Are there “laws of physics” in computing? Are there fundamental restrictions to what computers can and cannot do? If so, what do these restrictions look like? What would make one problem intrinsically harder to solve than another? And what would such restrictions mean for our ability to computationally solve meaningful problems?

In CS103, we'll explore the answers to these important questions. We'll begin with an introduction mathematical logic, proofs, and discrete structures (sets, relations, functions). These mathematical tools will enable the real heart of the course, which is to rigorously answer questions like “what does it mean for a computer to solve a problem?” and “what makes some problems (sorting) inherently harder than others (searching)?”

In the course of the quarter, you'll see some of the most impressive (and intellectually beautiful) mathematical results of the last 150 years. In some ways, I like to think of this course as a course in both art appreciation and practice. I’ll bring you through a gallery and show you some of my favorite achievements of mathematical artistic beauty, and like a good tour guide help you understand what is special about what you’re looking at. You’ll also need to pick up the paintbrush yourself and write some proofs of your own. You'll learn how to think about computation itself and how to show that certain problems are impossible to solve. Finally, you'll get a sense of what lies beyond the current frontier of computer science, especially with regards to biggest open problem in math and computer science, the P - NP problem.

### Lecturers
- Cynthia Bailey Lee (cbl@cs.stanford.edu or via staff email below)
- David Varodayan (varodayan@cs.stanford.edu or via staff email below)
- Amy Liu (liuamyj@cs.stanford.edu or via staff email below)

### Staff Email
- cs103-spr1920-staff@lists.stanford.edu

### Websites
- [https://cs103.stanford.edu](https://cs103.stanford.edu): Main course website (no login required)
- [https://canvas.stanford.edu](https://canvas.stanford.edu): Lecture videos (you must be officially enrolled to access)
- [https://gradescope.com](https://gradescope.com): Assignment submission (automatically syncs to Canvas roster)
- [https://us.edstem.org](https://us.edstem.org): Q&A forum (you will receive invitation after you enroll)
- [https://perusall.com](https://perusall.com): Course Reader and handouts (make your own account, then join our class using access code posted on Q&A forum)
- [https://overleaf.com](https://overleaf.com): Optional tool for typing psets in LaTeX (make your own account, use your Stanford email to access “Pro” license features)

### Units
Undergraduates must enroll for 5 units (this is department policy). If you are a matriculated graduate student, you may enroll for 3-5 units. Course requirements will be the same.

### Prerequisites
CS106B/X as a prerequisite or corequisite.

### Getting help
The course staff can be reached by at cs103-spr1920-staff@lists.stanford.edu, or on the Q&A forum Ed Discussion website [us.edstem.org](https://us.edstem.org) (we will be using this instead of Piazza). You may send any kind of question to either forum (course logistics, homework, lecture confusion, etc). Remember that posting any part of problem set solutions where other students can see it is a violation of the honor code. Course instructors and TAs will have office hours throughout the week. The instructors are happy to talk about topics including not only the psets, but also course and career advising, internships preparation, making grad school plans, etc.
Guiding Principles for Teaching and Learning in a Time of Pandemic
(by Prof. Brandon Bayne, UNC – Chapel Hill; with light adjustments for CS103)

1. Nobody signed up for this.
   - Not for the sickness, not for the social distancing, not for the sudden end of our collective lives together on campus
   - Not for an online class, not for teaching remotely, not for learning from home, not for mastering new technologies, not for varied access to learning materials

2. The humane option is the best option.
   - We are going to prioritize supporting each other as humans
   - We are going to prioritize simplicity
   - We are going to prioritize sharing resources and communicating clearly

3. We will foster intellectual nourishment, social connection, and personal accommodation.
   - Accessible asynchronous content for diverse access, time zones, and contexts
   - Optional synchronous tutorial sections to learn together and combat isolation
   - Mastery learning approach to take-home exam assessment that is designed around flexibility, second chances, and growth as first principles

4. We will remain flexible and adjust to the situation.
   - Nobody knows where this is going and what we’ll need to adapt
   - Everybody needs support and understanding in this unprecedented moment

Course Grades
Your final course grade of S/NC will be determined as follows:
   5% lecture participation (view pre-recorded videos and complete quick quizzes)
   15% tutorial section participation (attend weekly 1-hr Zoom session; or if unable, submit exercises)
   30% problem sets (groups of 2-3 students encouraged)
   45% take-home exams (5 exams, individual work)

You must receive a passing grade on each of the four components in order to pass the course (so in some sense, these percentages don’t matter; but they represent relative emphasis or effort expected in each area). What constitutes a passing grade in each component is explained in their respective sections below.

