

COS 451: AUTOMATA, COMPUTABILITY, AND LANGUAGES

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University of Maine

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Fundamentals of formal languages and the mathematical theory of computation; finite-state automata, nondeterminism, regular expressions, and Kleenes Theorem; context-free grammars, pushdown automata, the correspondence theorem and the pumping lemma; computability, Turing machines, and the halting problem.

Prerequisite: COS 250.

News and Reminders:

- Please read the newsgroup for timely announcements.
- Class newsgroup: Local group `umaine.cos451` on NNTP server `news.cs.umaine.edu`. Web interface to get started: <http://cs.umaine.edu/~chaw/news/>.
- The most recent version of this document may be found at <http://cs.umaine.edu/~chaw/cos451/>.
- Some sections below point to material in separate documents that are found on the class Web site, linked from the online version of this document.
- Please use the PDF version of this document for printing and reference: `cos451.pdf`

Goals and Learning Objectives

Goals

- Study various automata, such as deterministic and nondeterministic finite-state machines, pushdown automata, and Turing machines.
- Study formal languages of different kinds, such as regular and context-free languages.
- Understand the connections between languages and automata, and related algorithms for transformations.
- Understand the basic results on computability, including undecidable problems such as the halting and Post correspondence problems, and their significance.
- Study the basics of intractability, including NP-completeness and related topics.
- Make connections between theoretical results and topics in practical software development, such as finite automata and regular-expression libraries.
- Improve programming skills, with emphasis on connections between theoretical results and practical software.

Learning Objectives

Students should be able to

- determine the detailed action of given automata on given inputs (e.g., determine whether a given DFA accepts a given string).
- devise simple automata to satisfy given properties (e.g., devise a pushdown automaton to recognize a given language).

- perform tasks analogous to the above for grammars and other linguistic formalisms (e.g., devising a formal grammar for a language described in English).
- use standard algorithms to transform automata and languages in various ways (e.g., mapping context-free grammars to pushdown automata).
- map instances of problems using standard reductions (e.g., 3-SAT to CLIQUE).
- demonstrate understanding of the above by writing suitable programs.

Contact Information

Class meetings:

Time: Tuesdays & Thursdays, 12:30–1:45 p.m.

Location: Stevens Hall *North*, room 121.

Instructor: Sudarshan S. Chawathe

Office: Neville Hall, Room 224.

Office hours: (Please check for changes.)

Tuesdays & Thursdays: 8:00–9:00 a.m.; 4:45–5:15 p.m.

Phone: +1-207-581-3930.

Please avoid calling except for truly urgent matters.

Email: chaw@cs.umaine.edu

Use email only for messages unsuitable for the newsgroup. (See below.) Please use only this email address and put the string *COS451* near the beginning of the Subject header of your messages to me. *All other messages may be ignored.*

Web: <http://cs.umaine.edu/~chaw/>.

Teaching Assistant: Josh Kostura

Office: Neville Hall, Room 221.

Office hours: (Please check for changes.)

Tuesdays & Thursdays: 2:00–4:00 p.m.

Phone: +1-978-886-3462.

Email: joshua.kostura@maine.edu

Online Resources

Class Web site:

<http://cs.umaine.edu/~chaw/cos451/>

We will use the class Web site for posting assignments, readings, notes, and other material. Please monitor it.

Class Newsgroup: We will use the local USENET newsgroup `umaine.cos451` on the NNTP (net news) server `news.cs.umaine.edu` for electronic discussions. The Web interface at <http://cs.umaine.edu/~chaw/news/> provides convenient access. Some further, more general, information on USENET appears at <http://en.wikipedia.org/wiki/Usenet>. The newsgroup is the primary forum for electronic announcements and discussions, so please monitor it regularly, and post messages there as well. Unless there is a reason for not sharing a question or comment, please *use the newsgroup, not email*, for questions and comments related to this course.

Class mailing list: *Please make sure you are on the class mailing list.* A sign-up sheet is circulated at the first class meeting. If you miss it, please contact me to get on the list. We will use this mailing list only for urgent messages because all other messages will go on the class newsgroup. I anticipate fewer than a dozen messages on this list over the semester.

