Theory of Computation, Spring 2019 Syllabus

What is this class about?

Everyone appreciates the power of computers, but this appreciation tends to overwhelm us, rather than prod us into a deeper investigation. Why can computers beat a Grandmaster at Chess, but they can't verify the correctness of a mathematical formula? Why can computers easily find a Eulerian tour of your city, but they can't factor large numbers? Why are certain problems easy and others hard?

This class is an investigation of that question, but the path towards the answer is long and circuitous. We must start at the beginning, with the definition of a computer. We will investigate simple models of computation, and determine which problems are easy and hard for these simpler models. Using those answers, we will form a mathematical model of a computer which we will be able to use to prove various properties about what computers can and can't do. With that foundation, we will begin to explore the roadblocks that researchers have faced on the path towards resolving the P vs. NP problem. Why, after decades of concentrated effort, have we failed to provide a definitive answer to this problem?

Course Logistics

Staff	Email	Office	Office Hours
Aaron Cote	aaroncot@usc.edu	SAL 210	Mon 12:45-1:45pm, Tues 9:45-10:45am Wed/Thurs 3:30-4:30pm

Textbook (required): Introduction to the Theory of Computation, by Michael Sipser
Textbook (required): The Universal Computer, by Martin Davis

Grading

Artifact	Weight	Date
Problem Sets	45%	Various
Project	15%	Wednesday, April 25th
Midterm	20%	Wednesday, February 28th
Take-home Final	20%	Wednesday, May 2nd

Project

You will choose an interesting topic in the course. A relevant and important research paper (or papers) will be obtained and read. You will then write a 4-5 page paper summarizing the results and their importance. You may work in pairs for this project, but your paper should be 8-10 pages if you do so.

A list of suggested paper topics will be given at the mid-point of the semester.

Collaboration Policy

You are free to work together on the homework. Just make sure to clearly indicate your collaborators at the top of your submission, and make sure you understand each of your answers.

Exams

You will be provided with paper on which to take the midterm, which will be held in the normal classroom. The midterm will be individual effort, open-book and open-notes.

The final will be a take-home exam. It will be individual effort, open-book and open-notes.

Tentative Schedule

Week	Day	Topic	Sipser	Davis	HW
1	1/8	Finite State Machines	Ch. 0, 1.1		
	1/10	Nondeterminism	Ch. 1.2	Ch. 1	
2	1/15	Nonregular Languages	Ch. 1.4	Ch. 2	HW 1 Out
	1/17	Context-Free Languages	Ch. 2.1	Ch. 3	
3	1/22	CFLs, and the Pumping Lemma	Ch. 2.3		HW 1 In
	1/24	Non-context-free Languages		Ch. 4	HW 2 Out
4	1/29	Turing Machines	Ch. 3.1	Ch. 5	
	1/31	Turing Machines	Ch. 3.2, 3.3		HW 2 In
5	2/5	Turing Machine Variants		Ch. 6	HW 3 Out
	2/7	Decidable Languages	Ch. 4.1	Ch. 7	
6	2/12	The Halting Problem	Ch. 4.2		HW 3 In
	2/14	Undecidable Problems		Ch. 8	
7	2/19	Reducibility	Ch. 5.1	Ch. 9	HW 4 Out
	2/21	The Post Correspondence Problem	Ch. 5.2, 5.3		
8	2/26	Midterm Review			HW 4 In
	2/28	**Midterm**			
9	3/5	P and NP	Ch. 7.1-7.3		Project Proposal In
	3/7	The Cook-Levin Theorem	Ch. 7.4, 7.5		HW 5 Out
		Spring Break			
10	3/19	Space Complexity	Ch. 8.1, 8.2		
	3/21	PSPACE	Ch. 8.3		HW 5 In
11	3/26	PSPACE-Complete			HW 6 Out
	3/28	Logarithmic Space	Ch. 8.4-8.6		
12	4/2	L and NL			HW 6 In
	4/4	NL-Complete			HW 7 Out
13	4/9	Hierarchy Theorems	Ch. 9.1		
	4/11	Relativization	Ch. 9.2		HW 7 In
14	4/16	Why is P vs. NP hard?			HW 8 Out
	4/18	Quantum Computing			
15	4/23	Quantum Computing			HW 8 In
	4/25	Quantum Computing			Project In