- **Harvard College/Graduate School of Arts and Sciences:** 128073 and **Harvard Extension School:** 17144
- **Term:** 2024 Fall / Full Term
- **Course Instructor(s):** Michael Mitzenmacher and Kitty Ascrizzi
- **Teaching Fellows**
  - Simeon Sayer (Head TF)
  - Wissam Alghabra
  - Megan Ong
  - Navya Ramakrishnan
  - Eric Tang
  - Alice Wu
- **Location:**
  - **For college students:** 114 Western Ave 2111+2112
  - **For extension students:** Zoom
- **Meeting Time:**
  - **For college students:** Monday 09:45 AM - 11:00 AM; Wednesday 09:45 AM - 11:00 AM; Friday 09:45 AM - 11:00 AM
  - **For extension students:** Thursday 7:40 PM - 9:40 PM Eastern Time
- **Exam Group:** FAS02_H
- **Course Description:** Widely applicable mathematical tools for computer science, including topics from logic, set theory, combinatorics, number theory, probability theory, and graph theory. Practice in reasoning formally and proving theorems.
- **Notes:** Covers material used in Computer Science 1200 (formerly CS 120), Computer Science 1210 (formerly CS 121), and Computer Science 1240 (formerly CS 124). Ordinarily, not to be taken after those courses or after courses such as Applied Mathematics 106, Applied Mathematics 107, Mathematics 101, and Mathematics 153.
- **Contacts:** For absences and extensions, please email Head TF Simeon Sayer at ssayer@fas.harvard.edu

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Course goals:

CS 20 is a fun, collaborative introduction to discrete mathematics for computer science. The course is designed to welcome students into the study of computer science and proof-based mathematics. In it you will learn proof-based discrete mathematics in a highly collaborative, active environment. You will also learn how to utilize these analysis tools for applications and with experimental work. During our class meetings students work in small groups to collaboratively solve problems with the help of a teaching fellow. Classes are active. Participation counts. The teaching and learning methods of this course are likely to be quite different from those of most of your courses.

CS 20 teaches all the math not taught in the traditional calculus/linear algebra sequence that is needed to take more advanced courses in theory of computation and/or algorithms. That is, CS 20 teaches discrete mathematics, logic, and basic probability, but does not teach calculus or linear algebra. It also gives a good introduction to reading mathematical notation and writing formal proofs. Many of the topics in CS 20 are not part of the typical secondary school math curriculum. Prospective students may find it helpful to take our "placement test" to gauge whether the course material is appropriate for you.

A principal objective of CS 20 is to develop mathematical maturity, by which we mean that CS 20 prepares you to think mathematically, to read and write mathematics, and apply mathematical methods for problem-solving. It is these skills, even more than the specific topics covered, that students will find they use again and again in future coursework.

Course format:

CS20 is taught as a â€œflipped classâ€. What this means is that the traditional class lecture is provided to you as a video that you must watch prior to class so that we can spend the class time engaged in active problem solving. This does not mean, however, that you can skip the lecture! If you come to class without watching the video and doing the readings you are likely to be quite lost in class and to have a very difficult time indeed. Weâ€™ve kept the lectures as short as possible so that the total amount of work for the class is still reasonable (though it feels very intense during the compressed, intensive summer session).

Prior to each class we will provide preparatory video and readings and some pre-class work and/or questions to help you verify your not necessarily complete understanding of the material. **It is essential**

to your success in this class that you do the reading/watching the preparatory materials and complete the pre-class work before each class. (Due dates are set accordingly.) Coming prepared to class will enhance your learning and make you a more valuable collaborator to the others in your group. Pre-class work submitted after the beginning of the class session will not receive credit (though you may redo the problems later as part of studying without any penalty).

