MATH 4800/5080 - Probability Theory

Fall 2024

Instructor: Vahan Huroyan

Webpage: http://vahan.huroyan.com

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Regular Office Hours: MWTh 2-2:50

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Lecture: MWF 3:10-4pm.

Lecture Location: Ritter 323

Course Webpage: https://vahan.huroyan.com/math4800.html

Textbook:
Introduction to Probability, Second Edition, by Jessica Hwang and Joseph K. Blitzstein

Course Description:
MATH 4800/5080 is a course in the theory and application of probability. Probability is useful in other areas of mathematics, in engineering and sciences, and is essential for advanced study in statistics. In this course, we will develop (with proofs) the theory of probability. Topics include discrete and continuous random variables, expectation, jointly defined random variables, transforms of random variables, limit theorems, and a brief introduction to stochastic processes.

Prerequisites:
MATH/STAT 3850, (MATH 2660 or MATH 1660), MATH 2530.

Course Goals and Objectives:
This course will serve as an introduction to the study of theory of probability. Topics covered include probability spaces, axioms of probability, random variables, various discrete and continuous probability distributions, expectations, moment generating functions, laws of large numbers, central limit theorem, random walks on graphs and weighted graphs, Markov chains.

Learning Outcomes:
Upon completion of the course, the student will

1. Be able to "think probabilistically," and be familiar with the glossary of probability and statistics;
2. Be able to use R to run various simulations
3. Be able to interpret, explain, and apply probabilistic concepts such as probability, conditional probability, independence, expectations, variance;
4. Be able to set up and interpret probability models for variety of chance experiments;

5. Understand the relationship between random variables and their distributions / densities;
6. Understand the meaning, scope, and consequences of the Law of Large Numbers and the Central Limit Theorem;
7. Be able to interpret and do calculations with the most common probability distributions, e.g., the normal, the exponential, and the uniform distributions.

Exams:
There will be 2 midterms and one final exam
Midterm 1: *October 2, 2024*
Midterm 2: *November 15, 2024*
Final Exam: *TBA*

Grading Policy:
Homework: total 25%; 2 midterms: total 40% (20% each); final exam (35%).

Letter Grade Distribution:
$\geq 93\%$ - A; 90% - 92.99% - A−;
$87\% - 89.99\%$ - B+; $83\% - 86.99\%$ - B; 80% - 82.99% - B−;
$77\% - 79.99\%$ - C+; $73\% - 76.99\%$ - C; 67% - 72.99% - C−;
60% - 66.99% - D; < 60 - F;

Course Policies / Honesty Policy:

- General
  - The programming language R is allowed on all assignments, except possibly for exams.
  - No makeup exams will be given. If a student misses an exam due to a university approved absence, then either an oral exam will be given or the final exam will count for a larger percentage of points. Documentation for absences is required.
- Grades
  - Grades will be maintained by the professor. Graded assignments will be returned to students, who are responsible for keeping track of their own grades should they wish to know how they are doing during the semester.
- Homework
  - There may be both individual assignments and group assignments. Students may choose to do the group assignments as individuals, but individual assignments must be done with no outside assistance. Receiving assistance on an individual assignment from any source (e.g. person, book, or webpage) other than the textbook for this class and the R help manual will be considered academic dishonesty.
  - Homework assignments not turned by the due date receive an automatic zero. Extensions may be granted on a case by case basis, either with prior permission of the instructor (a valid reason must be given) or with instructor's agreement in cases of emergency. In the latter case, the student must contact the instructor within 24 hours if possible.
- Attendance and Absences
  - Regular attendance is essential and expected.

- Students are responsible for all missed work, regardless of the reason for absence. It is also the absentee's responsibility to get all missing notes or materials.

Tentative schedule of topics and activities:
Weekly coverage may change, as it depends on the progress of the class.

Week 1 Axioms of probability, sampling, review of counting, counting techniques.

Week 2 More Counting, conditional probability, independence and independent trials, Binomial and Poisson distributions.

Week 3 Discrete Random Variables: Expectation, transformations, joint distributions and independence.

Week 4 Discrete Random Variables: Variance and covariance. Conditional distributions. Expectation of a function of a random variable.

Week 5 Discrete random variables: Geometric, Negative bionomial, hypergeometric.

Week 6 Continuous probabilities from density functions.

Week 7 Continuous random variables: Distribution functions, expectation, variance and transformations of random variables.

Week 8 Continuous random variables: uniform, normal, exponential and others.

Week 9 Continuous random variables: joint distributions, independence, covariance and transformations of random variables.

Week 10 Continuous Random Variables: Gamma, Beta, Pareto.

Week 11 Conditional distributions and conditional expectations.

Week 12 Limiting Theorems: Strong and Weak Laws of large numbers. Moment generating functions.

Week 13 Central Limit Theorem. Monte Carlo Integration. Method of moments.

Week 14 Random walks on graphs and weighted graphs. Markov chains.

Academic Integrity:

Academic integrity is the commitment to and demonstration of honest and moral behavior in an academic setting. Since the mission of the University is "the pursuit of truth for the greater glory of God and for the service of humanity," acts of integrity are essential to its very reason for existence. Thus, the University regards academic integrity as a matter of serious importance. Academic integrity is the foundation of the academic assessment process, which in turn sustains the ability of the University to certify to the outside world the skills and attainments of its graduates. Adhering to the standards of academic integrity allows all members of the University to contribute to a just and equitable learning environment that cultivates moral character and self-respect. The full University-level Academic Integrity Policy can be found on the Provost's Office website at: https://www.slu.edu/provost/policies/academic-and-course/academic-integrity-policy.pdf.

