CS 334 Course Syllabus

Course Title: Theory of Computation

Program(s): Computer Science

Course # or Level: Junior level, CS 334.

Catalog Description: Introduction to models of computation and their languages: finite-state machines, non-determinism, and regular languages, pushdown automata and context-free languages, and Turing Machines and recursively enumerable languages. The limits of computability: The Church-Turing thesis, decidable languages, reducibility, the halting problem, and the recursion theorem. Time and space complexity measures, intractable problems, and the P vs. NP question.

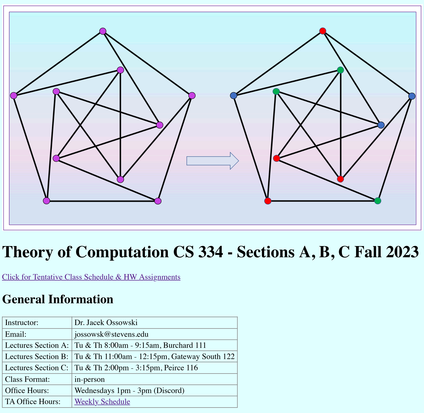
Course Objectives: This course introduces a mathematical framework to investigate the meaning and nature of computation. The questions addressed in this course include: what is a computable function, how do we distinguish between computable and non-computable functions? Moreover, among the computable functions, how do we distinguish between functions that can be computed quickly and those that require considerable amounts of time?

Required Textbook: Introduction to the Theory of Computation, 3rd edition, Michael Sipser.

List of Course Outcomes:

1. **Finite State Automata, Regular Languages, and Regular Expressions** - Describe the language recognized by a given automaton, and construct automata for a given language. Explain the concept of non-deterministic automata. Give formal definitions and specifications, prove their equivalence, and minimize finite state automata. Prove that certain languages are not regular.
2. **Context Free Languages and Pushdown automata** - Describe the language recognized by context free grammars and explain the relation between context free languages and pushdown automata.
3. **Computable functions** - Give formal descriptions of Turing machines and the languages they accept and explain the Church-Turing thesis.
4. **Undecidability** - Prove whether a language is Turing-recognizable or Turing-decidable. Develop proof methods using diagonalization, Turing-reducibility, and the Recursion theorem.
5. **Time Complexity** - Analyze the time complexity of decidable languages, explain the concept of reducibility among languages and P, NP, and NP-completeness.
6. **Coping with hard problems –** Design and analyze algorithmic techniques for coping with NP-complete problems: randomized and approximation algorithms.

Prerequisites: CS 135 (Discrete Structures), CS 385 (Algorithms)



Theory of Computation CS 334 - Sections A, B, C Fall 2023

Click for Tentative Class Schedule & HW Assignments

General Information

Instructor:	Dr. Jacek Ossowski
Email:	jossowsk@stevens.edu
Lectures Section A:	Tu & Th 8:00am - 9:15am, Burchard 111
Lectures Section B:	Tu & Th 11:00am - 12:15pm, Gateway South 122
Lectures Section C:	Tu & Th 2:00pm - 3:15pm, Peirce 116
Class Format:	in-person
Office Hours:	Wednesdays 1pm - 3pm (Discord)
TA Office Hours:	Weekly Schedule

Other Q&A resource: peer discussion forum will be set up on discord.com. See the "Software" section for instructions on joining our class on Discord.

Textbook

Michael Sipser, *Introduction to the Theory of Computation*, 3rd edition, Cengage Learning 2013
(for one possible textbook seller, copy and paste this link into your browser https://www.cengage.com/c/introduction-to-the-theory-of-computation-3e-sipser/9780357670583PF/)

A set of slides accompanying the textbook have been provided by the author.