Course Work:

- Active class attendance and participation at each class meeting:
  - **College students: MWF 9:45-11:00am**
  - **Extension students: Th 7:40-9:40pm ET**
- Pre-class mini-lectures, readings, and problems **before** each class
- 11 weekly problem sets + end-of-semester lab writeups
- 1 midterm exam
  - **College students:** tentatively Friday Oct. 18 during class (conflicts: a Google form will be posted closer to the midterm)
  - **Extension students:** tentatively Thursday Oct. 17 during class (on zoom) (conflicts: email head TF)
- 1 final exam
  - **College students:** tentatively Wednesday Dec. 11, 2-5pm, in-person, Location TBA (conflicts: see info from Registrar)
  - **Extension students:** tentatively Thursday Dec. 12 during class (on zoom) (conflicts: email head TF)

Course Policies

- 5 lowest attendance/participation scores [for college students; 2 for Extension students] will be dropped. Students should plan to use these 5 dropped scores to account for any foreseeable absences from class, including any travel for extracurriculars or vacations, minor illness, oversleeping, etc. If you need to miss more than 5 [or 2 for Extension] classes and believe the absences should be excused, please get a note of explanation from your resident dean before contacting Simeon (preferred), Kitty, or Michael.
- Each student has 8 "late days" to be used as self-granted extensions on problem sets. No more than 2 late days may be used on any given problem set. Late days are automatically counted based on the submission time of problem sets. There are no partial late days. Problem sets submitted more than two days late will not ordinarily be accepted. Late days may only be used for problem sets.
- 1 lowest problem set score will be dropped.
- Students will be permitted to add CS20 during the first 2 weeks of class. All missed work must be made up. Class absences before enrolling will be excused and extensions granted for the pre-class work to the time of enrolling. Problem Set 1 and 2 due dates may be extended to 2 days after the listed date for Pset 2 with instructor permission, but not beyond.

Classroom Environment

We are committed to providing an inclusive learning environment in which every student is welcomed and valued in the classroom. CS20 is a highly interactive and collaborative learning environment designed to foster collegial relationships and friendships. We expect that every member of the classroom will approach the collaborative experience with an orientation toward learning about, learning from, and learning with others and doing so with kindness and respect.

Should you or a peer feel excluded or uncomfortable due to the behavior of any member of the teaching staff or a peer, we ask that you tell us so that we can address it.

Attendance and Participation

Attendance at class meetings is mandatory. In addition to attending class, all students are expected to participate actively and collaboratively in problem-solving and solution presentations during class. Your active participation is critical to your learning and also very important for your peers. This is why we assess and reward it. The basis of the assessment will be whether the participation contributed to your understanding/learning or your classmatesâ€™ understanding/learning of a course concept. Asking a question, contributing to working something out on your group's whiteboard, volunteering an answer that turns out to be wrong, expressing a challenge in understanding a concept that you are experiencing, or creating a supportive environment for your peers are all examples of good participation. The TFs will be keeping track of your in class participation and attendance.

Typical enrollees:

CS20 is a "soft requirement" for all CS concentrators and a requirement for Extension Students in the Computer Science program. For college students, this means that either you need to take it or you need to attest to already knowing this foundational material. It is intended to be taken before more advanced course work, such as CS1200, CS1210, or CS1240.

Historically, about 1/3 of CS concentrators take the course. If the material is already familiar to you and doing the problems and proofs is time-consuming but not enlightening for you, then this course is not for you. If the material is new to you or if writing proofs is new to you, then taking CS20 may make your future coursework in CS easier and more effective. So how do you know if CS20 is for you?

- Read the information the CS concentration provides about CS20 placement and take a look at (and try) the official self-assessment.
  - *Note that the self-assessment is pretty challenging and may be quite time consuming if you do the entire thing. Our educated guess is that if we gave the self-assessment as a final exam for CS20, the average score would be about a 75%. If you find most questions straightforward or doable with effort, then you should skip CS20. If you can already correctly complete 75% of the assessment, you may want to consider skipping CS20 and doing some self-review of some material (or you may choose to take CS20 to further strengthen your foundation). If the self-assessment has a lot of unfamiliar material and/or you can't do near to 75% of it correctly in a reasonable amount of time, CS20 is for you.*

When is course typically offered?

