# CS 172: Computability and Complexity

Spring 2019

### Classes and Staff

Instructor: Amir Yehudayoff
Email: amir.yehudayoff@gmail.com

TA: Jonathan Shafer
Email: shaferjo@berkeley.edu

Reader: Justin Yokota
Email: jyokota@berkeley.edu

Class: Mon & Wed, 2:30pm–4:00pm, Soda 306
Office hours: by appointment

Discussion: Thu, 9:00am-10:00am & 10:00am-11:00am, Soda 320
Office hours: Wed, 5:00–6:00pm, Cory 212

Please include the string "CS172" in the subject line when writing to us.

### About this Course

This course is an introduction to the mathematical study of *computability*, which is concerned with the question "what can be computed?", and *complexity*, concerned with "what can be computed efficiently?".

Topics: Finite automata and regular languages. Turing machines. Decidability. Exponential and polynomial-time problems. Polynomial-time equivalence of all reasonable models of computation. NP-completeness. Selected topics in language theory, complexity and randomness.

**Prerequisites:** CS 170.

**Website:** piazza.com/berkeley/spring2019/cs172.

### Textbook

Sipser, M. (2012). *Introduction to the Theory of Computation (3rd Edition)*. Cengage Learning.

Note: this book is very good but also very expensive. If you can find a cheap used 1st or 2nd edition that's fine too.

### Grading

Homework: 35 %
Midterm I: 20 %
Midterm II: 20 %
Final exam: 25 %

### Homework

There will be weekly homework assignments. For further details please see the homework policy, to be posted on the website.

### Calendar

The following is preliminary and very much subject to change.

| Class | Date | Topic | Reading |
|---|---|---|---|
| 1 | Jan 23 | Deterministic finite automata | Chapter 0; Section 1.1 |
| 2 | Jan 28 | Nondeterministic finite automata | Section 1.2 |
| 3 | Jan 30 | Equivalence of regular expression and finite automata | Section 1.3 |
| 4 | Feb 4 | Myhill-Nerode theorem | Handout 1 |
| 5 | Feb 6 | State minimization | Handout 1 |
| 6 | Feb 11 | Streaming algorithms | Handout 2 |
| 7 | Feb 13 | Turing machines | Chapter 3; Turing (1936) |
| | Feb 18 | *Presidents' day* | |
| 8 | Feb 20 | Variants of Turing machines, non-determinism, enumerators | Chapter 3 |
| 9 | Feb 25 | The Halting problem | Chapter 4 |
| 10 | Feb 27 | More decidability and undecidability results | Chapter 4 |
| 11 | Mar 4 | **Midterm I** | |
| 12 | Mar 6 | Reducibility, Rice's theorem, and more undecidability results | Sections 5.1, 5.3; Handout 3 |
| 13 | Mar 11 | Gödel's incompleteness theorem | Handout 4 |
| 14 | Mar 13 | Kolmogorov complexity | Section 6.4; Handout 5 |
| 15 | Mar 18 | The classes P and NP | Sections 7.1, 7.2, 7.3 |
| 16 | Mar 20 | Boolean circuits | Section 9.3 |
| | Mar 25 | *Spring break* | |
| | Mar 27 | *Spring break* | |
| 17 | Apr 1 | NP-completeness of SAT | Sections 7.4, 9.3 |
| 18 | Apr 3 | More NP-complete problems | Handout 6 |
| 19 | Apr 8 | More NP-complete problems | Handout 6 |
| 20 | Apr 10 | NL-completeness | Sections 8.2, 8.5 |
| 21 | Apr 15 | **Midterm II** | |
| 22 | Apr 17 | Savitch's theorem, NL=coNL | Sections 8.4; Handout 7 |
| 23 | Apr 22 | PSPACE-completeness, hierarchy theorem | Sections 8.3, 9.1; Handout 8 |
| 24 | Apr 24 | Advanced topics | |
| 25 | Apr 29 | Advanced topics | |
| 26 | May 1 | Advanced topics | |
| | May 14 | **Final exam** | |