Recommended book for further reading:

John E. Hopcroft, Rajeev Motwani, Jefrey D. Ullman, *Automata Theory, Languages, and Computation*, 3rd edition, Pearson 2006
(https://www.amazon.com/Introduction-Automata-Theory-Languages-Computation-dp-0321455363/dp/0321455363/)

Description of Course

This course provides an introduction to models of computation and the languages they give rise to. After taking this course you will be able to

- build and analyze finite-state machines, understand and construct non-deterministic automata, construct and analyze regular expressions/languages,
- minimize finite automata, determine that certain languages are not regular (via application of the Pumping Lemma),
- construct and analyze pushdown automata, context-free languages, determine that certain languages are not context-free (via the CFL Pumping Lemma),
- construct Turing Machines, analyze recognizable and decidable languages,
- prove that certain languages are not decidable or even recognizable,
- state and understand the intuition behind Church-Turing thesis,
- measure a Turing Machine's complexity, perform polynomial reductions,
- identify intractable problems, understand the P vs. NP question.

Homework

- There will be 7 written and 3 programming assignments.
- The written assignments should be submitted to Canvas and must be typed using Latex or Microsoft Word. Manuscripts written in longhand, submitted late or in a wrong place will not be accepted.
- The programming assignments should be submitted to hackerrank.com. Details to follow.
- Using language models such as ChatGPT to find partial or whole solutions, copying solutions in part or in whole from the Internet or asking students not enrolled in the class is strictly prohibited.
  If you have any questions regarding your homework, test or quiz scores, **you must address them within two weeks** after those scores have been received. Scores more than two weeks old will not be reviewed.
- The binding due date of an assignment will be given on the assignment's statement. Tentative due dates are listed on the course's approximate schedule.

Exams

- There will be one midterm exam and a final exam.
- There will be no make-up exams given after the exam date. If you know in advance that you will have to miss an exam, you must check with me (in advance) to avoid getting a zero for that exam. In case of an illness on an exam date, please contact me as soon as possible. You will need to provide suitable documentation explaining your inability to take the exam. Depending on the credibility of the documentation (an e-mail from the affected student is not enough) arrangements will – or will not – be made for a makeup exam.

Attendance

Since it is important to attend lectures, I will be taking attendance. You will be allowed three unexcused absences during the semester. Attendance will account for 5% of your final grade.

Grading

Participation:	5%
Written Assignments:	30%
Programming Assignments:	10%
Midterm Exam:	25%
Final Exam:	30%

Two worst written assignments and one programming assignment will not be counted towards your grade. Please note that this allowance can be easily depleted, and you should take advantage of it judiciously.

IMPORTANT NOTE: If on all three written ingredients of the course (i.e., written homework, midterm exam, and the final exam) a student scores < 60%, then regardless of the scores on the other parts of the course, the student's overall grade will be an F.

Grading Scale

Numeric Grade	Letter Grade
93+	A
90-92	A-
87-89	B+
83-86	B
80-82	B-
77-79	C+
73-76	C
70-72	C-
67-69	D+
63-66	D
60-62	D-
0-59	F

Discord Discussion Forum

If you have a question regarding the material or homework, chances are that somebody might have encountered that problem already. Check our Discord discussion forum first and post your question there if it has not been answered yet (see the "Software" section for setup). If you don't get the answer this way in a reasonable amount of time, (only then) you can ask me that question *outside* of my office hours. Naturally, you can ask me any question regarding the course *during* my office hours.

Hardware and Technical Requirements

The hardware/technical requirements for this course include:

- Computer satisfying the following minimum technical requirements
  - In general, the device must be portable, sufficiently up to date, and have adequate memory and storage so that it can run the current version of its operating system
  - Intel Core i5 or AMD Ryzen 5 processor (i7 or Ryzen 7 preferred)
  - 8GB of RAM (16 GB preferred)
  - Mac OS 10.15 or Windows 10
  - 256 GB SSD hard drive (512 GB preferred)
  - Wireless networking adapter
  - Camera and microphone
- Dedicated access to high-speed internet with a minimum speed of 1.5 Mbps (4 Mbps or higher is recommended).
- Webcam (for proctoring during remote exams)
- Microphone (a working microphone in your computer is fine)
- Respondus Lockdown Browser (if exams are held remotely)
- If exams are held remotely, it will be your responsibility to ensure that all the involved technology works as expected (i.e., your computer, internet, webcam, etc.).
- Fortunately, all students I gave a remote exam to in the past were able solve all their technical issues. Being able to set up the equipment needed for remote learning and assure that it works properly has become a prerequisite of academic coursework.

