# ISE 402: Applied Models in Operations Research
**Spring 2021**

Syllabus

## Who, When, Where

**Instructor:** Prof. Larry Snyder (he/him)

**Office:** Mohler 321, phone 8-6696

**E-mail:** `larry.snyder@lehigh.edu` (Lehigh ID `lvs2`)

**Class Hours:** M/W 9:35–10:35 AM EST, Mohler 451 and by Zoom

**Office Hours:** By appointment. Please DM me on Slack to set up a time to meet by Zoom.

## Course Description

This course covers applied models in operations research, including applications in supply chain management, energy, health care, and disaster relief. Students will learn seminal models, theorems, and algorithms, and will gain experience in translating practical problems into mathematical ones. This course is required for first-year students in the ISE Ph.D. program.

Students in this course will gain:

1. a thorough understanding of problems faced by OR modelers and decision makers in public- and private-sector organizations
2. skills in modeling real-world problems as quantitative, OR-based models
3. intuition about what makes models more or less tractable, and which algorithmic approaches may be more or less appropriate for a given model
4. an introduction to the key theoretical and analytical results that underlie the application of OR models in these fields

## Prerequisites

ISE 406 (Introduction to Mathematical Optimization) and 429 (Stochastic Models and Applications), or the equivalent.

## Class Format

This class will use a combination of in-person and remote meeting modes.

- **Monday** classes will be held in person, except when instructed otherwise. In-person meetings will be held in Mohler 451. You may attend in-person classes by Zoom, if you prefer to or are unable to attend in person.
- **Wednesday** classes will be held remotely, by Zoom, except when instructed otherwise. The Zoom link will be posted on Slack.

**Please plan to attend all class meetings synchronously,** either in person or by Zoom. If you cannot attend synchronously once in a while, please view the class recordings and catch up on all other class materials, which will be posted on Slack. Class meetings will primarily consist of lectures and discussion, with occasional small-group assignments or other activities. I will usually use a virtual whiteboard (which will be posted on Slack) rather than slides. In addition, there will be pre-reading assignments before most classes.

I encourage questions, discussions, and other (productive) interruptions during class. This helps you learn and makes class more fun!

*When you are joining class in person*: Follow all COVID-19 guidelines, including face masks, hand washing, and social distancing. Do not come to class if you are feeling unwell, have COVID-19 symptoms, or have had a possible exposure to someone with COVID-19.

*When you are joining class by Zoom*: I encourage you to keep your camera on whenever possible. It helps me a lot to be able to see your face while I'm teaching. Please keep your microphone muted when not speaking in class.

## Readings

There is no textbook for this course. Readings will be assigned from books and journal articles; these will be posted on Slack. Detailed references and tentative timing are given later in this syllabus, and I will post updated reading assignments on Slack each week.

## Requirements

1. Homework assignments (40%)

   You will be given 4–5 homework assignments. The homework problems will be based on the readings and in-class material. They will challenge you to understand, interpret, and extend

the models and solution techniques we discuss in class. Some homework assignments will require you to do some coding and/or number-crunching, which you can do in any language you choose. (I am most familiar with Python and MATLAB and can offer help in these languages, but if you prefer another language, feel free.)

2. Midterm exam (20%), Final exam (30%)

   You will be given a take-home midterm exam and a take-home final exam. Both will test your understanding of the material covered in class. The midterm will cover the first two units of the course (supply chain management and health care). The final exam will be cumulative, covering all material from the course. It will be distributed on the last day of class (Thursday, May 6) and will be due one week later. You may use books, notes, and any other sources, except people (other than me) as you work on both exams.

3. Class participation (10%)

   You are expected to attend class regularly (in person or remotely), come to class prepared, participate in the discussions we have in class and on Slack, and ask questions when you are confused.

## Homework Policy

The homework assignments are likely to take you a fair amount of time, so get started on them early. You may work on the homework assignments individually or with a partner. If you work with a partner, you and your partner should submit a single write-up. Remember that you are ultimately responsible for mastering the material on your own, and your performance on the exams will depend on your ability to do so. Therefore, you should make sure you fully understand all of the details of the work you submit, even if you work with a partner.

You may discuss the homework with students other than your partner, but you must cite any people or sources that helped you on a particular problem. For example: "Smarty McPants and I worked on this problem together" or "I got help from Smarty McPants and consulted *Facility Location for Dummies* when solving this problem." I also encourage you to come to me for help when you are stuck.