Starting in AY24-25, we expect the course to be offered both fall and spring in most years. It is also typically offered online (for college and extension credit) in the Harvard Summer School.

What can students expect from you as an instructor?

This semester we will have two instructors for the course: Professor Michael Mitzenmacher and Preceptor Kitty Ascrizzi.

A bit about Michael:

Iâ€™m a Professor of Computer Science. I've been a professor at Harvard for... well let's just say a long time now. And some time before that, I was an undergraduate at Harvard also, where I did a joint concentration in Mathematics and Computer Science. I'm a big believer that if you're doing computer science, the more math you know, the better. (I wish I knew more, often.)

I taught CS20 last year, and previously CS124 19 times. (Someday, I'll aim to teach it a 20th time, because it seems like a nice milestone.) So I know the material in CS20 is very important to later courses in the CS curriculum. I'm looking forward to co-teaching this year and teaching the course in future years.

I'm used to being called Professor Mitzenmacher but am also happy to be called Michael, or just "Hey, you". I take he/him pronouns. (I also would like to use whatever pronouns and name you are most comfortable with, and please help me to do so!)

My email is michaelm@eecs.harvard.edu, but I'll strongly encourage you post any course content-related questions to the Ed Discussion board because youâ€™ll get a much faster answer. I also do try to get to all emails, but I have a difficult time keeping up.

I will have weekly open office hours, and am happy to also meet (by zoom or in person) if you want to make an appointment. (I'm a night owl -- meeting on zoom at 10pm or later is not unusual for me at all.) I'm also happy to meet students for lunch, either one-on-one or more usually in groups, at your dining hall, if you want to talk in depth about something (careers, paths to graduate school, senior theses, the best TV shows, etc.)

A bit about Kitty:

I am a Preceptor in Computer Science for SEAS, where I help teach a number of introductory courses -- typically two per semester. This is my fourth time teaching CS20, but my first time as a co-instructor. In past semesters, I've also taught CS32, CS61, CS 1210, and CS 1240.

I studied Space Science and Engineering at the University of Michigan, and in the process figured out that teaching introductory engineering classes like this one is what I really love to do.

I prefer that you call me Kitty and I take she/her pronouns. (I would like to call you what (and how) you prefer to be called, so please help me to do so!)

You can always reach me by email at kascrizzi@seas.harvard.edu, but I strongly encourage you post any course content-related questions to the Ed Discussion board because youâ€™ll get a much faster answer.

I will have weekly open office hours for getting help with course material and assignments. I am also happy to meet (by zoom or in person) if you want to make an appointment via email. These appointments are good for situations where you want to talk in person about an individual issue, if youâ€™re having a lot of difficulty with course content, or even just to get to know each other a bit outside of class. In contrast, regular office hours are the right place for getting help with homework, etc.

Homework

All homework will be submitted and graded in Gradescope (accessible from the homework assignments in Canvas). All feedback on your work will be available to you directly in Gradescope. Starting the second week of class, all homework sets must be typeset using LaTeX. We recommend trying to use LaTeX for the first homework as well, but if you prefer, you may submit a scanned handwritten problem set in week 1.

We will not accept revisions on problem sets after grades have been returned. However, if you believe there was an error in grading (which definitely happens, we are only human!) you may submit a request for a â€œregradeâ€ in Gradescope within one week after grades are returned.

Collaboration Policy

We strongly suggest you attempt each problem on your own before talking it over with your friends, classmates, or the course staff. Students who succeed in CS20 tend to start their problem sets a few days before the due date with a first attempt at each problem, attend an office hour and/or meet with a study group with questions, and then complete the problem set individually.