Software

- Canvas (free) - Hosts all class materials and meetings
- Discord (free) - Communication platform for discussions. Use the Canvas link in the course navigation to join this class on Discord. When choosing your Discord name please give your full name so that I can confirm that you are enrolled in the class.
  - Install (cut-and-paste https://discord.com/download into the browser if the link does not work)
  - Privacy Statement (cut-and-paste https://discord.com/privacy into the browser if the link does not work)

  For information on managing your privacy at Stevens Institute of Technology, visit the University's Privacy page.

NOTE: This course has NOT been designed for use with mobile devices.

Communication

- The homework assignments, solutions, readings, and announcements will be posted on Canvas.
- Please ensure that you can receive emails from Canvas so that you can get course announcements.
- Discussions will take place on Discord. I will also answer questions Discord, but I encourage students to try to answer questions jointly as well.
- **Do not ask for or provide actual solutions to homework problems on Discord.**
- Personal questions should be sent directly to my email or handled in person during office hours.
- I will not answer emails from Friday 6pm to Monday 9am.

Collaboration

All homework assignments must be completed individually.

- You must first consider each problem on your own and generate ideas on how to solve the problem.
- You may discuss how to solve homework problems only at a high level, e.g., "I used such and such theorem", or "this chapter in the textbook handles a similar problem". Do not go further than this.
- You must write solutions completely on your own.
- Do not use other resources (outside of your textbooks and collaborators) to find partial or whole homework/test problems' solutions. This includes using language models or searching for whole or partial solutions on the Internet.
- Posting the problems assigned in this course on the Internet (say, Reddit, Chegg, etc.) is not allowed.

Accommodation For Personal Circumstances including Religious Holidays

The course offers generous allowance for personal circumstances such as family events, religious holidays not observed by SIT, or other situations. You are allowed to miss three lectures without any impact on your participation score. Two worst written homework assignments and the worst programming assignment will be dropped at the end of the semester. Please plan accordingly in order not to deplete prematurely the course's allowance so that you can confine your special needs within the provided limits. No additional relief will be offered for the above reasons. Further accommodation may only be provided in cases of credibly documented illness, hospitalization, an accident, or similarly serious and unexpected situations.

Academic Integrity

Undergraduate Honor System

Enrollment into the undergraduate class of Stevens Institute of Technology signifies a student's commitment to the Honor System. Accordingly, the provisions of the Stevens Honor System apply to all undergraduate students in coursework and Honor Board proceedings. It is the responsibility of each student to become acquainted with and to uphold the ideals set forth in the Honor System Constitution. More information about the Honor System including the constitution, bylaws, investigative procedures, and the penalty matrix can be found online. The following pledge shall be written in full and signed by every student on all submitted work (including, but not limited to, homework, projects, lab reports, code, exams) that is assigned by the course instructor. No work shall be graded unless the pledge is written in full and signed.

"I pledge my honor that I have abided by the Stevens Honor System."

Reporting Honor System Violations

Students who believe a violation of the Honor System has been committed should report it within ten business days of the suspected violation. Students have the option to remain anonymous and can report violations online

The collaboration policy described above is designed to allow students the resources to succeed while ensuring they learn and master the material. If you are unsure whether something is acceptable according to the collaboration policy, talk to me! Violations of this policy will be considered violations of the academic integrity policy and will be reported to the appropriate school offices. Consequences may include (but are not limited to) failure of the class. Academic misconduct includes, but is not limited to:

- not reporting collaborators
- jointly writing solutions
- copying or plagiarizing solutions in whole or in part from fellow students or other sources
- screen sharing text/code on any platform (Discord, VS Code LiveShare, ...) counts as sharing the solution.
- unintentionally sharing solutions through platforms mentioned above, or sharing more of the solution than you intended.
- it is your responsibility to be mindful of who can access your files and which files they can access; note that it may be easy for strangers to access voice channels on a Discord server and that many code/text sharing platforms (e.g. VS Code LiveShare) give participants access to all files and directories within the directory you share.
- cheating on the exams
- discussing any information about exams with classmates before all grades are posted.
- posting questions on forums like Reddit, StackOverflow, or Chegg. You can refer to previously posted questions on these forums, but not create new ones for this course.

