IE 335: Operations Research−Optimization

Spring 2023

1 Basic Information

1.1 Course delivery

The course is organized in in-person and online sessions, which comprise every week:

In-person class: Tuesday class (4:30 pm - 5:45pm) will be in-person in Class of 1950 Lecture Hall 224.

Online asynchronous deliveries: Thursday class will be delivered in the form of asynchronous (pre-recorded) modules; video-lectures will be pre-recorded and posted on Brightspace by 10am of the day of the class. You are expected to regularly access course materials and watch the video-lectures as well as complete associated coursework by the deadlines indicated on the module of the class on Brightspace.

The rationale of the above organization of the course is the following:

1. Asynchronous classes are the lectures of the course whereby you will learn the new concepts. Video-lectures will be paired with short quizzes on the topic of the videos to submit within the same week (as indicated on Brightspace);

2. The synchronous class will be the place to address all the questions you might have on the asynchronous lectures and work together on specific examples and exercises (studio problems) aiming at reinforcing the concepts learned during the asynchronous classes. You are required to watch the videos of the asynchronous class and learn the topics therein before attending the forthcoming Tuesday class.

It is your responsibility to find appropriate internet connectivity when needed in order to complete asynchronous components.

1.2 Course Team

Instructor: Dr. Gesualdo Scutari (gscutari@purdue.edu), Office: 384, Grissom Hall

Teaching Assistants:

- Yao Ji (ji151@purdue.edu);
- Xiaokai Chen (chen4373@purdue.edu);
- Anurag Ravindra Deodhar (adeodhar@purdue.edu).

Office Hours:

- Yao Ji: Monday, 1:15pm – 4:00 pm. Griss 157D;

- Xiaokai Chen: Thursday, 10:00am – 12:45pm, Griss 157E;
- Anurag Ravindra Deodhar: Wednesday, 11:00am – 1:45pm, Griss 157C;
- Gesualdo Scutari: Tuesday, 5:45pm – 7pm (or by appointment), Griss 384.

Correspondence: Announcements will be made during classes (Tue), Brightspace, and/or email. When sending email to the teaching staff, send to ALL the TAs (not a single one). To prevent delay or loss by spam blockers, use the subject line (without quotes and appropriate course component): "IE335: lecture/exam/quiz/other".

2 Course Information

Course credits: 3.

Course Description: IE 335 is an introduction to deterministic optimization models and algorithms in operation research. The emphasis is on i) translating decision-making problems into the frameworks of linear and nonlinear optimization problems; ii) recognizing and analyzing convex optimization problems; and iii) developing solution methods solving these optimization models. One feature of our approach is the use of MATLAB codes to demonstrate the computational aspects of the course.

Course Objectives: At the end of this course, students are expected to be able to

- Formulate real life problems into (linear/nonlinear) optimization problems;
- Graphically solve two or three dimensional (linear/nonlinear) optimization problems;
- Use MATLAB to solve higher dimensional (linear/convex nonlinear) optimization problems;
- Performing solution analysis: existence/uniqueness, (in)feasibility, (un)boundedness, and optimality;
- Understanding linear programming: solution analysis, solution methods (the simplex and interior-point algorithm);
- Identify and formulate network flow models;
- Formulate integer linear programming and use the branch and bound solver;
- Basic understanding of Least Square and simple (constrained) nonlinear programming problems and first-order algorithms.

The instructor reserves the right to lower these standards during the semester if deemed necessary. These standards will not be raised or new objectives added.

Prerequisites: 1) Linear Algebra (Undergraduate level MA 35100 or MA 26500, minimum grade of D-); and 2) Calculus (MA 26100, MA 27101, MATH 26100, MA 17400, MA 26300, and MA 18200). **These prerequisites are mandatory.**

Most of the assignments will require the use of MATLAB, which will also be used extensively in the lectures. You are required to have a basic knowledge of Matlab programming.

Textbooks: There is no official textbook; handouts of class slides will be posted on Backboard a few days before class. Some relevant textbooks are:

- Hamdy A. Taha. *Operations Research: An Introduction.* Tenth edition. Pearson, 2017;
- W. Winston. *Operations Research: Applications and Algorithms.* Fourth edition. Thomson-Brooks, 2004;
- R. Rardin. *Optimization in Operations Research.* Prentice-Hall, 1998.