Lectures
Due to the need for this course to be all online this Spring, all videos will be pre-recorded. Cynthia and David discussed recording new lecture videos of us lecturing to empty rooms, but ultimately decided that we would rather invest as many of our hours as possible in individual and small group tutoring. Thus we will be using the great resource that is the Autumn 2019 SCPD recordings with Lecturer Keith Schwarz. To encourage timely viewing and as a way for you to check your understanding, there will be 3-question quizzes on each lecture. These are given on Gradescope, and are due by noon PDT on Monday the following week. In other words, each Sunday, lectures for Monday, Wednesday, and Friday will be released, and the quiz about them will be due the following Monday at noon PDT. You may resubmit as often as you wish before the deadline, so we encourage you to watch Mon lecture on Mon and submit just those 3 questions, then watch Wed on Wed, and so on. **UPDATE:** You need to get 100% to pass. You need to get 72/81 to pass. Remember that you can get 100% by submitting, seeing that some were incorrect, and resubmitting before the deadline. If you miss a deadline, we have some back-up options, but the whole purpose is to prevent falling behind on lecture viewing, so let’s work to minimize use of the back-up options.
**Tutorial Sections**

There will be several instructor-hosted, interactive tutorial sections held Monday and Tuesday each week via Zoom. You should choose one of them and plan to attend that same one regularly, in order to build community with your fellow sectionees and instructor. If you are unable to attend any of the sections (whether once or ever), you may complete the exercises for that week’s tutorial and submit them by Thursday at noon PDT to receive make-up participation credit for the tutorial. One tutorial section each week will be recorded for students who are unable to attend live. **You must attend or make-up 7/10 tutorials.**

**Problem Sets**

There will be 9 total problem sets in CS103, given out once per week. They will be posted on Saturdays and due the following Thursday at noon PDT. You are encouraged to work on them in groups of up to 3 people. Submit homework on the Gradescope website. Most students should be automatically registered already, or you may need to wait 24 hours for it to sync with Canvas (which in turn syncs with Axess enrollment). For groups, only one person submit to Gradescope (then add partners’ name(s)). You are responsible for the correctness, completeness, and timeliness of your submission to Gradescope. That means you need to allow plenty of time before the deadline for tagging each problem, for any hiccups in the process, and for double-checking to catch errors such as uploading the wrong file, forgetting partner’s name, not tagging each problem correctly, etc.

You will receive detailed grading feedback on your psets, but the score will be 0-1-2:

- 0 = missing or severely incomplete
- 1 = missing problems or significantly below completeness expectations for the content of the problems’ work
- 2 = completed with reasonable-effort (not necessarily correct) solutions

To pass, you must have an average of at least 1.6. We strongly urge you to focus on being ready for the take-home exams by finishing the psets on time even if not perfectly. In the software industry, they often say, “Shipped is better than perfect.” Therefore, **there are no free “late days” this quarter.** That said, if your group needs an extension on a pset due to extenuating circumstances, please feel free to reach out to us via the course staff email. The psets sometimes include “extra credit” problems. These are for your enjoyment and enrichment. They are not for points, but if you complete at least 3 of them during the quarter, you will earn a special commendation certificate from the instructors.
Honor Code Guidelines for Psets

The problem sets are open-book (meaning open Course Reader, handouts, textbooks, course lecture videos, and internet searches for conceptual information e.g. Wikipedia). All work done with the assistance of any material in any way (other than provided CS103 course materials) must include citation (e.g., “Referred to Wikipedia page on DeMorgan’s Law for Question 2.”). Copying solutions is unacceptable, even with citation. If you are still working on a problem and chance encounter solutions to the problem, close it before you feel tempted to copy. Consulting (e.g., via call or text chat) with classmates other than your official group members for the assignment is fine (this is different from usual CS103 rules), but you should name all the people you consulted with in a citation, and you should write up your own solutions (copy-pasting solutions is unacceptable). Once you have all written solutions, peer-critiquing each others’ proofwriting is an excellent practice for honing your mathematical communication skills. We are encouraging a more collaborative approach to psets than usual, because the most crucial outcome from them is that you be ready to solve similar problems completely on your own on the take-home exam that immediately follows the pset deadline. So make sure that if you complete the psets with a group or in consultation with other groups, you personally completely understand the problem and its solution.

For those retaking the course: If you did not have a partner last time, and you do not have any partners this time, then you may resubmit (or edit and resubmit) your previous work. But you should not add a new partner’s name to your previous work, or even edited copies of your previous work, since that would essentially constitute a “copy-pasting solutions” violation by your partner.