Study Groups

We encourage students to collaborate in small groups (2-4 people) on homework. Small study groups can be a big help in mastering course material, and also be fun and a good way to make friends. But students must write up solutions on their own, neither copying solutions nor providing solutions to be copied. What you turn in should be your own work product; you should be able to explain and reproduce it.

Office Hours

The teaching fellows, Michael, and Kitty will each hold multiple â€œOffice Hoursâ€ each week. These are open drop-in sessions at which you can get help with concepts and homework problems and also collaborate with other students. It is a common misconception among students is that it is somehow better to try to do the problem sets all on oneâ€™s own without attending TF office hours. Students who do attend find these sessions among the most useful supports in the class.

Online Discussion

Throughout the course we will use the Ed Discussion platform (accessed from the left-hand navigation in Canvas) for announcements and Q&A. It is probably the single best place to get help as all of the TFs, Michael, Kitty, and your peers can all pitch in to answer your questions. You can post privately to the teaching staff or publicly to the whole course and you can post with your name or anonymously.

Feel free to use the discussion forum to ask questions about homework problems. If you are posting any part of a solution or otherwise revealing part of a homework solution, please keep the post private within the teaching staff.

Other Sources

While working on your problem sets, you may not refer to existing solutions, whether from other students, past offerings of this course, materials available on the internet, or elsewhere. Sources beyond the course materials will not be needed for the problem set solutions. If you find yourself needing or wanting to use an outside source, it is often a sign that you are missing the way to do the problem with the tools/methods/concepts covered in class. However, if a source beyond the course materials is used in a solution, there must be a proper scholarly citation of the source.

All significant collaborators must be identified clearly on your problem sets. You need not list others who attended the same office hour as you. Nor do you need to list help that you received on the Ed Discussion forum.

Generative AI Policy

You may not use generative AI tools when solving or writing up homework assignments. You can use them for general knowledge questions (e.g., how to make a table in LaTeX.) You may use them for your own studying (e.g. making practice multiple choice questions for an exam) and in certain in-class exercises where we instruct you to use them.

Preparatory Materials and Pre-Class Work

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Prior to each class we will provide preparatory video and readings and some pre-class work and/or questions to help you verify your not necessarily complete understanding of the material. **It is essential to your success in this class that you do the reading/watching the preparatory materials and complete the pre-class work before each class.** (Due dates are set accordingly.) Coming prepared to class will enhance your learning and make you a more valuable collaborator to the others in your group. Pre-class work submitted after the beginning of the class session will not receive credit (though you may redo the problems later as part of studying without any penalty).

A Note About Mini-Lecture Videos

For some reason, the Harvard Key login for the mini-lecture videos sometimes gets out of sync with Canvas. When this happens, the videos appear as an unplayable gray box. To fix it, you can log out of Canvas and log back in. We apologize for this annoying bug!

Course Texts

We will be drawing reading materials from three sources:

- *An Essential Discrete Mathematics for Computer Science*, Harry Lewis and Rachel Zax. This book is available in the Files section of the course site for registered students. Professor Lewis, the lead author of this text, taught CS20 for many years. This book is designed for use in this course and courses like it. We are grateful to Harry and Rachel for allowing you to use pre-print copy with their permission.
- *Mathematics for Computer Science*, Eric Lehman, F Thomson Leighton, Albert R Meyer (also available under Canvas > Files)
- *Building Blocks for Theoretical Computer Science*, Margaret Fleck

Every year there are a smattering of complaints from students that it is annoying and/or confusing to have three different textbooks and yet we persist in having all three. That is because they have different virtues and students have strongly different preferences between them:

- Lewis & Zaxâ€™s *Essential Discrete Math* is concise while also providing quite a bit of depth and detail. It tracks very closely with what we study in the course and provides what you need to know and some extra depth. Some students find it to be difficult to understand because it goes briefly and quickly through concepts and examples.
- *Mathematics for Computer Science* is the book used by CS20â€™s MIT counterpart 6.042. It is extremely detailed. It is often a good option as a second reading when you want more depth or another explanation of a given concept. Students sometimes find its sheer size to be daunting.
- Fleckâ€™s *Building Blocks* is the most readable of the three books. Most students find it clear and easy to understand. It does not cover some of the topics in as much depth.

