

**Theory of computation**

<b>Instructor:</b>	<a href="#">Fang Song</a>
<b>Course Meeting Schedule:</b>	T/R 14:00 – 15:15 @ CH 449
<b>Email:</b>	<a href="mailto:fsong@pdx.edu">fsong@pdx.edu</a> Stat email subject line with “f21-581-toc”
<b>Course webpage:</b>	<a href="https://fangsong.info/teaching/f21_581_toc/">https://fangsong.info/teaching/f21_581_toc/</a>
<b>Office hours:</b>	TBD

**Course Description**

Computation is a familiar term to all computer scientists. But what is computation after all? What problems are computable (Computability), and how “efficient” can we compute them (Complexity)? This course, assuming a prior introductory exposure to the theory of computation, continues an in-depth exploration to these fundamental questions. The focus will be on computational complexity, including time, space, randomness complexity. We will also dive into selected advanced topics such as interactive proof systems and quantum computing.

**Course Objectives**

Upon the successful completion of this class, students will be able to:

1. understand and describe Turing machine, Boolean circuits, and related computational models.
2. describe time complexity classes, e.g., P & NP, their relationships, and show NP-completeness by reductions.
3. describe and analyze space complexity classes including L, NL, and PSPACE.
4. describe randomized computation classes, analyze randomized algorithms and pseudorandom techniques.
5. understand and apply basic techniques to prove hardness (lower bound) results.
6. understand and analyze interactive proof systems.

**Course Prerequisites**

CS 311 or equivalent. You need to be familiar with the basics of computability theory, and be comfortable with reading and writing mathematical proofs.

**Readings**

No required text. The books below are recommended.

- [AB] Sanjeev Arora, Boaz Barak. *Computational complexity: a modern approach*. Cambridge University Press, 2009. PSU Library [Link](#)
- [W] Avi Wigderson. *Mathematics and Computation*. Princeton University Press, 2019. [Link](#)

**Grading Policies**

- Homework: 50%. Biweekly.
- Quizzes: 15%. Biweekly.
- Exam: 30%.
- Participation: 5%.

## Homework Policy

- You have a quota of 5 days in total for late submissions of homework or quizzes without penalty. You can use them at your will. Once the quota runs out, no late submissions will be accepted.
- Quizzes must be completed on your own. Collaboration on homework problems is highly encouraged, but you must write up solutions entirely on your own and clearly list who you discussed with for each problem. You must also clearly cite any other source you have referenced other than the text (a person, a book, a research paper, a webpage, etc.).
- All assignments must be submitted in PDF format. It is recommended to type-set your solutions using LaTeX, and you will get extra credit doing so.
- “I’ll take 15%” option on homework problems. Your solutions should be as clear and concise as possible. Partial credit will only be given for answers that make significant progress towards correct solutions. If you realize you cannot solve a problem, you may write “I’ll take 15%” instead of your answer, so you get 15% for this problem (or part of the problem). But if you do write an answer, you will get 0 if your solution is completely wrong. “I’ll take 15%” option does not apply to problems of bonus credits.
- For each assignment, a random subset of problems will be graded.

## Course Topics and Tentative Schedule

Check course webpage for details and updates

Week	Topic	Suggested Reading
1	Intro, basic models, Turing machine.	AB 0 – 1
2 – 4	Time complexity, P vs NP, NPC, EXP, time hierarchy, diagonalization.	AB 2 – 3
5 – 6	Space complexity, L, NL, PSPACE. Polynomial hierarchy, Boolean circuits.	AB 4 – 5
7 – 8	Randomization, BPP, pseudorandomness, derandomization.	AB 7, 20
9	Interactive proofs	AB 8 – 9
10	Quantum computing	AB 10

## PSU Policies & Resources

### *Academic Integrity*

Academic integrity is a vital part of the educational experience at PSU. Please see the [PSU Student Code of Conduct](#) for the university’s policy on academic dishonesty. A confirmed violation of that Code in this course may result in failure of the course.

