Theory of Computation
18.404/6.5400
Fall 2023

Michael Sipser

Course Information

Instructor: Michael Sipser, 2–438, sipser@mit.edu, office hours: Tu 4:15–5:15,
zoom hours Mo 5-6pm (see homepage for zoom link)

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Course Outline

I **Automata and Language Theory (2 weeks).** Finite automata, regular expressions, push-down automata, context free grammars, pumping lemmas.

II **Computability Theory (3.5 weeks).** Turing machines, Church–Turing thesis, decidability, halting problem, reducibility, recursion theorem.

– **Midterm Exam:** Thursday, October 26, 2023.

III **Complexity Theory (7 weeks).** Time and space measures of complexity, complexity classes P, NP, L, NL, PSPACE, BPP and IP, complete problems, P versus NP conjecture, quantifiers and games, hierarchy theorems, provably hard problems, relativized computation and oracles, probabilistic computation, interactive proof systems.

– **Final Exam:** 3 hours, emphasizing second half of the course.

Prerequisites

To succeed in this course you require experience and skill with mathematical concepts, theorems, and proofs. If you did reasonably well in 18.062/6.1200, 18.200, or any other proof-oriented mathematics course, you should be fine. The course moves quickly, covering about 90% of the textbook. The problem sets generally require proving some statement, and creativity in finding proofs will be necessary.

Note that 18.400/6.1400 has a significant overlap with 18.404, depending on who is teaching it, and it often uses the same book though it generally covers less, with less depth, and with easier problem sets. Taking 18.400/6.1400 before 18.404 is not recommended.

Should I register for 18.404, 18.4041, or 6.5400?

Course 18 and 18C majors may register only for 18.404 which carries undergraduate (U) credit. All other majors, including double majors with Course 18 and 18C, should register for 18.4041 or 6.5400 which carry graduate (G) credit (may be useful in MEng and PhD programs) for the non-math major. The subject number doesn't affect the course material or grading.

Grading

- **Problem sets:** 40% of grade, based on 6 biweekly problem sets. Cooperating on p-sets is allowed and may be helpful, but you are strongly encouraged to spend some time thinking about each problem yourself first. Solutions must be written up individually (not copied). ***Using course bibles or other outside or online materials is not permitted.*** Submit your problem sets online via Gradescope, due by noon on days given by the Course Schedule (see homepage). Unexcused late p-sets will be accepted on the following day up to 11:59pm, but will be charged a 1 point per problem (out of the 10 point maximum) late penalty. After that date, problem sets may be submitted by email only. It may not be graded but will be kept for reference.

  Every problem set will contain one or two optional problems. I will consider your solutions to these challenging problems when assigning A+ grades, writing recommendation letters, and choosing graders and TAs in future years. Besides that, solving the optional problems will not affect your course grade.

  If personal or medical problems interfere with your work, please contact Student Support Services at `studentlife.mit.edu/s3` for undergraduates or GradSupport at `https://oge.mit.edu/student-support-development/gradsupport` for graduate students.

- **Exams:** One midterm (20% of grade) on October 26, 2023 during a class session and one final (40% of grade) during finals week. Both exams are closed book. No access to the textbook or course notes (printed or electronic) or to the internet is allowed. You are allowed to bring and use a one page (printed on both sides) summary sheet (also known as a cheat sheet) of your choice to the midterm and two pages (printed on both sides) to the final. The page(s) must be physical and on regular (8.5×11 inches) paper. Laptops are not allowed.

Textbook

Introduction to the Theory of Computation, third edition, Sipser, Cengage, 2013.
You may use the second edition, but it is missing some additional practice problems.
We will cover Chapters 1, 2 (except 2.4), 3, 4, 5, 6.1, 7, 8, 9.1, 9.2, 10.2 (except the part on Primality), and 10.4 through Theorem 10.33.

Recitations

Recitations are primarily for going over lecture material in more detail, giving additional examples, and answering questions. Recitation attendance is optional, and you may attend any recitation you wish. BUT, if you are having trouble, we expect you to attend recitations weekly, and active participation may improve low grades. To help the TAs keep track of active participants, we recommend attending the same recitation consistently.