CS 154 (Sections 1, 2): Formal Languages and Computability, Fall 2021

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Fall 2021 office hours:

- Monday, 2:00-2:30 (in person).
- Tuesday, 11:30-12:30 (zoom link at https://sjsu.zoom.us/j/82534164368, except September 7 will be in person by reservation).
- Wednesday, 2:00-2:30 (in person).
- Other times available, set up an appointment by email.

Class Meetings:

- Section 1: Mon/Wed 10:45-12:00, Duncan Hall 250.
- Section 2: Mon/Wed 12:30-1:45, Duncan Hall 250.

Course Website

The main course website will through SJSU's Canvas website at https://sjsu.instructure.com/. Basic course information, including a link to this greensheet, is at http://www.cs.sjsu.edu/faculty/~taylor/term/current/CS154/.

Course Goal and Description

Goal: To introduce students to the basic concepts of theoretical computer science, and to show them that many of the origins of these questions came from some very practical considerations.

Topics covered will include context-free grammars, finite automata, minimization, regular expressions, Kleene's Theorem, pumping lemmas, closure properties, nonequivalence of deterministic and non-deterministic PDA's, Turing machines and decidable and undecidable problems.

Prerequisite Courses

You must show me that your prerequisite courses have been satisfied. **If you do not show me by Monday, August 30 (the second week of classes, the last class meeting before drop date), you may be dropped from the course.** Further, I will not give out any add codes without first seeing prerequisite proof. You should show me grades for CS46B and Math42, or their equivalents on a San Jose departmental course equivalence form. You must have a C- or better in each course. It does not matter what language your CS46B course used. Prerequisite courses and what they covered:
CS46A: Iteration and recursion (you don't need to bring proof of this one)
CS46B: Stacks and queues, lists, dynamic arrays, binary search trees. Iteration over collections. Hashing. Seaching, elementary sorting. Big-O notation. Standard collection classes.
Math42: Sets, logic, proofs, induction, combinatorics, probability, and equivalence classes.

Textbooks

This semester, you won't be required to buy any textbook, I will try to use my own course notes. I made daily course notes in Fall 2020, organized them into one reader for Spring 2021, and will edit and rerelease them as the semester progresses.

Jeff Erickson's Draft has (some of) the material in much more depth than we will cover, and I tried to use this book in Fall 2021, but I think that some students struggled with it, so my notes have most topics in simpler form, but I do include a couple of topics he doesn't.

Course Objectives

- To teach students how to construct and use regular expressions and finite automata.
- To teach students how to construct and use context-free grammars and pushdown automata.
- To teach students how to construct and use simple Turing machines.
- To introduce students to the properties of various automata and languages.
- To teach students how to use pumping lemmas to show non-membership in a language category.
- To teach students how to turn a non-deterministic finite automaton into a deterministic one.
- To teach students how to minimize a deterministic finite automaton.
- To acquaint students with closure properties of languages, and state minimization of automata.

Student Learning Outcomes

Upon successful completion of this course, students should be able to:

- Write a grammar for a language described otherwise. Construct deterministic and non-deterministic machines for various languages.
- Describe a language in terms of a regular expression.
- Find a regular expression for a language described by a finite automaton and conversely. Construct a deterministic finite automaton from a non-deterministic one.
- Minimize a deterministic automaton.
- Be able to use a pumping lemma to show that some languages are not regular and/or not context-free
- Use closure properties to simplify proofs of non-regularity of languages.
- Be able to construct a pushdown automaton accepting a given language.
- Construct a Turing machine accepting some simple languages.
- State in precise mathematical terms what is meant by undecidablity of the Halting Problem, and be able to show the undecidability of simple extensions of the Halting Problem, using the reduction technique.

Workload

The following will be regularly assigned for time outside of class:

- Readings from my course notes
- Homework problems (mostly/all on Canvas) to practice and test your own knowledge
- Occasional videos to watch

During the introduction of new material, homework is our chance to learn by making mistakes. Pressure to get correct homework answers "for a good grade" influences students to priotize getting the right answer over learning the material. Therefore, in this class, **homework will not be counted towards your course grade. That does not mean that it is optional.** It is required. It just doesn't count towards your grade.

Note: After the first couple of homework assignments (when things are still settling down), homework will only be available until it is due. If you submit the homework, you will still be able to see it afterwards, but if you don't

get around to looking at your homework before its due date, it won't be. (This paragraph was added on August 31.)

Class Participation

Class partiticipation and feedback are very important to keep the course interesting. *If I am covering material too slowly or quickly, or if I am not clearly explaining things, you must let me know.* I prefer an interactive learning environment. If you disagree with something I say, speak up. Argue with me in front of the class. It will make the class better, and right or wrong, constructive interaction will not not hurt your grade. If you are correct, clearly my mistake should be corrected. If you are incorrect, probably I have not explained something clearly anyway, and at least half of the class is confused by it. Point it out right then and there. In cases of exceptional participation that seem to benefit the class as a whole, I reserve the right to improve a student's grade by up to 1/3 grade.

University Policies

University Policies: Office of Graduate and Undergraduate Programs maintains university-wide policy information relevant to all courses, such as academic integrity, accommodations, etc.

You may find all syllabus related University Policies and resources information listed on GUP's Syllabus Information web page at http://www.sjsu.edu/gup/syllabusinfo/

Homework does not count towards your grade. The reason to do it is because it will help you to learn the material. It is not possible to have an academic integrity issue with the homework, because I will not put any rules on what you are not allowed to do. Exams, obviously, need to be taken as individuals, without any devices to help you. You will be allowed blank paper and something to write with on the exams.