Take-Home Exams

UPDATE: There will be 5 take-home exams, which will go out on Thursday and be due on Saturday noon PDT, approximately every other week (2nd, 4th, 6th, 8th, and 9th weeks). There will be 3 take-home exams, which will go out on Thursday and be due on Saturday noon PDT, approximately every third week (2nd, 5th, and 8th weeks). Unlike the problem sets, the take-home exams are strictly individual work. Even course staff assistance will be limited to clarifying questions of the kind that might be allowed on a traditional in-person exam.

The problems on each take-home test are directly related to the problems on the pset that is due the day the take-home test goes out. They are intended to ensure that whatever open and collaborative process you may have used to complete the pset, it ultimately resulted in you personally understanding that week’s content. UPDATE: To pass, you must solve all take-home exam problems correctly. A grade of 90% is passing for each exam, meaning that you do not need to revise & resubmit if you already reached 90%. There is some flexibility for passing with grades below 90% even after two rounds of revise & resubmit, handled on an individual basis. This is to enable us to certify that all alumni of CS103 have developed competency in all of the primary learning objective areas of the course.

Understanding that it is impossible that every single student would get every single take-home exam problem correct on the first try, if your solution is unsatisfactory, you will be asked to revise it and resubmit it by the following Saturday at noon PDT. UPDATE: A second round of revise & resubmit will then be available in the week following that. Course staff will be available to coach you on understanding where your work needs improvement and how to proceed.
Honor Code
Guidelines for Take-Home Exams

The take-home exams are open-book (meaning open Course Reader, handouts, textbooks, course lecture videos, and internet searches for conceptual information e.g. Wikipedia). Consultation of other humans in any form or medium (e.g., communicating with classmates, asking questions on forum websites such as StackOverflow) is prohibited. All work done with the assistance of any material in any way (other than provided CS103 course materials) must include citation (e.g., “Referred to Wikipedia page on DeMorgan’s Law for Question 2.”). Copying solutions is unacceptable, even with citation. If you chance encounter solutions to the problem, navigate away from that page before you feel tempted to copy. Also, please never forget that because of the revise & resubmit policy, there is no reason to violate your conscience to complete a take-home exam.

Withdraw and Incomplete Grades

In order to be eligible for an Incomplete, University policy says you must have completed a “substantial” part of the course work in “satisfactory” fashion. This means that Incompletes are appropriate for serious medical or family emergencies that occur late in the quarter, which prevent you from completing the course despite having done well up to that point. Incomplete grades are not for problems arising from overscheduling, not doing as well as you had wanted in the course, or similar circumstances. Withdrawing is the appropriate option in those circumstances.

Readings

The primary readings are in the form of a Course Reader and various handouts. These materials are available on perusall.com, a website with a nice interface for digital highlighting and notetaking, as well as sharing highlights, notes, questions, and discussion about the readings with other students in the class. We encourage you to set an active reading goal for yourself, such as making at least 3 highlights and/or comments per chapter. We hope this helps make the reading process more social and productive. The Course Reader and handouts will also be available on the course website in raw PDF form, but we recommend Perusall.

In the second half of the course, we will use the textbook is Introduction to the Theory of Computation, Third Edition by Michael Sipser. (Earlier editions would work just as well.) You might be able to get along without it if you study the lectures, lecture slides, and handouts carefully, but I think it’s a very clear book and would recommend it if you at all regard yourself as the kind of student who likes learning with a book.

A recommended supplementary help for the proof-writing part of the course is How to Read and Do Proofs by Daniel Solow.

Equity and Inclusion

We strive to create an inclusive and equitable classroom. Since much of your experience in the course is with your peers, we also depend on you to help each other feel welcome and obtain excellence, rather than mistaking Stanford or this class for a zero-sum game.

- **Office of Accessible Education accommodations:** If you have an OAE letter, please present it to us (by email to the staff list) at your earliest convenience, so we can ensure that the course materials and staff support comply with your needs.

- **Class expenses:** All students should retain receipts for books and other course-related expenses, as these may be qualified educational expenses for tax purposes. If you are an undergraduate receiving financial aid, you may be eligible for additional financial aid for required books and course materials if these expenses exceed the aid amount in your award letter. For more information, review your award letter or visit the Student Budget website: https://financialaid.stanford.edu/undergrad/budget/index.html.

- **Course assistance and personal support:** In every quarter we have taught, there have been individual students who have encountered life-altering challenges, so it is not the case that empathy and
compassion have only just become relevant. However, the magnitude of the current crisis underscores the need to support each other. If you feel overwhelmed for any reason—by work for this class, or a family issue, or just the weight of the present moment for the globe, please don’t hesitate to reach out. We aren’t trained as psychologists, but we would be more than happy to connect you with one if that’s what you need. If you just need to talk, or have us send you a kitten video, or if you need extra tutoring support in the class, we are here for you. Please ask us. Please ask us.