On the reading assignments we will indicate the reading options from each of the texts and a default suggested reading (usually drawn from Lewis & Zax, which we think of as the compromise option) for

those who do not want to make their own choice.

A note on reading (that is general to all math courses). Reading these texts is not like reading a novel or a newspaper or even some fairly involved English texts. To get value from the reading, you should do it with a pad and pencil beside you and make sure you understand the definitions and derivations presented there. Mathematical notation can be dense, so donâ€™t expect yourself to be able read and understand it at first glance!

Exams

We will have one midterm exam and a final exam. They are in-class, closed-book, timed exams.

For Harvard Extension School students, these exams will be proctored live on Zoom in our regular class time. You will not need any special software.

Time Commitment

We expect the preparation materials and pre-class work to take about 1 hour per class session and the homework problem sets to take about 5-7 hours each, including attending office hours and typesetting. The time required for course work varies significantly.

Grading

The grade breakdown will be as follows:

- 44% Problem Sets
- 24% Final Exam
- 12% Midterm Exam
- 15% Attendance and Participation
- 5% Pre-Class Work

Although we will adhere to this proportional weighting of the course work components*, **there is no pre-set raw course score that translates to a particular letter grade**. The raw scores and grade information available to you in Canvas should be treated as a tool to help you keep track of your progress (but note that they can be misleading when you've still got substantial work yet to be submitted). It is typical in CS20, though not guaranteed, that raw percentage value will provide a floor for the grade you might receive. A, A-, and B+ are typically the most common grades in the course.

*We do reserve the right to make adjustments to the weightings where they produce an inequity for particular students. For instance, we sometimes take into account the trajectory of an individual student's work across the term and adjust the weighting of earlier assignments down a bit to account for this. Again, this is something we would only do to increase a student's final grade and only at my own discretion.

Finally, it is worth noting that the course is not curved. We are willing to assign as many of a given grade as there are students whose work merits it.

Weekly Schedule

For the most part, CS 20 follows a weekly rhythm. We meet together as a group three times each week. Before each class meeting students must do the readings and watch the mini-lecture videos for the class session's topics and complete (and submit) the pre-class work. Problem sets will typically be due on Mondays.

The best way to navigate the course expectation is to use the Modules page of the course Canvas site, which is set up to give you a week-by-week list of what you need to do.

Flexibility

We want the work in this course to be challenging conceptually rather than because of the strain it puts on you to balance your school/life commitments. We want the assessment we do of your work to reflect your mastery of the materials, not the challenges youâ€™ve faced during the term that caused you to have to make some compromises. Weâ€™ve tried to build a good amount of flexibility into the class with late days, dropped attendance scores, and dropped low/missing problem set. But life has a way of getting in the way, often with very good reason. If you find yourself in a situation where you need some additional flexibility in completing the course work or in which your learning would benefit from an exception to some class practice or policy, we encourage you to write Kitty or Michael an email or come speak to us about it. Within bounds of fairness, and in consultation with your resident dean, we are willing to make adaptations

in service of equity and learning.

ARC Tutors

Individual and small-group tutoring through the Academic Resource Center (ARC) is available to college students through the ARC scheduler and Extension students thought the ARC referral form. ARC has dedicated CS20 tutors.

Accessibility

Harvard College and the Harvard Extension School are committed to providing an accessible academic community. The Disability Access Office (for college students) and the Accessibility Services Office (for Extension students) offer a variety of accommodations and services to students with documented disabilities.

Course Summary

Please see the Modules page of the course Canvas site for a detailed summary of topics, readings, and assignments.