Math 36a - Probability - Summer 2024
Mondays, Tuesdays, Wednesdays and Thursdays, 11:20 am - 1:40 pm
Remote learning, https://brandeis.zoom.us/j/96439428676

Instructor: Jonathan Touboul
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Office: Goldsmith 303
Student Hours: Monday 2:30-3:00pm, Wednesday 2:30-3:00pm, Thursday 2:30-3:00 pm
In person in Goldsmith 303 or Zoom, same link as class.

Prerequisites Math 20A or 22B (Multivariable calculus)

Course material: All course material and assignments will be made available on LATTE, the Brandeis learning management system. Login on to http://latte.brandeis.edu using your UNET ID and password. For LATTE help, contact Library@brandeis.edu.

Attendance: Attendance at all classes is expected, even if recordings are made available.

Interactive Class forum We will be using Piazza for class discussion. The system is designed to getting you help fast and efficiently from classmates and myself, and I encourage you to post your questions and thoughts on Piazza regularly. You should have been added automatically, and if that's not the case, please find our class signup link at:
https://piazza.com/brandeis/summer2024/math36a
and use access code: 31415

Course description and objective: Recent event just confirmed that, in nature, some phenomena are unpredictable. In fact, rigorously, most phenomena cannot be said for sure to occur or not. Think about it for a minute: which natural phenomenon can you name that is fully predictable? In general, we can rather estimate the chance, or, in mathematical terms, the *probability*, for an outcome to occur. Appropriately handling uncertainty is thus essential in a variety of domains including economics, investing strategies on the stock market, strategies to beat the casino, machine learning and artificial intelligence, game theory, political polls, and, in fact, any medical or societal statistics one is exposed everyday in newspapers and internet. *Probability theory* is the axiomatic mathematical formalization of these uncertain events.

This theory was initiated by two French mathematicians, B. Pascal and P. de Fermat, as they were corresponding about games of chance; these problems and seminal works continued to influence outstanding scientists including Huygens, Bernoulli, and DeMoivre, leading to establishing the bases of the modern mathematical theory of probability. Today, probability theory is a well established branch of mathematics. It is an active area of fundamental research, and, of course, of applied mathematics development dealing with economics, finance, neurobiology, physics, ecology, climate change, medical treatments or pandemics.

This course introduces the foundations of mathematical probability, completed with plenty of real world examples. The main topics of study will be: combinatorics (how to count things), random variables ('events' with chances of occurring), conditional probability ('what are the chances that it is currently raining given that I see my friend taking their umbrella?'), discrete and continuous distributions, jointly distributed random variables, moments of random variables and the basic limit theorems (strong/weak law, central limit theorem).

Textbooks (recommended)
The material presented in this class is original and does not follow a specific textbook. Lecture notes will be provided at the end of each chapter. No textbook is required.

Interesting references include:

- *Elementary Probability Theory*, by KL Chung and F. AitSahlia (Springer) [closest to class level]
- *An Introduction to Probability Theory and its Applications*, Vol. 1&2, William Feller (Willey) [more theoretical than the class]
- *First Course in Probability* by Sheldon Ross (Pearson) [least theoretical]

Expectation of students' effort: Success in this course is based on the expectation that students will spend a minimum of 9 hours of study time per week in preparation for the class (reviewing class material, completing homework, preparation for exams, etc.).

Learning goals: Upon successful completion of Math 36A students will be able to:

- Solve basic counting problems
- Compute probabilities on a set theoretic basis & use the axioms of probability
- Compute conditional probabilities and check independence of events
- Define random variables for simple random experiments
- Calculate probabilities, expectations and variances of discrete and continuous random variables
- Perform simple computations involving jointly distributed random variables
- Use the weak and strong laws, and the central limit theorem to approximate probabilities

Course Plan

- *Set theory, combinatorics, probability*: 6/3 - 6/6
- *Discrete Random Variables and Conditional Probability*: 6/10 - 6/18
- **Take Home Midterm**: 6/24. Expected duration: 90 minutes.
- *Conditional Probability, Independence*: 6/19 - 6/25
- *Continuous Random variables, Limit Theorems*: 6/26-7/3
- *Review session: 7/4*
- *Exam - set by the registrar, either 7/6 or 7/7*

Grading Policy:

- The grade will be based at 30% on the weekly homework assignments, 30% on a midterm exam and 40% on a final examination.
- Homework and midterm will be submitted on Gradescope. You should have been already registered. If you have not been notified of your registration to gradescope, please email me asap.

- Bonus up to 5 points will be granted based on significant participation. Participation includes answering instructor's questions in class, asking questions in class, posting to asynchronous discussions online on the piazza forum, speaking during in-class discussions, raising questions as soon as ideas become unclear, responding thoughtfully and constructively to the contributions made by other class members, reading and responding to course-related e-mails and posts.
- The lowest homework grade will be dropped.
- Collaboration and discussion on homework is encouraged but you must write up your solutions independently of your classmates.
- Collaboration on exams is forbidden and will be strictly enforced; any suspicion will be reported to academic integrity (see below).

Late homework policy: Unless a specific extension is requested and approved 24h in advance, any homework returned late of less than 24 hours will get a 10 points penalty, and after 24 hours, the homework will not be accepted.

Accommodations for Students with Disabilities: I am more than happy to support any accommodation students may need, and it is my objective to make this class meaningful for everyone. If you are a student who needs accommodations as outlined in a Brandeis accommodation letter, please talk with me as early as possible and present your letter of accommodation as soon as you can, as I can provide accommodation in advance, but not retroactively. If you have questions about documenting a disability or requesting accommodations, please contact Student Accessibility Support (SAS) at 781.736.3470 or access@brandeis.edu.

Academic Integrity: You are expected to be honest in all of your academic work. Please consult Brandeis University Rights and Responsibilities for all policies and procedures related to academic integrity:
https://www.brandeis.edu/student-rights-community-standards/rights-responsibilities/index.html
Students may be required to submit work to TurnItIn.com software to verify originality. Allegations of alleged academic dishonesty will be forwarded to the director of academic integrity. Sanctions for academic dishonesty can include failing grades and/or suspension from the university. Citation and research assistance can be found on the university library website
(https://guides.library.brandeis.edu/c.php?g=301723).