Learning Accomodations

Stevens Institute of Technology is dedicated to providing appropriate accommodations to students with documented disabilities. The Office of Disability Services (ODS) works with undergraduate and graduate students with learning disabilities, attention deficit-hyperactivity disorders, physical disabilities, sensory impairments, psychiatric disorders, and other such disabilities in order to help students achieve their academic and personal potential. They facilitate equal access to the educational programs and opportunities offered at Stevens and coordinate reasonable accommodations for eligible students. These services are designed to encourage independence and self-advocacy with support from the ODS staff. The ODS staff will facilitate the provision of accommodations on a case-by-case basis.

Student Disability Files are kept separate from academic files and are stored in a secure location within the Office of Disability Services. The Family Educational Rights Privacy Act (FERPA, 20 U.S.C. 1232g; 34CFR, Part 99) regulates disclosure of disability documentation and records maintained by Stevens Disability Services. According to this act, prior written consent by the student is required before our Disability Services office may release disability documentation or records to anyone. An exception is made in unusual circumstances, such as the case of health and safety emergencies. For more information about Disability Services and the process to receive accommodations, visit https://www.stevens.edu/office-disability-services. If you have any questions please contact: Phillip Gehman, the Director of Disability Services Coordinator at Stevens Institute of Technology at pgehman@stevens.edu or by phone (201) 216-3748.

Inclusion Statement

Stevens Institute of Technology believes that diversity and inclusiveness are essential to excellence in academic discourse and innovation. In this class, the perspective of people of all races, ethnicities, gender expressions and gender identities, religions, sexual orientations, disabilities, socioeconomic backgrounds, and nationalities will be respected and viewed as a resource and benefit throughout the semester. Suggestions to further diversify class materials and assignments are encouraged. If any course meetings conflict with your religious events, please do not hesitate to reach out to your instructor to make alternative arrangements. You are expected to treat your instructor and all other participants in the course with courtesy and respect. Disrespectful conduct and harassing statements will not be tolerated and may result in disciplinary actions.

Name And Pronoun Usage

As this course includes group work and in-class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect. This includes the ability for all students to have their chosen gender pronoun(s) and chosen name affirmed. If the class roster does not align with your name and/or pronouns, please inform the instructor of the necessary changes.

Mental Health Resources

Part of being successful in the classroom involves a focus on your whole self, including your mental health. While you are at Stevens, there are many resources to promote and support mental health. The Office of Counseling and Psychological Services (CAPS) offers free and confidential services to all enrolled students who are struggling to cope with personal issues (e.g., difficulty adjusting to college or trouble managing stress) or psychological difficulties (e.g., anxiety and depression). Appointments are strongly encouraged and can be made by phone (201-216- 5177) or in-person (on the 7th floor of the Howe Center). CAPS is open from 9:00 am – 5:00 pm Mondays, Wednesdays, Thursdays and Fridays and from 9:00 am – 7:00 pm on Tuesdays during the Fall and Spring semesters.

Emergency Information

In the event of an urgent or emergent concern about the safety of yourself or someone else in the Stevens community, please immediately call the Stevens Campus Police at 201-216-5105 or their emergency line at 201-216-3911. These phone lines are staffed 24/7, year round. Other 24/7 resources for students dealing with mental health crises include the National Suicide Prevention Lifeline (1-800-273-8255) and the Crisis Text Line (text "Home" to 741-741). If you are concerned about the wellbeing of another Stevens student, and the matter is not urgent or time sensitive, please email the CARE Team at care@stevens.edu. A member of the CARE Team will respond to your concern as soon as possible.

