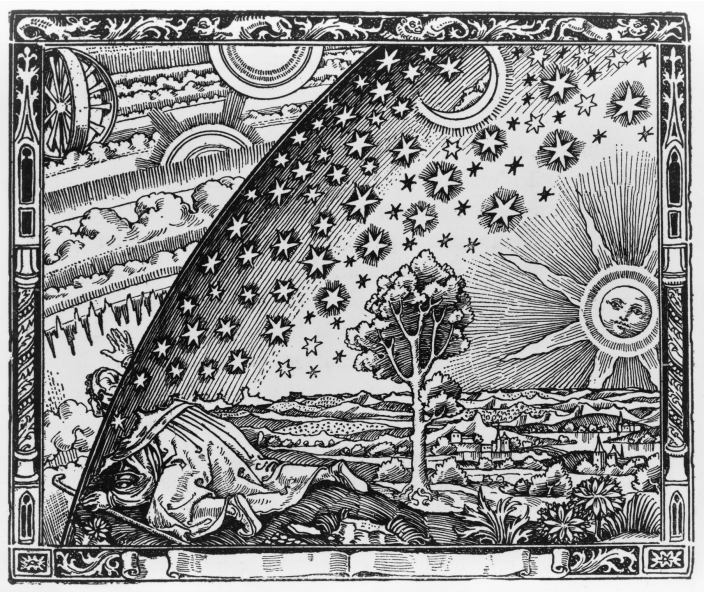
CS4510 Automata and Complexity

Summer 2026 9:30-11:40AM MW ES&T 1105



People

- Lecturer: Abrahim Ladha
- TAs:
  - Alex Ichetovkin
- See piazza for office hour times and updates.
- Office hours are located at outside CCB203, an open area on the second floor of CCB.
- My Office is in CCB 207B, second floor. I have an open door policy. If my door is open, you may come in and ask any questions. I am also extremely responsive on piazza. Please use me as a resource, even for simple quick questions.

Course Information

This course answers two main questions:

- What are the fundamental limits of computation?

- What makes some problems easy, and others hard?

The first question is the study of the area of **Computability theory**. Most of its questions are solved, which is what makes this subject fun. We are concerned with such extremal, almost philosophical questions. What even is computation? What even is a computer? Are all problems solvable? We will explore several models of computation and explore their relative power, and weaknesses.

The second question is the study of **Complexity theory**. Most of its questions are unsolved. This subject does not have a happy ending (and perhaps won't, in our lifetimes) but this contrast is what makes it interesting. We may not know how to solve certain questions, but ironically, we know a lot about how hard these questions are.

I like to think of this course as a finale to your CS degree. It is simultaneously the most important and least important course you will take. It is the least important as it doesn't develop any single technical skill. It is the most important, as it develops your ability to conceptualize and theorize. This is the course where you will learn why computer science gets to be called a science. It puts the rest of your degree into context.

This course has a lot of pre-reqs, some of which I would disagree should be a requirement. All you really need is good proof skills, like those found CS2050. If you think you might be rusty, please refresh chapter zero of the Sipser book.

The book for the course is Introduction to the Theory of Computation by Michael Sipser. It is an excellent textbook, can't count how many times I've read it. The notes and lectures for the course are the authoritative reference, but it is expected you follow along with Sipser's book. Later on, I may reference the Arora-Barak and Li-Vitanyi books.

Evaluation

In order to accomodate students who wish to take this course fully remote, I have decided to make all assignments take home. The tradeoff here is that the difficulty will increase. You will have four exams. They are open note and open book, but not open internet. You will also have ten problem sets. Your tentative exam dates are:

May 29 Exam 1

Jun 12 Exam 2

Jul 10 Exam 3

Aug 05 Exam 4

Schedule

This is subject to change as I realize what takes more or less time.

No.	Date	Lecture
L01A	May 18	Introduction
L01B	May 18	Deterministic Finite Automata
L02A	May 20	Nondeterminism
L02B	May 20	Powerset Construction
L03A	May 27	Regular Expressions
L03B	May 27	The Pumping Lemma
L04A	Jun 01	Context-Free Grammars
L04B	Jun 01	Regular Grammars and Closure
L05A	Jun 03	Syntactic Structures
L05B	Jun 03	Chomsky Normal Form
L06A	Jun 08	Pushdown Automata
L06B	Jun 08	Equivalence of PDAs and CFGs
L07A	Jun 10	Pumping Context-Free Languages
L07B	Jun 10	Parikh's Theorem
L08A	Jun 15	Turing Machines
L08B	Jun 15	The Church-Turing Thesis slides, required reading1, required reading 2, required reading 3
L09A	Jun 17	CTT as a falsifiable hypothesis
L09B	Jun 17	Turing-completeness
L10A	Jun 22	Countability
L10B	Jun 22	Diagonalization
L11A	Jun 24	Foundations of Mathematics

No.	Date	Lecture
L11B	Jun 24	Russell's Paradox
L12A	Jun 29	Godel's Incompleteness Theorems
L12B	Jun 29	The Halting Problem
L13A	Jul 01	The Art of Reduction
L13B	Jul 01	Post's Correspondence Problem
L14A	Jul 06	Recursion and Truth
L14B	Jul 06	Kolmogorov Complexity
L15A	Jul 08	Computational Complexity
L15B	Jul 08	Nondeterministic Polynomial Time
L16A	Jul 13	Cook-Levin Theorem
L16B	Jul 13	Ladner's Theorem
L17A	Jul 15	Savitch's Theorem
L17B	Jul 15	PSPACE-completeness
L18A	Jul 20	Hierarchy Theorems
L18B	Jul 20	Relativization
L19A	Jul 22	Circuit Complexity
L19B	Jul 22	Circuit Lower Bounds
L20A	Jul 27	Polynomial Time Hierarchy
L20B	Jul 27	Karp-Lipton Theorems

Other Resources

Besides the notes we will publish this semester, I recommend you use the following two references:

- RECORDED LECTURES
- Typeset notes

Integrity Statement

Submission of any work not your own will result on a zero on the assignment to a report to OSI, which may incur further sanctions.

Statement of Intent for Classroom Inclusivity

As a member of the Georgia Tech community, I am committed to creating a learning environment in which all of my students feel safe and included. Because we are individuals with varying needs, I am reliant on your feedback to achieve this goal. To that end, I invite you to enter into dialogue with me about the things I can stop, start, and continue doing to make my classroom an environment in which every student feels valued and can engage actively in our learning community.