### Student Services

#### *Disability Access Statement*

If you have, or think you may have, a disability that may affect your work in this class and feel you need accommodations, contact the Disability Resource Center to schedule an appointment and initiate a conversation about reasonable accommodations. The DRC is located in 116 Smith Memorial Student Union, 503-725-4150, [drc@pdx.edu](mailto:drc@pdx.edu), <https://www.pdx.edu/disability-resource-center/>

### *Safe Campus Statement*

Portland State University desires to create a safe campus for our students. As part of that mission, PSU requires all students to take the learning module entitled Creating a Safe Campus: Preventing Gender Discrimination, Sexual Harassment, Sexual Misconduct and Sexual Assault. If you or someone you know has been harassed or assaulted, you can find the appropriate resources on PSU's Enrollment Management & Student Affairs: Sexual Prevention & Response website at <http://www.pdx.edu/sexual-assault>

### *Title IX Reporting*

As an instructor, one of my responsibilities is to help create a safe learning environment for my students and for the campus as a whole. Please be aware that as a faculty member, I have the responsibility to report any instances of sexual harassment, sexual violence and/or other forms of prohibited discrimination. If you would rather share information about sexual harassment, sexual violence or discrimination to a confidential employee who does not have this reporting responsibility, you can find a list of those individuals on PSU's Enrollment Management & Student Affairs: Sexual Prevention & Response website at <http://www.pdx.edu/sexual-assault>.

### *Cultural Resource Centers*

The Cultural Resource Centers (CRCs) create a student-centered inclusive environment that enriches the university experience. We honor diversity, explore social justice issues, celebrate cultural traditions, and foster student identities, success, and leadership. Our centers include the Multicultural Student Center, La Casa Latina Student Center, Native American Student & Community Center, Pan African Commons, Pacific Islander, Asian, Asian American Student Center and the Middle Eastern, North African, South Asian program. We provide student leadership, employment, and volunteer opportunities; student resources such as computer labs, event, lounge and study spaces; and extensive programming. All are welcome!

### *Classroom Requirements for All Students and Faculty Due to Covid-19*

The University has established rules and policies to make the return to the classroom as safe as possible. It is required for everyone to follow all the Return to Campus rules and policies. To participate in this class, PSU requires students to comply with the following.

#### **Masks Required at all Times in Classroom**

- [Wear a mask or face covering indoors](#) at all times. Your mask or face covering must be properly worn (fully covering nose and mouth and tight fitting). Mesh masks, face shields, or face covering that incorporates a valve designed to facilitate easy exhalation are not acceptable. **Because a mask must be worn in the classroom, there should be no eating or drinking in the classroom.** If you have a medical condition or a disability that prevents you from wearing a mask or cloth face covering, you must obtain an accommodation from the [Disability Resource Center \(DRC\)](#) to be exempt from this requirement.
- CDC, State, and County guidance does not limit class size for in-person instruction or require physical distancing.

#### **Vaccination**

- Be vaccinated against COVID-19 and complete the [COVID-19 vaccination attestation](#) form. Those students with medical or nonmedical exemptions or who will not be on campus at all must complete the process described on “COVID-19 Vaccine Exemption Request Form” to establish those exemptions.

### **Health Check, Illness, Exposure or Positive Test for COVID-19**

- Complete the [required self-check for COVID-19 symptoms before coming to campus each day](#).
- If you are feeling sick or have been exposed to COVID-19, do not come to campus. Call SHAC to discuss your symptoms and situation (503.725.2800). They will advise you on testing, quarantine, and when you can return to campus.
- If you test positive for COVID-19, [report your result to SHAC](#) and do not come to campus. SHAC will advise you on quarantine, notification of close contacts and when you can return to campus.
- Please notify me, (i.e. your instructor), should you need to miss a class period for any of these reasons so that we can discuss strategies to support your learning during this time.
- If I become ill or need to quarantine during the term, either I or the department chair will notify you via PSU email about my absence and how course instruction will continue.

### **Failure to Comply with Any of these Rules**

As the instructor of this course, the University has given me the authority to require your compliance with these policies. If you do not comply with these requirements, I may ask you to leave the classroom or I may need to cancel the class session entirely.

In addition, failure to comply with these requirements may result in a referral to the Office of the Dean of Student Life to consider charges under PSU’s Code of Conduct. A student found to have violated a university rule (or rules) through the due process of student conduct might face disciplinary and educational sanctions (or consequences). For a complete list of sanctions, see Section 14 of the [Student Code of Conduct & Responsibility](#).

### **Guidance May Change**

Please note that the University rules, policies, and guidance may change at any time at the direction of the CDC, State, or County requirements. Please review the University’s main [COVID-19 Response](#) webpage and look for emails from the University on these topics.