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Last modified: August 24, 2023

Week		Content	Reading	HW Assigned	PA Assigned
week1	Tuesday, September 5, 2023	Course policies, introduction to Th. Of Comp. First look at Finite State Automata (FSA)	Chapter 0		
	Thursday, September 7, 2023	Terminology and formal defnition of FSAs state diagrams, regular languages (RL) operations on RLs	Chapter 1.1	PS1 Out Due Fri, 09/22, 11:59pm	
week 2	Tuesday, September 12, 2023	Closure of RLs under operations of union and intersection, the product machine	Chapter 1.1		
	Thursday, September 14, 2023	Non-deterministic Finite Automata, closure under concatenation & Kleene star	Chapter 1.2		PA1 Out Thu, 10/12, 11:59pm
week 3	Tuesday, September 19, 2023	Other regular operations Equivalence of NFAs and DFAs, Subset Construction	Chapter 1.2		
	Thursday, September 21, 2023	NFAs whose DFAs have exponential size, Regular Expressions, Conversion from REs to NFAs/DFAs	Chapter 1.3	PS2 Out Due Fri, 10/06, 11:59pm	
week 4	Tuesday, September 26, 2023	RE to DFA conversion Example GNFAs and conversion from DFAs ↦ REs	Chapter 1.3		
	Thursday, September 28, 2023	Distinguishable & equivalent states in a DFA, Distinguishability Lemma, the Quotient automaton	Hopcroft, et al. 4.4		
week 5	Tuesday, October 3, 2023	State minimization algorithm for DFAs, the Pumping Lemma for regular languages	Hopcroft, et al. 4.4.3 Sipser 1.4		
	Thursday, October 5, 2023	Examples of non-regular languages, using the the Pumping Lemma to prove non-regularity	Chapter 1.4	PS3 Out Due Thu, 10/19, 11:59pm	
week 6	Tuesday, October 10, 2023	Context Free Grammars, parse trees	Chapter 2.1		
	Thursday, October 12, 2023	CFG ambiguity, converting DFAs to CFGs, Chomsky normal form	Chapter 2.1		PA2 Out Due Tue, 11/14, 11:59pm
week 7	Tuesday, October 17, 2023	CFL Closure Properties Pushdown Automata	Chapter 2.2		
	Thursday, October 19, 2023	Review		PS4 Out Due Thu, 11/02, 11:59pm	
week 8	Tuesday, October 24, 2023	MIDTERM EXAM			
	Thursday, October 26, 2023	Pushdown Automata & CFL The Pumping Lemma for CFLs	Chapter 2.2, 2.3		
week 9	Tuesday, October 31, 2023	Examples of non-CFL languages	Chapter 2.3		
	Thursday, November 2, 2023	Turing Machines	Chapter 3.1	PS5 Out Due Thu, 11/16, 11:59pm	
week 10	Tuesday, November 7, 2023	Equivalence of Multi-tape, Nondeterministic and Single-Tape Machines	Chapter 3.2		
	Thursday, November 9, 2023	Decidable Languages, Enumerators	Chapter 4.1		
week 11	Tuesday, November 14, 2023	Undecidable & Unrecognizable Languages	Chapter 4.2		PA3 Out Due Thu, 12/16, 11:59pm
	Thursday, November 16, 2023	Reductions	Chapter 5.1, 5.3	PS6 Out Due Thu, 11/30, 11:59pm	
week 12	Tuesday, November 21, 2023	The Recursion Theorem	Chapter 6.1		
	Thursday, November 23, 2023	Thanksgiving!			
week 13	Tuesday, November 28, 2023	Polynomial Complexity/class P	Chapter 7.1, 7.2		
	Thursday, November 30, 2023	Class NP	Chapter 7.3	PS7 Out Due Thu, 12/14, 11:59pm	
week 14	Tuesday, December 5, 2023	Examples of NP Problems Polynomial Reductions	Chapter 7.3, 7.4		
	Thursday, December 7, 2023	Cook's Theorem NP-Completeness	Chapter 7.4, 7.5		
week 15	Tuesday, December 12, 2023	Polynomial Verifiers Examples of NP-complete Problems	Chapter 7.5		
	Thursday, December 14, 2023	Review			
	TBA	FINAL EXAM			