychological documentation to support a student's claim. Students should not bring such information to their instructors, nor should it be requested by a faculty member. The Dean of Students has a physician and staff psychologists to evaluate such information to verify its legitimacy. The Dean of Students will then notify the faculty member(s) if a student has a legitimate absence and will ask that the student receive consideration in making up any missed course work or exam. This process ensures confidentiality of students' information and, just as important, consistency in dealing with such matters.

2.2.3 Exam Grading

- The instructor will finish grading and post grades within 10 days of the submission deadline.
- Partial credits can be given for essay questions that ask students to show detailed work. In this case, grading rubrics will be provided to explain how partial credits are awarded.

3 Course Grade

A numerical weighted-average score is calculated based on a student's performance in in-class participation and exams. Weights assigned to each category are shown in the following table:

Category	In-class Participation♣	Exam 1	Exam 2	Final Exam	Total
Weight	10%	30%	30%	30%	100%

♣ Average in-class participation score calculation: The lowest two in-class participation scores will be dropped. This means that students may miss up to two classes without negatively impact their performance.

3.1 Letter grade

Mapping from a numerical grade to a letter grade follows the following table.

Course Grade	≥ 82.5	73.5-82.4	64.5-73.4	55.5-73.3	46.5-55.4	< 46.5
Letter Grade	A	B+	B	C+	C	F

3.2 Extra Credit

No extra credits will be awarded. Please click here to read an article for a detailed explanation.

3.3 Incomplete (I)

The university's policy on requesting and awarding an I grade is as follows:

- The I grade is only given in rare instances when a student who would normally have completed the course work but who could not do so because of extenuating circumstances.
- When a student invokes extenuating circumstances and requests an I grade, the student must contact the Dean of Students first. The Dean of Students will be making the determination of whether extenuating circumstances exist or not and will be notifying the instructor accordingly.

- Except for cases determined by law, the instructor is **not** required to accommodate student requests even when extenuating circumstances are certified by the Dean of Students.
- When giving an *I* grade, the instructor will notify the student (and copy the Department Chair and the Dean of Students), in writing, of the exact work to be completed and the date by which it must be submitted.
- If the specified work is **not** submitted by the specified date. The *I* grade will be automatically changed to a *F* grade in the next regular semester.

The instructor will only grant an *I* grade when **all** of the following conditions are satisfied:

1. There is a written statement from the Dean of Students certifying the student's circumstance qualifies for an *I*.
2. The student has completed at least 70% of all coursework when requesting an *I* grade.
3. The instructor and the student are able to come to an agreement, in writing, before the final grade due date on the exact work to be completed and the date by which it must be submitted.

4 Other

4.1 Technical Assistance

The Information Services & Technology (IST) manages all courseware, such as *Canvas*, *Zoom*, and *Respondus LockDown Browser*. When encountering any technical issue with any courseware (including during an exam), submit a ticket to the IST Service Desk using this website:

https://ist.njit.edu/ist-service-desk.

The Office of Digital Learning, after receiving a ticket, will assign a representative to help resolve the technical issue. **Please note that the instructor has neither the admin authorization nor the in-depth knowledge to help students with technical issues.**

4.2 *Respondus LockDown Browser* Q&A

- *Q: What is the Respondus LockDown Browser?*

  A: It is a proctoring application that assists with the academic integrity of online exams by preventing students from printing, copying, going to another URL, or accessing other applications during an exam. Students cannot access the exam via a standard web browser.

- *Q: What role does the Respondus LockDown Browser play during an online exam?*

  A: It will access the students' webcams to record them during the entire exam.

- *Q: What role does the Respondus LockDown Browser play after an online exam?*

  A: It analyzes the recorded videos to catch violations of academic integrity. Click here to see NJIT's Policy on Academic Integrity.

- *Q: How does the Respondus LockDown Browser work?*

  A: Click here to watch a video to get a basic understanding of the *Respondus LockDown Browser*.

- *Q: How to install the Respondus LockDown Browser?*

  A: Click here to install the *Respondus LockDown Browser*.

- *Q: How to do the Respondus Environment Check?*

  A: Click here for a YouTube video that shows how to do *Respondus Environment Check*. Note: the video demonstration allows for a calculator. However, students may not bring a calculator. The *Respondus LockDown Browser* provides one.

4.3 Campus Resources

The most relevant on-campus resources are highlighted in this section.

- The Robert W. Van Houten Library (http://library.njit.edu/) offers electronic and print resources, including a core collection of academic books, databases, and journals, as well as research and consultation services.
- The Office of Accessibility Resources and Services (OARS), https://www.njit.edu/accessibility/, works in partnership with administrators, faculty and staff to provide reasonable accommodations and support services for students with disabilities.
- The Center for Counseling and Psychological Services (C-CAPS), https://www.njit.edu/counseling/, is committed to assisting students in the achievement of their academic goals as well as benefiting from their personal experience on campus.

4.4 Modifications to Syllabus

The syllabus is subject to change. Students will be notified by the instructor should any modifications or deviations from the syllabus occur.

5 Tentative Schedule and Learning Outcomes

Table 2: Tentative Schedule and Learning Outcomes

Date	Topic	Learning Outcomes/Learning Objectives
9/2	OR Overview	
	LP Formulation	Formulate a LP problem with four components: (1) variable definitions; (2) objective function in linear terms; (3) linear constraints; and (4) variable restrictions.
9/9	The Simplex Method	Convert an LP model to its Standard Form; Identify when Simplex is used; Perform Simplex iterations using tableau.
9/16	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.
9/23	Midterm Exam 1 Review	Topics covered: LP Formulation, Simplex Method, and Duality.
9/30	**Midterm Exam 1 via *Respondus LockDown Browser*, 6-9 pm**	
10/7	Unconstrained NLP: 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.
10/14	Unconstrained NLP: Solution Methods	Apply algorithms to find optimal solutions; Determine when to stop these algorithms.
10/21	Constrained NLP: Optimality Conditions	Determine whether a function is convex or concave; Classify a given solution as a local or a global optimal solution.

Table 2: Tentative Schedule and Learning Outcomes

Date	Topic	Learning Outcomes/Learning Objectives
10/28	Constrained NLP: 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.
11/4	Midterm Exam 2 Review	Topics covered: Unconstrained NLP, Constrained NLP
11/11	**Midterm Exam 2 via *Respondus LockDown Browser*, 6-9 pm**	
11/18	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; and (4) adding a new constraint.
11/25	N/A	No classes, Thursday classes meet instead.
12/2	Two-Phase Method	Identify when Two-Phase is necessary; Setup initial Simplex tableau in both phases; Perform Simplex iterations using tableau.
12/9	Final Exam Review	All topics covered in the course
12/16	**Final Exam via *Respondus LockDown Browser*, 6-9 pm**	
12/22	**Final Grade Posted on Pipeline**	