Grading

Tests: There will be **five** in-class tests during the semester, and some of them (especially the first one) may not even take the entire class. These exams will be (unequally) weighted to give you a a test average for the semester. Dates and weightings are on the course schedule below. Your expectation should be that you get nearly 100% on the first exam, which will just barely cover anything beyond prerequisite knowledge and notation, and will be worth 10%. For each exam, the exam questions should have the same format as some of the homework questions.

The second exam will be the one with the highest weight, 40%. It is also the one with the simplest of all of the new course material you will see. The first two tests account for 1/2 of your in-semester exam score. Your goal should be to do very well on these first two exams, as the material for the rest of the semester is more challenging. **Do not fall behind early in this class.** It is much better to invest time at the beginning of the semester to fully understand that material, and then just try to hang on for the end of the semester as the material gets more difficult.

You will be allowed scratch paper, and something to write with on the exams, but no notes, nor any other devices to help you. **You are expected to have a laptop, with the lockdown browser installed, that you can use to take exams.**

Final:

- For Section 1, the final exam will be Wednesday, December 8, at 9:45-12:00
- For Section 2, the final exam will be Tuesday, December 14, at 12:15-2:30

Your final exam will be comprehensive for the semester, excluding preliminary material. (You have to understand that material to answer other questions, but there won't be explicit questions overlapping the first

exam.) You will not be given a template, but some questions (but not all) will have a format similar to something you have already seen in homework, or on an exam, during the semester.

Course grade: Your course grade will be the maximum of either your weighted test average, and the final exam, 50% each, or just your final exam. I will take whichever is better for you.

Curve: I am not exactly sure what the cut-offs for grades will be. If I were to put a (possibly overly optimistic) guess, it might be:

- [95+: A+
- [90-95): A
- [85-90): A-
- [80-85): B+
- [75-80): B
- [70-75): B-
- [65-70): C+
- [60-65): C
- [50-60): C-
- [45-50): D+
- [40-45): D
- [35-40): D-
- -35): F

My best guess is that cut-offs will be made more generous, in which case they will be updated here. I will not make them more stringent. Additionally, I may need to curve the final exam separate from the in-semester exams, again to allow for more generous cut-offs. In that case, I may just assign a numeric score corresponding to a letter grade for your final exam. In call cases, any changes will only make it easier to achieve any particular letter grade, I will not make any changes to the above curve that make it more difficult to get a higher grade.

Recording Lectures or Sharing Course Materials

You can make audio recordings of class for your own personal use. Perhaps you want to want to have my dulcet tones lull you to sleep at night instead of only during class, that is fine. Weird, but fine. Perhaps you want to torture your neighbors by blasting it on your porch, that is not fine: aside from possible violations of the Geneva Convention, recordings should not be reproduced, distributed, or publicly broadcasted. If you want to make video recordings, please discuss it with me.

Course material developed by the instructor is the intellectual property of the instructor and cannot be shared publicly without his/her approval. You may not publicly share or upload instructor generated material for this course such as exam questions, lecture notes, or homework solutions without instructor consent.

Drop and Add Dates

Note that for this semester, the last day to drop without consequence is ***Tuesday, August 31***, and the last day to add is ***Wednesday, September 8***. After these dates it becomes very difficult to drop or add a class, so be sure you are where you want to be before these dates arrive!

Class Schedule

The following table gives a general idea of what pace we will go.

Approximate Date	Topics Planned	Actual Topics if Different

Subject to change	
August 23	Introductions, Administrivia, and Warm Up: induction?
August 25	Review: strings, logic, sets, set notation, quantitatives, equivalence classes, closure, more induction
August 30	Finish review from last time. Start talking about sets of strings, basics
September 1	Finish talking about sets of strings: union, concatenation, *. Test run for Lockdown Browser with Respondus Monitor.
September 8	**Exam 1:** 25 minutes. 10% of your in-semester test grade. Class will continue after the exam. Regular Expression Definitions Regular Grammars
September 13	**Briefly** discuss exam, questions about regular expressions?, questions about regular grammars?, Start DFAs
September 15	DFAs and minimization
September 20	NFAs and FA Equivalence
September 22	Regular grammar equivalence, regular expression to NFA
September 27	NFA to regular expression via GNFAs
September 29	Closure rules for regular languages
October 4	**Exam 2:** 40%. This will take the entire class period
October 6	Brief exam coverage, Our first non-regular language, The Pumping Lemma.
October 11	Pumping Lemmag Continued, the Myhill-Nerode Theorem.
October 13	Non-regularity by closure rules
October 18	**Exam 3:** 15%. This will not take the entire class period.
October 20	Context Free Languages and Context Free Grammars
October 25	CNF and the CYK Algorithm
October 27	Pushdown Automata
November 1	Equivalence, Closure Rules, Pumping Lemma, and Non-CFLs: Way more than can possibly be covered in one class.
November 3	**Exam 4:** 15%. This will not take the whole class.
November 8	Brief exam coverage, introduction to Turing Machines
November 10	TM Encodings, counting, and diagonalization

November 15	TM variants: NTMs, multi-tape. P and NP.
November 17	UTMs
November 22	An undecicable language by fundamentals
November 29	Rice's Theorem
December 1	**Exam 5:** 20%. This might not take the entire class.
December 6	Review

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