All you need to know for this course about MATLAB can be found in (either one of) the following (free) references:

- Introduction to MATLAB by Mark S. Gockenbach;[1]
- MATLAB Primer by Kermit Sigmon.[2]

Brightspace: All course materials (e.g. this syllabus, handouts, homework assignments and solutions) will be posted on Brightspace. In addition, all course announcements will be made through Brightspace. Hence, check Brightspace regularly.

The material of the course (slides, handouts, HW, Exam, Quizzes, etc.) is protected by copyright. You are not allowed to share with others outside the class or posted online anywhere. This will be considering failing ethic, and by consequence, getting an F for the course.

3 Course Components

The course will have weekly work for you to deliver. You will find specific directions weekly in the Brightspace module "Week-by-Week View". The weekly workload is organized along the following modules:

Asynchronous Lectures (Thursdays): There will be **multiple video-lectures** (typically two videos) per week, delivered **asynchronously** (i.e., pre-recorded). They will be posted on Brightspace by Wed. morning along with lecture handouts. In these video-lectures, you will be introduced to new concepts and given examples of how these concepts work. You are required to watch each video and learn the content by the week the lecture is posted online. You are strongly encouraged to print the handouts and having in front of you while you are watching the videos and take notes accordingly. You will be also asked to submit **by the end of the same week** (unless otherwise stated) your answers to some quiz posted online along with the lectures (see below about quizzes). Note that each asynchronous class can be split in multiple modules, meaning that you can find multiple videos associated each to some parts of the same lecture (slides)–this can help you to learn the key concepts without getting lost in a long single video.

Synchronous Lectures (Tuesday, 4:30pm - 5:45pm): These lectures will be organized as follows: (i) In the first part of each lecture the instructor will address all the questions from the students, in particular, those on the topics of the asynchronous class posted the previous week. In the module of Brightspace, you will find a submodule where you can pose all the question to be addressed during the online class.

[1] Html: http://www.math.mtu.edu/%7Emsgocken/intro/intro.html
Poscript: http://www.math.mtu.edu/%7Emsgocken/intro/intro.ps
[2] PDF: https://www.dropbox.com/s/wmhs3f8iwai7lo2/matlab_primer3.pdf?dl=0

Quizzes & Studios: To reinforce important concepts introduced in the lectures and make sure that you keep up with the material, there will be quizzes and studio problems to submit from your side. **Quizzes** are in the form of few questions related to the content of each lecture, to be submitted by the end of the week the lecture is posted online (the precise deadline is reported on Brightspace). There can be a single quiz per Video-lecture (typically, two quizzes/week) or a cumulative quiz covering all the video-lectures of the week (hence, one quiz/week). Cumulative quizzes can be in the form of a problem to solve (similar to those you will find in the HW). Quizzes will be posted within the Brightspace module of the associated lecture(s). **Studios** are long exercises ($\sim$30 to 40 minutes) based on material covered in the previous-week lectures. **Studios will be dispensed during the in-person class on Tuesdays**; the instructor will guide you throughout the formulation aiming at engaging the class in a collaborative discussion, but he will not solve the problem for you. You are required to follow the discussion, write down your own formulation, and submit your studio by the end of the class.

There will be no make-up quizzes/studios.

Homeworks: There will be about 5 homework assignments throughout the semester, each consisting of several problems related to the recent course material. The homework problems are designed to reinforce the material introduced to you in lecture, on your own time. HW and solutions will be posted on Brightspace. **The lowest homework grade will be dropped**.

Homework will be turned in via Gradescope. You will be given the assignments well in advance, *so do not wait until the last minute to do or turn in the homework*. **No homework will be accepted later than noon of the day after the homework is due (including Saturday if the homework is due on Friday)**. Such a submission will be marked as late and have point deduction.

You are encouraged to work with others on your homework, but each person must submit their own work. Simply photocopy or transcribe someone else's work is not allowed, and will be considered cheating. Similarly, cutting and pasting solutions from the book or websites will also not be accepted. Also, you must show your work (all steps) to receive credit.

Exams: There will be three exams, two midterms and one final. All the exams will be administrated in class (likely, evening exams). The dates for the midterm exams are TBD (they will be communicated within the first two weeks of the course). For the exams you are required to bring your Purdue ID. You may be asked to show it before, during, or after the exam. Failure to do so will result in a 0 for the exam. Also, all the exams will be closed note/book, and no electronic devices will be allowed.