Grading Scheme

Grade components: *Students are expected to complete and submit all assigned coursework in good faith; those who fail to do so will earn a failing grade, regardless of overall numerical score.*

Component	% grade
class participation	10
classroom exercises and journal	10
homeworks	30
two quizzes (short exams)	10
two midterm exams	20
final exam	20

Class participation: Students are expected to contribute to learning by asking questions and making relevant comments in class and on the class newsgroup. Quality is more important than quantity. Disruptive activity contributes negatively. See policies below.

Classroom exercises and journal: Our work in the classroom will include a number of short group exercises, meant to solidify understanding of the concepts being discussed. One or more such exercises are likely to be part of most class meetings. Students must maintain a journal of their progress through the course and submit the journal periodically (typically on the dates of quizzes and exams) for grading. The journal consists of neatly organized classroom exercises, student observations on their own learning, and other material as announced in class. The exercises and journal will be graded primarily for effort, group work, and other contributions, and less so for simple correctness. Since attendance is not mandatory (cf. policies), some low-scoring exercises will be dropped for each student. Please ask for clarifications if there are concerns about the interaction of this component and the attendance policy.

Homeworks: Homeworks include programming and non-programming ones, often mixed. No collaboration is permitted. Everyone is encouraged to discuss the problems and solution strategies *at a high level*, but the final solution and details must be individual work. If the boundary between permissible and non-permissible interactions is unclear, please ask for clarifications.

Exams and Quizzes: All exams and quizzes are *open book, open notes*. You are free to bring with you any resources that you find useful. However, no communications are permitted other than between students and me. The use of computers during exams is strongly discouraged, but brief use may be permitted provided it does not cause a disturbance, at the discretion of the proctor. You may use the Internet, but only as a library to look up material you may find useful. Ask for clarifications in case of any doubt. The exams are designed to require no equipment other than a pen and paper, along with the textbook and assigned readings.

Midterm exams will be held during regular class meetings, and will be roughly an hour long. Each quiz is a short exam, roughly half an hour long, held during part of a class meeting. The final exam follows the usual university schedule, and is thus held outside of regular class meeting times, and often in a different location.

Policies

Due dates: All due dates and times, as announced in class, are strict, to the second. If you believe your work was delayed by truly exceptional circumstances, let me know as soon as those circumstances are known to you and I will try to make a fair allowance. However, *the default is that you get a zero if you don't turn in the work on time*, and fail the class if you don't turn it in at all (cf. Grade Components above).

Attendance: Although I expect students to attend all class meetings, I will not be taking attendance. *If you miss a class meeting, you are responsible for catching up on the lost material, including any important announcements made in class, on your own.* If you have a valid reason for missing a class, let me know early and I will try to help you make up the class. There will be no make-up exams or quizzes. A missed test earns zero credit. If you have a valid reason for missing a test, let me know as early as that reason is known to you and I will make a fair allowance but there will be no make-up tests in any case.

Classroom activities: This course is based on an active learning format, so effective classroom activities are critical to its success. Students are expected to contribute to their own learning and that of their classmates, and to devote 100% of their attention to these activities while in class. On a similar note, all electronic and other distractions (computers, phones, assorted gizmos, etc.) must be completely silenced and put away for the entire duration of the class. (Students who need any such devices for disability accommodations should follow the guidelines outlined below. Others who need any accommodation in this regard due to special circumstances should make advance arrangements with the instructor.) No food or drink is allowed in class, other than water in a spill-proof container. Students who violate these rules or otherwise cause distractions in class will be asked to leave with *no warning*; habitual violators will face disciplinary action.

Office hours: All students are encouraged to make use of both the instructor's and TA's office hours to further their learning, obtain assistance on homework assignments, obtain feedback on their class performance, etc. However, office hours are not to be used as a substitute for attending and participating in class meetings (see above). Similarly, assistance with homework assignments will be limited to what is appropriate based on fairness to all; students are expected to demonstrate substantial effort on the assignment before seeking assistance.

Make-up classes: I may have to reschedule a few classes due to my other professional commitments. I will make every attempt to minimize the number of such occurrences and to reschedule for a time that works for most students. Further, I will make sure no student is penalized by such occurrences.

Academic honesty (standard university wording): Academic dishonesty includes cheating, plagiarism and all forms of misrepresentation in academic work, and is unacceptable at The University of Maine. As stated in the University of Maine's online undergraduate Student Handbook, plagiarism (the submission of another's work without appropriate attribution) and cheating are violations of The University of Maine Student Conduct Code. An instructor who has probable cause or reason to believe a student has cheated may act upon such evidence, and should report the case to the supervising faculty member or the Department Chair for appropriate action.