Disability Accommodations:

Students with a documented disability who wish to request academic accommodations must formally register their disability with the University. Once successfully registered, students also must notify their

course instructor that they wish to use their approved accommodations in the course.

Please contact the Center for Accessibility and Disability Resources (CADR) to schedule an appointment to discuss accommodation requests and eligibility requirements. Most students on the St. Louis campus will contact CADR, located in the Student Success Center and available by email at accessibility_disability@slu.edu or by phone at 314.977.3484 Once approved, information about a student's eligibility for academic accommodations will be shared with course instructors by email from CADR and within the instructor's official course roster. Students who do not have a documented disability but who think they may have one also are encouraged to contact to CADR. Confidentiality will be observed in all inquiries.

Note: due to accreditation requirements, regulatory differences, and/or location-specific resources, the School of Law, the School of Medicine, and SLU Madrid have their own standard language for syllabus statements related to disability accommodations. Faculty in those units should seek guidance for syllabus requirements from their dean's office.

Title IX:

Saint Louis University and its faculty are committed to supporting our students and seeking an environment that is free of bias, discrimination, and harassment. If you have encountered any form of discrimination on the basis of sex, including sexual harassment, sexual assault, stalking, domestic or dating violence, we encourage you to report this to the University. Discrimination on the basis of sex includes discrimination on the basis of assigned sex at birth, sex characteristics, pregnancy and pregnancy related conditions, sexual orientation and gender identity. If you speak with a faculty member about an incident that involves a Title IX matter, that faculty member must notify SLU's Title IX Coordinator that you shared an experience relating to Title IX. This is true even if you ask the faculty member not to disclose the incident. The Title IX Coordinator will then be available to assist you in understanding all of your options and in connecting you with all possible resources on and off campus.

If you are pregnant or experiencing a pregnancy related condition, the Title IX Coordinator can assist you in understanding your rights and options as well as provide supportive measures.

Anna Kratky is the Title IX Coordinator at Saint Louis University (DuBourg Hall, room 36; anna.kratky@slu.edu; 314-977-3886). If you wish to speak with a confidential source, you may contact the counselors at the University Counseling Center at 314-977-TALK or make an anonymous report through SLU's Integrity Hotline by calling 1-877-525-5669 or online at http://www.lighthouse-services.com/slu To view SLU's policies, and for resources, please visit the following web addresses:

https://www.slu.edu/about/safety/sexual-assault-resources/index.php

Note: due to accreditation requirements, regulatory differences, and/or location-specific resources, the School of Law, the School of Medicine, and SLU Madrid have their own standard language for syllabus statements related to Title IX. Faculty in those units should seek guidance for syllabus requirements from their dean's office.

Classroom Behavior Policy:

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Student Success Center:

The Student Success Center (SSC) supports students in reaching their goals in and out of the classroom. Providing a variety of resources, the Student Success Center houses both the Center for Accessibility and Disability Resources (CADR) and Academic Support, which includes Tutoring, Supplemental Instruction, University Writing Services, and Student Success Coaching. The Student Success Center is located in the

Busch Student Center, Suite 331, and students can make an appointment with any SSC resource via EAB Navigate. To learn more about the Student Success Center and its resources, please visit our website: https://www.slu.edu/life-at-slu/student-success-center/index.php.

University Counseling Center:

The University Counseling Center (UCC) offers free, short-term, solution-focused counseling to Saint Louis University undergraduate and graduate students. UCC counselors are highly trained clinicians who can assist with a variety of issues, such as adjustment to college life, troubling changes in mood, and chronic psychological conditions. To make an appointment, call 314-977-8255 (TALK), or visit the clinic on the second floor of Wuller Hall.

Statement allowing the limited use of generative AI:

You are allowed to use generative AI in a limited capacity in this course. Tools such as [ChatGPT, Microsoft Copilot, Gemini, Midjourney, DALL-E or GitHub Copilot] can be used for specific assignments as directed in the assignment. I have thoughtfully chosen when to implement the use of generative AI for your assignments. Please note the assignments for which generative AI is allowed come after you have been introduced to foundational skills and concepts. Tools that perform readability analysis, detect tone and provide editing suggestions as well as those that paraphrase, summarize and outline are allowed for general use on any assignment.

Using a generative AI tool may assist your learning by [simplifying texts, helping you brainstorm, providing choices of theses when writing, assisting you with forming arguments, providing grammar checks or feedback for structure, debugging code or creating works of art]. However, becoming dependent on generative AI could undermine your learning by eroding your ability to ideate independently, participate fully and intentionally in the writing process, or critically problem solve by debugging your code. The use of generative AI can strip a writer of her/his voice diminishing a creative work. Generative AI still produces inaccurate information and hallucinations are still common which if left unchecked can harm your grade on the assignment. Any work generated with AI should be fact checked to ensure accuracy. You are responsible for the content of your work.

If you have a question regarding if you are allowed to use generative AI for an assignment or whether you are using it appropriately, please discuss your concerns with me at your earliest opportunity. If you choose to use a generative AI tool to assist with an assignment, you need to document its use. The proper citation format can be found here. Please append your assignment with how you used generative AI for your work, where in the assignment it is used and provide proper citation. Your original work and your AI assisted work should be clearly evident. In addition, use of generative AI should conform to academic integrity policies for the university and regulations put forward by the College of Arts and Sciences. Please review item three in the section labeled Plagiarism in the Saint Louis University Academic Integrity Policy.