

Main class 1: What is this course, and why does it matter?

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1 Takeaway and Summary

- The syllabus has all the information about the structure of the class.
- Course assignments, materials and discussions are on Canvas.
- For each class, there are readings and quizzes. Each week, a PSet. Course project, midterm, final.
- Lab classes focuses on programming, in Python.
- There are 5 units/modules in the class:
 - Probability, focusing on the later parts of IEMS 302, especially conditional distributions. Law of Large Numbers and Central Limit Theorem. ~ 8 main classes
 - Stochastic Processes and Discrete-time Markov Chains. ~ 6 main classes.
 - Poisson processes. ~ 5 main classes.
 - Continuous-time Markov Chains. ~ 4 main classes.
 - Queueing theory (my research area! Love to talk more!) and Markov Decision Processes. ~ 6 main classes.
- This course is about theoretical tools for modeling, understanding, and controlling variability and uncertainty in operational systems.
- Operational systems include disease spread, staffing decisions, inventory control, queueing, and much more.
- Theoretical tools means using mathematics to be precise and abstract.

2 Beginning of class

Before class and at start of class: **Hand out syllabus** (First 5 minutes of class)

Today's goals: Introducing and motivating the class.

3 Introduction to the class (15 min)

This class is IEMS 315, Stochastic Models

Stochastic is just a fancy word meaning probability over time. So this is a probability course, looking at sequences of random events.

Instructors:

Izzy Grosof (me!). They/she. Office: Tech E280. izzy.grosof@northwestern.edu

Heyuan Yao. He/him.

Main classes: Monday, Wednesday, Friday, 10-10:50am. Tech L251 (here!).

Lab classes: Two options: Friday 1-1:50pm or 2-2:50pm. Tech C135. If you want to go to a different one than you're registered for, that's fine, just talk to me or email me.

Office hours:

- Monday, 9-10am: Heyuan, location TBD.
- Tuesday, 4-5pm: Izzy, Tech E280
- Wednesday, after 2pm, time to be voted on, location TBD.
- Friday, 4-5pm: Izzy, Tech E280

Everyone is required to go to an office hours in the first week. We'll discuss what you're anticipating about the class – what you're looking forward to or what you might anticipate needing help with. We're handing around an information sheet – please write down name, pronunciation and pronouns if you like, and when you're planning to go to office hours. Note: Just a plan, not a commitment.

Hand around info sheet

Hold vote on Wednesday OH.

If you can't make any of the times, that's fine, just let me know in person or over email, and we'll figure something out, might add or move OHs to find what works better.

If you end up going to a different time than you signed up for, or multiple times, that's fine too.

Introduce a bit about myself: Trans, nonbinary, where I've lived, programmatic art, D&D. Course forum: On Canvas, under "Discussions". There's an intros post, post there, want to make sure everyone knows where it is. If you're looking to form or join a study group, can put it in your intro.

Class structure:

- Main classes (3x/week)
- Readings – textbook sections. One per main class, reinforcing that class's content. *Introduction to Probability for Computing*, either physical or online (3x/week). Sections listed on Canvas, first reading after Friday's class.
- Quizzes – correspond to readings, multiple choice. To help guide your reading. One per reading. On canvas. (3x/week)
- Lab classes – programming based. Assignment is a partially-written Python programming, you'll make it work. Heyuan and I will walk around and help debug. (1x/week)
- Problem sets (1x/week).
- Midterm (1)
- Course Project (1)
- Final (1)

Grading: Problem sets and quizzes: 20%. Course project: 10%. Midterm: 30%. Final: 40%. Participation: bonus 10%.

Questions?

4 What is the course about? (30 min)

Theoretical tools for modeling, understanding, and controlling variability and uncertainty in operational systems.

4.1 Why does it matter? (10 min)

Say we're trying to simulate an emergency room waiting area, because we're trying to figure out how to bring down people's waiting times.

Say we've measured things, and on average a person shows up every minute. And on average, a nurse frees up to see someone every 50 seconds.

So we make our simulator as follows:

- Every minute, a patient arrives.
- 50 seconds later, a nurse frees up and sees them.

(Draw graph of number in system)

Does this look realistic?

Why not?

No variability!

We'll learn how to create a randomized model, which can match not just the average arrival rate seen in the real emergency room, but also the variability in those arrivals.

(Draw graph with randomness – Poisson process!)

More realistic, more useful for improving actual emergency rooms!

If we understand the math behind the theoretical models, we can design models that usefully emulate the real world, we can prove things about those models, and we can simulate them, all of which will let us better understand and better control operational systems.

4.2 Outline of the class (5 min)

- Probability (IEMS 202/302 with extra rigor) and Limit Theorems for sequences of random variables. ~ 8 main classes
- Stochastic Processes and Discrete-time Markov Chains. ~ 6 main classes.
- Poisson processes. ~ 5 main classes.
- Continuous-time Markov Chains. ~ 4 main classes.
- Queueing theory (my research area! Love to talk more!) and Markov Decision Processes. ~ 6 main classes.

4.3 Again, what this course is about (5 min)

Theoretical tools!

For modeling, understanding and controlling variability and uncertainty in operational systems.

What does theoretical tools mean?

Using mathematics to be precise. Can communicate ideas and concepts exactly, can program them, can understand what people in the field are talk about.

Using mathematics to be abstract. Focus on the essential parts of the problem, everything's easier in a simpler setting. People may already known how to handle that simple version, we can make use of that. Only once we understand the simplest version of the problem do we add back in the unique parts to our specific setting.

4.4 Goals (5 min)

By the end of the course, we want to be able to create and understand models applicable to these real-world settings:

- Stochastic Models of disease spread and epidemics
- Modeling games of chance (applicable to financial settings)
- The PageRank algorithm – figuring out which websites are important, if all you know is which sites link to which other sites. (Google)
- Shuffling cards – how many shuffles before a deck is essentially fully randomized?
- Call center staffing – fewer staff, longer wait times (or vice versa)
- Inventory control – how much stock is best to keep on hand?

Key skills that we'll build along the way:

- Mathematical reasoning – being precise and being abstract.
- Mathematical intuition
- Formalizing that intuition
- How to learn mathematics

4.5 Resources to help achieve these learning goals (5 min)

- Reading assignment and quiz after each main class, to
- Review – try the exercises in the textbook, they've got worked out solutions, it's a good way to improve skills
- Problem sets – meant to be difficult, failing doesn't mean you're bad at the class. 10+ hours is not uncommon.
- Office hours. Let me know what you're confused about – maybe I didn't explain it so well. Putting in to words what's confusing is often really helpful.
- Asking questions, in main class and lab class. I love it when people ask questions! Especially the “I'm confused, could you go over that again?” kind of questions. I asked a lot of questions like that when I was taking classes like this one, it really helped me. I totally get it can be hard to not look like you know what's going on, but it'll make my day, and it'll help you too. And the rest of the class, because I constantly have people saying “Oh I'm glad they asked that I was wondering too”.

Feedback: Can talk to me, email, forum, office hours. Or, if you want to give anonymous feedback, there's an option on the forum for that, or can be used to anonymously ask questions. Also, at the end of every other main class Friday, we'll have an opportunity for in-class anonymous feedback – I'll pass around notecards.

Questions?