Disabilities (standard university wording): If you have a disability for which you may be requesting an accommodation, please contact Ann Smith, Director of Disabilities Services, 121 East Annex, 581-2319, as early as possible in the term.

Special circumstances (standard university wording): In the event of an extended disruption of normal classroom activities, the format for this course may be modified to enable its completion within its programmed time frame. In that event, you will be provided an addendum to the syllabus that will supersede this version.

Textbook and Readings

Textbook: Michael Sipser. *Introduction to the Theory of Computation*. Cengage Learning, 3rd edition, 2013. The university bookstore carries this book, which is a required textbook for this course.

Other Readings: This list will change as we progress through the semester.

1. Lov K. Grover. A fast quantum mechanical algorithm for database search. In *Proceedings of the 28th Annual ACM Symposium on the Theory of Computing (STOC)*, pages 212–219, Philadelphia, PA, May 1996.

Exercises, Homeworks, Tests, and Notes

Material will appear here as we progress through the semester.

It may be useful to refer to the homeworks and tests from the previous session: <http://cs.umaine.edu/~chaw/201301/cos451/>.

- Class exercises:
 - Class Exercise 1: [hwq/ce01.pdf](#).
 - Class Exercise 2: [hwq/ce02.pdf](#).
 - Class Exercise 3: [hwq/ce03.pdf](#).
 - Class Exercise 4: [hwq/ce04.pdf](#).
 - Class Exercise 5: [hwq/ce05.pdf](#).
 - Class Exercise 6: [hwq/ce06.pdf](#).
 - Class Exercise 7: [hwq/ce07.pdf](#).
 - Class Exercise 8: [hwq/ce08.pdf](#).
 - Class Exercise 9: [hwq/ce09.pdf](#).
 - Class Exercise 10: [hwq/ce10.pdf](#).
 - Class Exercise 11: [hwq/ce11.pdf](#).
 - Class Exercise 12: [hwq/ce12.pdf](#).
 - Class Exercise 13: [hwq/ce13.pdf](#).
 - Class Exercise 14: [hwq/ce14.pdf](#).
 - Class Exercise 15: [hwq/ce15.pdf](#).
 - Class Exercise 16: [hwq/ce16.pdf](#).
 - Class Exercise 17: [hwq/ce17.pdf](#).
 - Class Exercise 18: [hwq/ce18.pdf](#).
 - Class Exercise 19: [hwq/ce19.pdf](#).
 - Class Exercise 20: [hwq/ce20.pdf](#).
 - Class Exercise 21: [hwq/ce21.pdf](#).
- Homework assignments:
 - Homework 1: [hwq/hw01.pdf](#).
 - Homework 2: [hwq/hw02.pdf](#).
 - Homework 3: [hwq/hw03.pdf](#).
 - Homework 4: [hwq/hw04.pdf](#).
 - Homework 5: [hwq/hw05.pdf](#).
 - Homework 5: [hwq/hw06.pdf](#).
- Quizzes and Exams:
 - Quiz 1: [hwq/q01.pdf](#).
 - Midterm Exam 1: [hwq/mt01.pdf](#).
 - Quiz 2: [hwq/q02.pdf](#).
 - Midterm Exam 2: [hwq/mt02.pdf](#).

Submissions

Illegible, hard to read, or otherwise messy submissions, whether handwritten on typed, hardcopy or electronic, are likely to be returned without grading, for zero credit.

All electronic submissions must be made using the upload interface at <http://cs.umaine.edu/~chaw/u/>. *Electronic submissions in all other forms, such as email or physical media, will be discarded and receive no credit.*

Uploaded files must be named following this template:

```
cos451-hw01-Lastname-Firstname-N.jar
```

The substrings `hw01` and `jar` are replaced by others depending on the material being submitted and N is an arbitrary 4-digit number, such as 4231. Multiple submissions, within reason, may be made by selecting different values of N .

If your upload is successful, you will be presented with a confirmation Web page similar to the following sample. You should record the reported MD5 checksum and timestamp.

```
SUCCESS: Please note the following for your records.
```

```
Successfully saved cos451-hw01-Aardvark-Alice-1389.jar.  
MD5 checksum: 09ee098b83d94c7c046d6b55ebe84ae1  
Timestamp: 2013-01-13 13:32:34
```

If you do not see something very similar then your submission is unsuccessful.