Makeup exams: No makeup exams will be given, except in the event of illness, University sponsored activities, and family death.

- In the event of illness, you must bring a signed letter from your physician stating that you were unfit to take the exam at the original date and time. *A yellow PUSH note is not acceptable.*
- In the event of a University sponsored activity, you are responsible to provide valid official documentation.

- In the unfortunate case of family death, you must follow the Grief Absence Policy for Students (GAPS) through the Office of the Dean of Students. It is your responsibility to arrange for a makeup exam.

Arrangements for makeup exams must be finalized within one weeks of the original exam date.

Other form of interactions: To facilitate interactions among the students, there will be a discussion section in each week module. Everybody is welcome to contribute and ask question. I will go over all the questions during the next in-person class.

4 Grading

Grading policy: The overall numerical grade will be calculated as

- 40% HomeWorks (HW) (average; lowest score dropped)
- 50% EXams (EX) (equally weighted)
- 10% Studio Problems (ST)
- Bonus up to 10% from Quizzes (QZ), *BUT only if at least 3/4 of them have been turned in, otherwise zero.*

The final number "Grade" coming from the above policy, will be converged in letter according to the following table:

A+: $\geq$95	B+: [83.3, 86.6)	C+: [73.3, 76.6)	D+: [63.3, 66.6)	F: $<$ 56.6
A: [90, 95)	B: [80, 83.3)	C: [70, 73.3)	D: [60, 63.3)	
A-=[86.6, 90)	B-: [76.6, 80)	C-: [66.6, 70)	D-: [56.6, 60)	

There is also a grade for "ethics." This is Pass-Fail. Not cheating and not being involved in any other unethical behavior according to the student honor code will be considered Pass. (Otherwise, it is a failure). Posting online any of the course material (HW, Exams, slides, etc.) will be considered failing ethics. **Failing ethics will result in you getting an F for the course.**

There will be extra credit opportunities in the form of one long project.

Do not ask to be bumped-up if you are near the threshold (eg. 86.2 and request an A-). I will not modify the thresholds for individuals. Note: I reserve the right to lower the thresholds for specific letter grades or drop more than the lowest 3 quiz scores. Any changes will be applied to **all** students.

Regrades: If you believe there was a mistake in the grading of a homework, quiz, or exam, you may request a regrade. However, your entire homework, quiz, or exam may be regraded, so your final score could increase or decrease. (If simply the total score was incorrectly added, we will not regrade).

Any regrade request for a hard-copy submission must consist of a typed or written note (dated and signed), clearly explaining the error, attached to the original document. For electronic submissions (if any) an email containing the same information is needed. **No in-person arguments about regrades are allowed**. If you argue verbally, your work will not

be regraded. The regrade request must be submitted to the TA who graded that work (if in doubt, to the whole TA staff).

All regrade requests must be made within **one-week** of when the graded work was first available for pickup.

End of semester "negotiations": You can only question your grade regarding accuracy. Accuracy problems include such things as missing grades and incorrect grades, but not "but I really tried hard and turned everything in." I will not give you extra work, I will not bump you up if you are 0.1 below a threshold, and I will not change the threshold. If you don't want to "just miss" an A, don't be close to the threshold. The time to worry about your grade is during the semester, not at the end of it.

5 Academic Honesty

You are encouraged to work with other students. Discussing the course material and homework assignments is a great way to learn. Work with each other to figure out how to do the work, but then do the work yourself and record it for the homework/assignment.

Cheating will not be tolerated. Cheating includes, but is not limited to:

- copying (photo or transcribe) someone else's homework;
- looking at another student's quiz or exam paper;
- asking someone else to take a quiz or exam for you;
- using unauthorized notes during a quiz or exam; and
- turning in an altered homework, quiz or exam for a regrade.

Don't cheat. It is not worth it and it will not be tolerated. You will fail this course and be reported to the Dean of Students if you are caught. This will be much more difficult to explain than a low grade in the course and it may ultimately lead to the end of your career at Purdue.

You will be carefully monitored when taking tests/quizzes by many people. All we are looking for is cheating. If you cheat on a test/quiz, you will almost certainly be caught. Homework are checked for cheating.

