# Administrivia

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**Office Hours:** Wednesdays 3:30-5:30pm in Gates 315 and by appointment

**Class web page:** [http://cs109.stanford.edu](http://cs109.stanford.edu)

You should regularly check the class web site for announcements and other information, including the most up-to-date information on assignments and errata. The class web page will also have the schedule of topics to be covered and links to other class materials, including class handouts.

## 1 Prerequisites

The prerequisites for this course are CS103, CS106B or X, and Math 51 (or equivalent courses). Probability involves a fair bit of mathematics (set theory, calculus and familiarity with linear algebra), and we’ll be considering several applications of probability in computer science that require familiarity with algorithms and data structures covered in CS106B/X. Since some students who may not have taken CS103 and/or Math 51 at Stanford have asked what level of mathematics background is necessary, here is a quick rundown of some of the mathematical tools we’ll be using in this class: calculus (integration and differentiation), linear algebra (basic operations on vectors and matrices), an understanding of the basics of set theory (subsets, complements, unions, intersections, cardinality, etc.), and familiarity with basic proof techniques (including induction). We’ll also do combinatorics in the class, but we’ll be covering a fair bit of that material ourselves in the first week. If you don’t feel comfortable with these mathematical topics and still insist on taking CS109 without having taken CS103 and Math 51, we sincerely regret the pain that this class may cause you—but don’t say you weren’t warned. I mean, after all, we just warned you.

## 2 What are CS109 and Probability Theory all about?

While the initial foundations of computer science began in the world of discrete mathematics (after all, modern computers are digital in nature), recent years have seen a surge in the use of probability as a tool for the analysis and development of new algorithms and systems. As a result, it is becoming increasingly important for budding computer scientists to understand probability theory, both to provide new perspectives on existing ideas and to help further advance the field in new ways.

Probability is used in a number of contexts, including analyzing the likelihood that various events will happen, better understanding the performance of algorithms (which are increasingly making use of randomness), or modeling the behavior of systems that exist in asynchronous environments ruled by uncertainty (such as requests being made to a web server). Probability provides a rich set of tools for modeling such phenomena and allowing for precise mathematical statements to be made about the performance of an algorithm or a system in such situations.
Furthermore, computers are increasingly often being used as data analysis tools to glean insights from the enormous amounts of data being gathered in a variety of fields; you’ve no doubt heard the phrase “big data” referring to this phenomenon. Probability theory is now used as one of the primary methods for designing new algorithms to model such data, allowing, for example, a computer to make predictions about new or uncertain events. In fact, many of you have already been the users of such techniques. For example, most email systems now employ automated spam detection and filtering. Methods for being able to automatically infer whether or not an email message is spam are frequently rooted in probabilistic methods. Similarly, if you have ever seen online product recommendation (e.g., “customers who bought X are also likely to buy Y”), you’ve seen yet another application of probability in computer science. Even more subtly, answering detailed questions like how many buckets you should have in your a hash table or how many machines you should deploy in a data center (server farm) for an online application make use of probabilistic techniques to give precise formulations based on testable assumptions.

Our goal in this course is to build foundational skills and give you experience in the following areas:

1. Understanding the combinatorial nature of problems: Many real problems are based on understanding the multitude of possible outcomes that may occur, and determining which of those outcomes satisfy some criteria were care about. Such understanding is important both for determining how likely an outcome is, but also for understanding what factors may affect the outcome (and which of those may be in our control).

2. Working knowledge of probability theory: Having a solid knowledge of probability theory is essential for computer scientists today. Such knowledge includes theoretical fundamentals as well as an appreciation for how that theory can be successfully applied in practice. We hope to impart both these concepts in this class.

3. Appreciation for probabilistic statements: In the world around us, probabilistic statements are often made, but are easily misunderstood. For example, when a candidate in an election is said to have a 53% likelihood of winning does this mean that the candidate is likely to get 53% of the vote, or that that if 100 elections were held today, the candidate would win 53% of them? Understanding the difference between these statements requires an understanding of the model in the underlying probabilistic analysis.

4. Applications: We are not studying probability theory simply for the joy of drawing summation symbols (okay, maybe some people are, but that’s not what we’re really targeting in this class), but rather because there are a wide variety of applications where probability allows us to solve problems that might otherwise be out of reach (or would be solved more poorly without the tools that probability can bring to bear). We’ll look at examples of such applications throughout the class.

5. An introduction to machine learning: Machine learning is a quickly growing subfield of artificial intelligence which has grown to impact many applications in computing. It focuses on analyzing large quantities of data to build models that can then be harnessed in real problems, such as filtering email, improving web search, understanding computer system performance, predicting financial markets, or analyzing DNA.
The class starts by providing a fundamental grounding in combinatorics, and then quickly moves into the basics of probability theory. We will then cover many essential concepts in probability theory, including particular probability distributions, properties of probabilities, and mathematical tools for analyzing probabilities. Finally, the last third of the class will focus on data analysis and machine learning as a means for seeing direct applications of probability in this exciting and quickly growing subfield of computer science.

3 “Working” Office Hours

To help make you more successful in this class, the course staff will hold “working” office hours (aside from Will’s office hours, which are primarily for conceptual and course level questions). The idea is to encourage you to work on your problem sets at these office hours, so you can immediately ask any questions that come up while working on your problem sets. While you are certainly not required to attend any of these working office hours, they are simply meant to encourage you to interact with the course staff more often in order to help you better understand the course material. Besides, our job is to help everyone learn the material for this class, and being more accessible to you when you are actually working on your assignments (rather than when you just have a problem) will help the course go more smoothly for you (and it’ll be more fun for us).

