General Description

This course is an introduction to computability and computational complexity theories. The general topics covered are: computational machine models and their language classes, undecidability, resource-bounded computations, central complexity-theoretic concepts such as complexity classes, reducibility, and completeness.

Textbook

Introduction to the Theory of Computation by Michael Sipser, 3rd edition.

Instructor

Alexandra (Sasha) Boldyreva, sasha@gatech.edu. Please use 4510 in the subject for all emails.

Office hours: Tuesdays 1-3pm, Klaus 3144. If you cannot make these times, send me email with options of times that work for you, so that we can schedule an appointment.

Teaching Assistants and their office hours

Keshav Ramani ramanikeshav@gmail.com, Fridays 12pm-2pm, seating area next to Klaus 3201.

Anmol Kalia anmolkalia@gatech.edu, Mondays 11am-1pm, CoC common area.

Karthik Gopalakrishnan gkarthik@gatech.edu, Wednesdays 10am-12pm, seating area next to Klaus 3201.

Venkat Abhishek Tondehal vtondehal3@gatech.edu, Wednesday and Friday 10:05am - 11:05am, seating area next to Klaus 3201.

Junghyun Kim conankun@gatech.edu, Thursday 5pm-7pm, 2116.

Piazza forum:

Signup Link: piazza.com/gatech/fall2017/cs4510

Class Link: piazza.com/gatech/fall2017/cs4510/home

Grading

-Homework assignments 20% total (Lowest homework score will be dropped.)

-3 tests 25% each OR 3 tests 55% total and final examination 20%. (I.e. the final is optional. After 3 exams you will be given your grade (and also where you stand in the class) and if you are happy with this, you don't have to take the final and you will get that grade. If you want to improve the grade, you can take the final. But then your grade will be re-calculated based on the final.)

-Participation 5%, tracked with the help of Socrative app.

Rules and grading policies

You can study with others, but you must write the homework solutions independently on your own. Homeworks are due in class on the day indicated on the problem set. They can be typed or handwritten. Indicate the names of your collaborators. Late homeworks are not accepted. (If you can't make it to class, give your homework to someone else to turn in for you or submit a pdf file on T-Square.) Re-grade requests are first addressed to the TA. If your homework solution has more than one sheet of paper, the sheets should be stapled together, not clipped or folded at the corner. Turn in neat, readable solutions. Points can be deducted otherwise. The exams are in class. The dates of the exams will be announced on TSquare. One ore more cheat sheets will be allowed. There are no makeup exams under any circumstances unless you have a note approved by the Dean of students. It is your responsibility to keep up with the happenings in the class. Piazza forum will be set up. Georgia Tech Academic Honor Code applies. Cheating will be taken very seriously.

Syllabus

1. Introductory concepts in formal languages and automata theory: languages, operations on languages, and basic machine models. (Sipser:Chapter 0)

2. **Regular languages:** Deterministic and nondeterministic finite state automata. Closure under union, intersection, complementation, concatenation, and star operations. Equivalence of non-deterministic finite state automata and deterministic finite state automata. Regular expressions and equivalence of regular expressions and regular languages. Pumping lemma, Myhill-Nerode theorem. (Sipser: Chapter 1)

3. **Context-free languages:** Context-free grammars. Ambiguity. Normal forms such as Chomsky normal form. Closure under union, concatenation, and star operations. Non-closure under intersection and complementation operations. Parse-trees. Pumping lemma. Pushdown automata. Equivalence of pushdown automata and context-free grammars. (Sipser:Chapter 2)

4. **Decidability:** Turing machines. Recursively-enumerable and recursive languages. Equivalence of varieties of models such as multi-tape and nondeterministic Turing machines with the deterministic Turing machines. Diagonalization. Undecidability of the Halting problem. (Sipser:Chapters 3, 4)

5. **Reducibility:** Undecidable problems from Language theory. Post Correspondence Problem. Many-one reducibility. (Sipser: Chapter 5).

6. **Complexity Theory:** Time Complexity Complexity classes P and NP. Polynomial time reducibility. NP-Completeness. The Cook-Levin theorem. Examples of NP-Complete problems. (Sipser: Chapter 7)

7. **Other topics in Complexity Theory,** time permitting (but most likely not): Space complexity. Savitch's theorem. PSPACE-Completeness. The classes L and NL. NL-Completeness. NL equals CONL. (Sipser: Chapter 8)

Schedule (subject to change)

08/23. Basic notions (alphabet, strings, languages).
08/28. Course info. DFAs informally. DFAs formally. Sipser 1.1.
08/30. NFAs informally and formally. Sipser 1.2
09/04. Labor day.
09/06. DFAs and NFAs are equivalent in power. Regular languages are closed under regular operations.

09/11. Irma
09/13 Regualr expressions. Regular expressions and DFAs are equivalent in power. Sipser 1.3
The Pumping Lemma for regular languages and its use.
Intro to context-free grammars.
Exam 1.
Context-free grammars.
PDAs, equivalense in power with CFGs.
The Pumping Lemma for CFLs.
The use of the Pumping Lemma. Non-closure under complement and intersection.
LR(0) parser.
DCFLs. DPDAs, DCFGs.
Exam 1 review, Exam 2 practice.
Exam 2.
Intro to Turing machines.
Non-deterministic TM and equivalence to regular TMs.
Exam 2 review. Deciders and recognizers.
Decidable languages. Closure of decidable and recognizable languages under union and intersection.
A_TM is undecidable.
More undecidable languages.
Exam 3.
Rice theorem. Mapping reducibility.
Problems about mapping reducibility.
Exam 3 solutions. Intro to complexity theory. TIME.
P, NP, NTIME, EXP.

Exam dates

Exam 1: September 27.
Exam 2: October 23.
Exam 3: November 27.
Optional Final: December 11, 3-4:30pm.