Fall 2021 CS 581

Theory of computation

Instructor:	Fang Song
Course Meeting Schedule:	T/R 14:00 – 15:15 @ CH 449
Email:	fsong@pdx.edu Stat email subject line with "f21-581-toc"
Course webpage:	https://fangsong.info/teaching/f21_581_toc/
Office hours:	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, 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!