California Institute of Technology
Department of Computing + Mathematical Sciences

ACM/EE/IDS 116 Introduction to Probability Models
Fall 2021

Lectures: Via pre-recorded videos on YouTube: links will be posted on Piazza on Tue & Thu at 9am PT.
Instructor: Konstantin (Kostia) Zuev
Email: kostia@caltech.edu (please include “116” in the subject line)
Office Hour: Thu 1pm-2pm, outdoor Chalkboard Space on the West side of Annenberg (or by appointment)
Head TA: Qilin Li (qli2@caltech.edu)
TAs and OHs: https://piazza.com/caltech/fall2021/acm116/staff
TA Office Hours: In person and via Zoom, you are welcome to attend as many office hours as you like.

Course Description
This course introduces students to the fundamental concepts, methods, and models of applied probability and stochastic processes. The course is application-oriented and focuses on the development of probabilistic thinking and intuitive feel of the subject rather than on a more traditional formal approach based on measure theory. The main goal is to equip science and engineering students with necessary probabilistic tools they can use in future studies and research.

Prerequisites
- Ma 3 or EE 55, or instructor's permission.
- Some familiarity with MATLAB, e.g. ACM 11, is desired.

Textbooks
- Comprehensive Lecture Notes and Videos (will be posted on Piazza)
- S.M. Ross, Introduction to Probability Models, Available online at https://caltech.tind.io/record/747436

Course Plan
The following is a detailed tentative outline of the topics to be covered this term.
- Probability models, basics of probabilities: sample spaces, axioms, independence
- Random variables: discrete and continuous, expectation, moments, variance, covariance
- Independent random variables, moment generating functions, Poisson paradigm
- Markov's and Chebyshev's inequalities, law of large numbers, central limit theorem, Monte Carlo method
- Conditional probability, conditional expectation, conditional variance
- Law of total expectation, application to the quick-sort algorithm analysis
- Compound random variables, computing probabilities by conditioning
- Classification of Poisson events, the best prize problem, the ballot problem, double conditioning
- Application: probabilistic analysis of random graphs
- Random vectors, covariance matrix, Karhunen–Loève expansion, transformation of random vectors
- Wiener filters, Gaussian vectors, joint probability density function
- Stochastic processes, Markov chains, counting processes, Poisson processes
- Inter-arrival and waiting times, generating the Poisson process
- Merging and splitting Poisson processes, conditional distribution of the arrival times, order statistics
- Multi-type Poisson process, application to insurance, health care, and traffic engineering
- Brownian motion (Wiener process), hitting times, and maximum variable
- General stochastic processes, the mean and correlation functions, stationary processes
- Gaussian processes, estimation of the correlation function, power spectral density
Grading
Your final grade will be based on your total score. Your total score is a weighted average of Problem Sets (60%), Midterm exam (20%), and Final exam (20%). You can increase your total score by up to 5% if you participate actively in Piazza discussions in the Q&A section. Every answer submitted before TAs or instructor answer, which is later endorsed as “good answer” by TAs or instructor, gets 1% of the total score. There are no fixed thresholds for grades, but if your total score is 90% (80%, 70%, 60%), you are guaranteed at least “A” (“B”, “C”, “D”).

Problem Sets
There will be six Problem Sets. Problems (and solutions) will be posted on Piazza. For assignment and due dates see “Important Dates” below. Late submissions will not be accepted, but the Problem Set with the lowest score will be dropped and not counted toward your total score. Submitting wrong files or files in a wrong format is considered as a late submission. Extensions may be granted for academic, personal, or medical reasons. For extensions, please email the Head TA.

Exams
There will be two exams: Midterm and Final. The Head TA will offer a review session before each exam. Both exams are take-home, self-timed, and closed-book, but you can use one sheet (double-sided) of your own notes. You can use your computer only as a typing device and for basic arithmetic operations. No other electronic devices are permitted.

Collaboration Policy
A detailed collaboration policy is given on the course website at: http://www.its.caltech.edu/~zuev/teaching/2021Fall/CollaborationACM116.pdf
In general, collaboration is (very) encouraged everywhere except for the exams. Let’s help each other and learn together! If you get stuck with a homework problem, I encourage you to discuss it with other students. But remember that you will have to prepare and submit your solution by yourself. No collaboration is allowed on the exams.

Piazza
This term we will be using Piazza for most class interactions and discussions. Piazza is designed such that you can get a quick help from your classmates, TAs, and instructor. Instead of emailing questions to the teaching staff, I strongly encourage you to post your questions on Piazza because a) you will get answers much faster b) your classmates may also benefit from seeing the answers to your questions. If you wish, you could ask questions on Piazza anonymously (for classmates, but not for the TAs and instructor). If you think that your question may partially reveal the solution, you could ask your question in a “private mode”, so that only TAs and instructor will see your question. If you want to find classmates for collaboration on coursework, you can fill out a simple form “Search for Teammates” on Piazza, and I will help you to find other students.