**You must submit your homework electronically, via Slack DM.**

## LaTeX

All work must be typed using LaTeX and submitted electronically. To assist you in learning LaTeX, I am happy to provide you with the source code for (most of) the documents I write for this course, upon request. I will also provide a template for homework solutions. You are not required to use the provided template, but I recommend it, especially if you are unfamiliar with LaTeX.

There are many good resources online to get you started, and several free software packages you can use for your LaTeXing.

## Proofs

This course will contain quite a few mathematical proofs, some that we discuss in class and others that you will develop in your homework and exams. The course therefore demands a high level of mathematical maturity. There is a short primer about proof-writing in Appendix B of Snyder and Shen (2019), which I have posted on Slack, but this is meant more as a refresher than as an introduction. If you are not already somewhat familiar and comfortable with the material in Appendix B, consider this as your chance to learn.

## Course Communications

Slack will be our primary platform for communication. I will not use CourseSite for this course. You should already have received an invitation to our Slack workspace, `ISE402-SP21`. I will post slides, videos, readings, homework assignments and their solutions, and other essential materials for the course on Slack. Please check there regularly. I recommend also setting your Notification preferences to receive notifications each time a new message is posted, at least on the `#ise402-announcements` channel. (The desktop and mobile apps are more reliable than the web app for notifications, in my experience.)

To contact me, please don't email me; DM me on Slack instead. I will do my best to respond quickly. *Exception*: If you need to discuss your grades, please do so by email, not Slack.

## Use of Mobile Devices

The use of computers, smart phones, tablets, and other mobile electronic devices is prohibited in class. I understand that there may be some legitimate reasons to use such devices in class, but please wait until after class ends to perform these functions. Screens are a distraction both to the students and to the instructor and may not be used.

## Academic Integrity

**Please read the material on Academic Integrity** available on the Provost's Academic Integrity site (`http://www.lehigh.edu/~inprv/faculty/academicintegrity.html`) and on the CITL web site (`https://citl.lehigh.edu/academic-integrity-resources`). Examples of behavior that violates Lehigh's academic integrity principles include (but are not limited to) plagiarism, cheating,

copying assignments from previous semesters, creating disruptions, unfairly exploiting the efforts of others, etc.

Perhaps the most misunderstood violation of academic integrity is plagiarism. Plagiarism is defined in the Lehigh student handbook as "the unacknowledged appropriation of another's work, words, or ideas in any themes, outlines, papers, reports, or computer programs." This includes so-called "innocent plagiarism," in which an author essentially quotes another author's work when attempting to paraphrase it. For more information about what plagiarism is and what counts as plagiarism, see `https://libraryguides.lehigh.edu/plagiarism`.

**Work that violates the academic integrity principles will receive a grade of 0**, and **repeat offenses will be grounds for failure for the course.**

## Accommodations for Students with Disabilities

If you have a disability for which you are or may be requesting accommodations, please contact both me and the Office of Academic Support Services, University Center 212 (8-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

## A Few Other Resources

- Graduate Writing Support (GWS) is part of the Graduate Education & Life department and will assist any graduate writer from any discipline at any stage of the writing process. They offer many kinds of support throughout the year, from campus-wide writing workshops to individual and small-group writing consultations. For a complete list of their support offerings, please visit their website at `https://grad.lehigh.edu/academics/graduate-writing-support`. The Graduate Writers' Studio is a part of that support program and offers individualized writing support for graduate writers. To schedule a writing consultation with a trained graduate consultant, visit `http://mywco.com/lehighgradwriting`. They currently offer real-time virtual consultations and delayed response online consultations that can be scheduled for 1–2 hours per consultation. For questions, please contact the Director of Graduate Writing Support, Yvonne Lee, at `yrl219@lehigh.edu`.
- The Operations Research Stack Exchange site (`or.stackexchange.com`) is a great resource for asking and answering questions about OR. The site has questions about theoretical aspects of OR, applied OR models, solvers and software, OR careers, and a number of other topics. Lots of OR experts (students, faculty, practitioners) frequent the site and ask and answer questions. Please feel free to post questions (and answers!) there. If you do, however, remember that the site is not a homework-help site; it works best when people ask careful questions that will have value to other people, not just the person asking. For more guidance about how to ask questions, see `https://or.stackexchange.com/help/on-topic`; and for specific guidance about

homework-related questions, see `https://or.meta.stackexchange.com/q/229/38`. *Note*: I read just about every question posted on the site. `;)`

### Maybe Most Importantly

Please be flexible and open-minded this semester. The format of this course this semester is somewhat experimental, and I might change some aspects of this syllabus as the semester progresses. I ask for your understanding and patience. In turn, I will be patient and understanding with you. We are all experiencing education, and life, in new ways.