4 Units

If you are an undergraduate, you are required to take CS109 for 5 units of credit. If you are a graduate student, you may enroll in CS109 for 3 or 4 units if it is necessary for you to reduce your units for administrative reasons. Taking the course for reduced units does not imply any change in the course requirements.

5 Handouts and Textbook

The core course material will be in the form of the lectures, lecture notes, and the occasional supplementary handout. You are responsible for material covered in any of these sources. So it probably goes without saying that it would be a really good idea to go to class, as it’s likely to increase your probability of getting a good grade. :-) Handouts are posted online on the class website; contact me if you want printed copies (to save paper, we will only print handouts on request).

We recommend the following textbook as a companion text for this course:


The structure of the course closely follows this textbook for the first 6-7 weeks. The text is not required material, but students may find Ross offers a different and useful perspective on the important concepts of the class. The text also contains many helpful examples that are different from those we cover in class lectures. The schedule on the course website includes suggested reading assignments from the textbook to go with each lecture.

Several copies of the textbook will be held on reserve in the Engineering library, located on the second floor of the Huang Engineering “octagon”, two floors above NVIDIA Auditorium. The Stanford Bookstore should also have some copies in stock, or you can order it online from your favorite book shopping site on the web.
6 Assignments and Exams

During the course, there will be six problem sets assigned. Each student is to submit individual work on the problem sets (more details on that below when we talk about the Honor Code). All homework assignments should be turned in by the beginning of class on the respective due date for each assignment.

In addition to the assignments, there will be a 2-hour midterm exam and a 3-hour final exam. The midterm exam will be administered on Tuesday, July 24, from 7:00pm to 9:00pm. If you have an exceptional circumstance regarding the midterm and absolutely cannot make the scheduled midterm exam, you must let me know, either via the Google Form from question 1 of the first problem set, or as a request by electronic mail to me (yanlisa@stanford.edu) by 5:00pm on Wednesday, July 18th, to arrange an alternate exam time. Any alternate midterm exam will be within at most one day (earlier or later) of the regular exam time, so make sure you are available in that time window if you cannot make the regular exam.

The final examination is scheduled for Friday, August 17th, from 3:30pm-6:30pm. For a variety of reasons (including university policy), there will be no alternate time for the final exam. Please make sure that you can attend the final exam at the specified time before enrolling in the class. If you cannot make the final exam, you should plan on taking CS109 in a different quarter.

As mentioned above, on the assignments and exams you will be responsible for material covered in the class lectures, textbook, and course handouts.

7 Grading

The grade for the course will be determined according to the following breakdown:

- Assignments: 45%
- Midterm Exam: 20%
- Final Exam: 30%
- Optional Participation: 5%

It has been observed over many quarters that attending classes highly correlates with improved class performance. One of the main reasons behind this is that it helps keep you from falling behind. To encourage class attendance, we are going to give you the option of having 5% of your final exam grade come from participation. To get full credit on participation you have to attend at least 80% of classes (which we track using Google Docs) and for two classes you have to give lecture feedback. We will let you know which two lectures to give feedback on. SCPD/off-campus students can also pursue this option.

8 Late Assignments

Since we anticipate that during the quarter, there may be unforeseen circumstances that make it difficult to turn in homework assignments on time, we will grant each student two free late days to be used when turning in assignments. Each free late day counts as a class day. Therefore, a homework assignment due on Monday may be turned on Wednesday before 1:30pm and count as one day late. A homework assignment due on Friday that is turned in on the following Monday is
also counted as one day late. *Note that no late days may be used beyond the last class day of the regular quarter (Wednesday August 15th).*

After the two free late days are used, late assignments will be assessed a 20% reduction in score for each class day that they are turned in late. Moreover, no assignment will be accepted more than a week late (regardless of the use of free late days), since we will be releasing solutions to the assignments one week after their due date. Extensions beyond these free late days are rarely granted, and then, only for medical emergencies. Such extensions must be cleared prior to the assignment being due, and the request should be made directly to me.

9 **Honor Code**

Each student is expected to do his/her own work on the problem sets in CS109. Students may discuss problem sets with each other as well as the course staff. *Any discussion of problem set questions with others should be noted on a student’s final write-up of the problem set answers.* Each student must turn in their own write-up of the problem set solutions. Excessive collaboration (i.e., beyond discussing problem set questions) can result in honor code violations. Questions regarding acceptable collaboration should be directed to the class instructor prior to the collaboration. *It is a violation of the honor code to copy problem set or exam question solutions from others, or to copy or derive them from solutions found online or in textbooks, previous instances of this course, or other courses covering the same topics (e.g., STATS 116 or probability courses at other schools).* Copying of solutions from students who previously took this or a similar course is also a violation of the honor code. Finally, a good point to keep in mind is that you must be able to explain and/or re-derive anything that you submit.

10 **Students with Documented Disabilities**

Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty. For students who have disabilities that don’t typically change appreciably over time, the letter from the OAE will be for the entire academic year; other letters will be for the current quarter only. Students should contact the OAE as soon as possible since timely notice (for example, at least a week before an exam) is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk (https://oae.stanford.edu, phone: 723-1066).