Important Dates (All times are Pacific Times)

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<th>Available</th>
<th>Due</th>
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<tbody>
<tr>
<td>Problem Set 1</td>
<td>1pm Tue, Oct 05</td>
<td>9pm Tue, Oct 12</td>
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<td>Problem Set 2</td>
<td>1pm Tue, Oct 12</td>
<td>9pm Tue, Oct 19</td>
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<td>Problem Set 3</td>
<td>1pm, Tue, Oct 19</td>
<td>9pm Tue, Oct 26</td>
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<td>Head TA Review</td>
<td>9am Thu, Oct 28</td>
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<td>Midterm Exam</td>
<td>1pm Thu, Oct 28</td>
<td>9pm Tue, Nov 02</td>
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<td>Problem Set 4</td>
<td>1pm Thu, Nov 04</td>
<td>9pm Thu, Nov 11</td>
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<td>Problem Set 5</td>
<td>1pm Thu, Nov 11</td>
<td>9pm Thu, Nov 18</td>
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<td>Problem Set 6</td>
<td>1pm Thu, Nov 18</td>
<td>9pm Tue, Nov 30</td>
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<td>Head TA Review</td>
<td>9am Mon, Dec 06</td>
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<tr>
<td>Final Exam</td>
<td>1pm Mon, Dec 06</td>
<td>9pm Fri, Dec 10</td>
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Websites

- Course website: http://www.its.caltech.edu/~zuev/teaching/2021Fall/ACM116.html
- Links to video lectures, lecture notes, problem sets, exams, solutions, updates, announcements, and class discussions will be managed via Piazza. Here is the Piazza page: http://www.piazza.com/caltech/fall2021/acm116/home
- Problem sets and exams will be graded via Gradescope.
  - If you are a registered student, you will be enrolled on Gradescope by the end of the 1st week of classes, and you will receive a notification from Gradescope about your enrollment.
  - If you are a registered student, but have not been enrolled on Gradescope by the end of the 1st week of classes, please email the Head TA as soon as possible and ask to enroll you to Gradescope. Your absence on Gradescope means that, according to my records, you are not registered.
  - If you want just to audit the course, it is fine, you will have access to Piazza and all course materials there (please email me and I will enroll you on Piazza), but you will not have access to Gradescope and your submissions will not be graded. If you audit the course this year, you should not register for the course in future years.

To submit your solution via Gradescope, you need to create a single PDF (not images) that contains the whole solution (for example, by scanning your solution), and then upload it to Gradescope. Here are some useful links:
  - Scanning on a mobile device: https://help.gradescope.com/article/0chl25eed3
  - Submitting an assignment: https://help.gradescope.com/article/ccbpppziu9

Should you have any questions regarding Gradescope, please ask on Piazza: we will have many experts there.

Suggested Study Process

To get the most out of ACM 116 this term, here is my suggestion on the study process:
- Watch Video Lectures and review the corresponding Lecture Notes on the same day they are released.
- If something is not clear, ask on Piazza, and help your classmates by answering their questions.
- Very briefly summarize my notes in your own notes, learn to extract the essence.
- Start working on each Problems Set on the same day it is released (or as soon as possible after that).
- Aim at finishing each Problem Set and Exam at least 1 day before they are due.
- If you get stuck with a problem, ask for hints on Piazza (unless it is an exam problem, and then you are screwed ;))

Wellness and Inclusion

It is very important to us that you succeed in ACM 116. It is also very important to us that you maintain your mental wellness throughout the course. A few points are not worth losing sleep over. Everyone on the course staff is available to chat, and you can always attend office hours for a non-academic conversation if necessary. You can also visit the counseling center (https://wellness.caltech.edu/counseling) if you find you need help beyond the course staff. If you have a temporary health condition or permanent disability (either mental health or physical health related), you should contact accessibility services (http://cass.caltech.edu/) if you have not already. Additionally, if there is something we can do to make your experience better, please let us know. Diversity, inclusion, and belonging are all core values of this course. All participants in this course must be treated with respect by other members of the community in accordance with the honor code. If you feel unwelcome or unsafe in any way, no matter how minor, we encourage you to talk to the Instructor or one of the Deans. We view these sorts of honor code violations as completely unacceptable, and we take them very seriously.

Honor Code

“No member of the Caltech community shall take unfair advantage of any other member of the Caltech community.”