## Tentative Schedule

The following is a **very tentative** outline of the course. I may add, subtract, or rearrange topics as the semester progresses. Readings marked as **Background** cover material that you are expected to know from the prerequisite courses, or additional resources for new material covered in this class. You should read this material, but we will not cover it in class.

### Introduction

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| *Week of February 1*: | Introduction to decision-making under uncertainty |
| **Reading:** | "Introduction to Decision-Making under Uncertainty" handout |
| **Background:** | "Modeling Basics" handout |

### Supply Chain Management

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| *Week of February 8*: | Introduction; inventory optimization |
| **Reading:** | Snyder and Shen (2019) §3.7, 4.1–4.3.2.6, 4.3.3, 4.3.4 (first 2 pages) |
| **Background:** | Snyder and Shen (2019) §3.1–3.2 |
| *Week of February 15*: | Inventory optimization (cont'd.); distribution-free newsvendor |
| **Reading:** | Gallego and Moon (1993) |
| *Week of February 22*: | Facility location |
| **Reading:** | Snyder and Shen (2019) §8.1–8.2.3.6 |
| **Background:** | Snyder and Shen (2019) Appendix D |
| *Week of March 1*: | Uncertainty and multi-objective optimization in facility location |
| **Reading:** | Snyder and Shen (2019) §8.6; handout |

### Health Care

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| *Week of March 8*: | Appointment and operating room scheduling |
| **Reading:** | Batun and Begen (2013) §1–3 |
| *Week of March 15*: | Queuing models for health care |
| **Reading:** | Creemers et al. (2007) |
| **Background:** | Gupta (2013) |
| *Week of March 22*: | Organ allocation |
| **Reading:** | Bertsimas et al. (2013) |

### Power Systems

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| *Week of March 29*: | Preliminaries; the optimal power flow (OPF) problem |

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| **Reading:** | Taylor (2015) §2.5; 3.1–3.3 |
| **Background:** | Taylor (2015) §2.1–2.4 |

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| *Week of April 5*: | Multi-period OPF; energy storage |
| **Reading:** | Taylor (2015) §4.1 |

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| *Week of April 12*: | Market-clearing algorithms |
| **Reading:** | Raghunathan et al. (2018) |

Disaster Relief

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| *Week of April 19*: | Overview; screening models; location models for disaster preparedness |
| **Reading:** | McLay (2015) §1–5 |

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| *Week of April 26*: | Disaster response and recovery |
| **Reading:** | McLay (2015) §6–8 |

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| *Week of May 3*: | Catch-up, wrap-up, review |

# References


S. Batun and M. A. Begen. Optimization in healthcare delivery modeling: Methods and applications. In B. T. Denton, editor, *Handbook of Healthcare Operations Management: Methods and Applications*, chapter 4, pages 75–119. Springer, New York, 2013.

D. Bertsimas, V. F. Farias, and N. Trichakis. Fairness, efficiency, and flexibility in organ allocation for kidney transplantation. *Operations Research*, 61(1):73–87, 2013.

S. Creemers, M. Lambrecht, and N. Vandaele. Queuing models in healthcare. *Tijdschrift voor economie en management (Review of Business and Economics)*, 52(3):471–497, 2007.

G. Gallego and I. Moon. The distribution free newsboy problem: Review and extensions. *The Journal of the Operational Research Society*, 44(8):825–834, 1993.

D. Gupta. Queueing models for healthcare operations. In B. T. Denton, editor, *Handbook of Healthcare Operations Management: Methods and Applications*, chapter 2, pages 19–44. Springer, New York, 2013.

L. A. McLay. Discrete optimization models for homeland security and disaster management. In D. Aleman and A. Thiele, editors, *INFORMS Tutorials in Operations Research*, pages 111–132. INFORMS, Hanover, MD, 2015.

A. Raghunathan, F. Curtis, Y. Takaguchi, and H. Hashimoto. Fast market clearing algorithms. In S. Meyn, T. Samad, I. Hiskens, and J. Stoustrup, editors, *Energy Markets and Responsive Grids*, volume 162 of *The IMA Volumes in Mathematics and its Applications*, pages 155–175, New York, 2018. Springer.

L. V. Snyder and Z.-J. M. Shen. *Fundamentals of Supply Chain Theory.* Wiley, Hoboken, NJ, 2nd edition, 2019.

J. A. Taylor. *Convex Optimization of Power Systems.* Cambridge University Press, Cambridge, 2015.