If you are caught cheating, you will be given an F for ethics and you will be reported to the Dean of Students. They will then contact you for a meeting to discuss the violation.

Read the student guide on academic dishonesty
http://webs.purduecal.edu/integrity/files/2008/09/academic_integrity_brochure_9-07.pdf

My job is to help you learn this material, and evaluate each of you regarding your understanding of the material. I will try very hard to do both well and fairly, without inflicting unnecessary workload on you. Cheating undermines the entire evaluation effort.

If you are having trouble keeping up with the workload of the class, or you believe that your grades are not accurately reflecting your understanding of the material, please make an appointment to discuss this with me. I am a reasonable person and will work with you to the best of my ability. You can recover from a bad grade. You cannot recover from getting caught cheating.

6 More Info & Rules

- Please join online classes in time. Joining in the middle of the class makes no sense. Therefore, no more than 15 min of delay will be tolerated (i.e., you will not be admitted in the zoom room if you are more than 15 min late).
- If possible, show yourself activating the camera, it will make the class less impersonal
- This class is difficult and fast-paced. Do not fall behind−read the slides, do the homework problems, join online lectures, and study for the tests.
- My experience has been that those that fail this class are those that do not try (for one reason or another). If you make a reasonable amount of effort, you can most likely get at least a C. If you don't make an effort, you will probably get a D or an F, then have difficulty in other classes that require optimization.
- Partecipate to office hours if you start having trouble with the material early in the semester. Don't wait until late in the semester−there is not much I can do at that point.

7 Non-discrimination

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life.

Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability, or status as a veteran. The University will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in Executive Memorandum No. D-1,[3] which provides specific contractual rights and remedies. Any student who believes they have been discriminated against may visit

https://publicdocs.maxient.com/reportingform.php?PurdueUniv&layout_id=14

to submit a complaint to the Office of Institutional Equity. Information may be reported anonymously.

8 Disabilities

Purdue University is required to respond to the needs of the students with disabilities as outlined in both the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 through the provision of auxiliary aids and services that allow a student with a disability to fully access and participate in the programs, services, and activities at Purdue University.

[3] http://www.purdue.edu/policies/index.html

If you have a disability that requires special academic accommodation, email the instructor to make an appointment to speak with him within the first two (2) weeks of the semester in order to discuss any adjustments. It is important that we talk about this at the beginning of the semester. It is the student's responsibility to notify the Disability Resource Center (http://www.purdue.edu/drc) of an impairment/condition that may require accommodations and/or classroom modifications.

9 Emergency Preparedness

Purdue University is a very safe campus and there is a low probability that a serious incident will occur here at Purdue. However, just as we receive a "safety briefing" each time we get on an aircraft, we want to emphasize our emergency procedures for evacuation and shelter in place incidents. Our preparedness will be important in case an unexpected event occurs.

Emergency preparedness is your personal responsibility. Purdue University is actively preparing for natural disasters or human-caused incidents with the ultimate goal of maintaining a safe and secure campus. Let's review the following procedures:

- For any emergency call 911;
- There are nearly 300 Emergency Telephone Systems throughout campus that connect directly to the Purdue Police Department (PUPD). If you feel threatened or need help, push the button and you will be connected to the PUPD;
- If we hear a fire alarm we will immediately evacuate the building and proceed to the sidewalk area near Class of 50 and the Recitation buildings;
- Do not use the elevator;
- If we are notified of a Shelter in Place requirement for a tornado warning we will remain in the lecture hall;
- If we are notified of a Shelter in Place requirement for a hazardous materials release we will shelter in our classroom shutting any open doors;
- If we are notified of a Shelter in Place requirement for a civil disturbance such as a shooting we will shelter in the lecture hall. We will lock the main doors and turn off the lights. On your way out look at how the doors lock.

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the blackboard or can be obtained by contacting the instructor or TAs via email.

If you need any help in dealing with such events, contact Counseling and Psychological Services:

Purdue Student Health Center (PUSH) Room 246

601 Stadium Mall Drive, West Lafayette, IN 47907

Phone: 765-494-6995; Fax: 765-496-2139.

Psychological Sciences Building (PSYC) Room 1120

703 Third Street, West Lafayette, IN 47907

Phone: 765-494-6995; Fax: 765-496-3004.

Also, for more information about health and safety, please visit https://www.purdue.edu/ehps/