COMS W3261: Computer Science Theory

Class time: Tuesdays and Thursdays 2:40 - 3:55 PM
Class location: MUDD 833
Instructor: Allison Lewko
Office hours for Instructor: Tuesdays 10:00 AM - 12:00 PM in CSB 519
Instructor email: alewko@cs.columbia.edu

1 TAs

- Arka Bhattacharya, ab3899@columbia.edu, Office hours: Friday 5-7PM
- Luke Kowalczyk, ltk2112@columbia.edu, Office hours: Mon 11:00 AM - 1 PM
- Sam Frank, smf2147@columbia.edu, Office hours: Mon/Fri 10-11 AM
- Sagar Sarda, ss4355@columbia.edu, Office hours: Mon 4:30-6:30 PM

All TA office hours will be in the TA Room, 122 Mudd. The hours listed above are subject to change.

2 Course Description

This course is an introduction to models of computation, computability, and complexity. We will ask questions like: How do we define the abstract notion of "computation" or a "computer"? What problems can be computed? What problems can be computed efficiently? Can we prove that some problems can never be computed, no matter how fast our computers become? The course is highly mathematical and abstract; in particular, there will be no programming assignments and homework problems will frequently involve proving or disproving various assertions. Students are expected to be comfortable with the material covered in Discrete Math (W3203) or the equivalent.

Schedule of Topics to be Covered (*Subject to Change)

Lecture	Date	Topic	Reading (HMU)
1	1/21	Course overview; automata, languages	Ch. 1
2	1/23	Deterministic Finite Automata	Ch. 2.1, 2.2
3	1/28	Nondeterministic Finite Automata	Ch. 2.3, 2.4
4	1/30	NFA w/ epsilon transitions; Conversion to NFA, DFA	Ch. 2.5
5	2/4	Regular expressions; Conversion to/from automata	Ch. 3.1, 3.2
6	2/6	Properties of regular expressions; Closure properties of regular languages	Ch. 3.3, 3.4, 4.2
7	2/11	Pumping lemma; Myhill-Nerode theorem	Ch. 4.1
8	2/13	Algorithms for regular languages; Equivalence, minimization of automata	Ch. 4.3, 4.4
9	2/18	Context-free grammars	Ch. 5.1
10	2/20	Parse trees, ambiguous grammars	Ch. 5.2, 5.4
11	2/25	Pushdown automata	Ch. 6.1, 6.2
12	2/27	Equivalence of PDA and CFG	Ch. 6.3, 6.4
13	3/4	Deterministic PDA; Pumping lemma for CFL	Ch. 6.4, 7.2
14	3/6	Closure properties of CFL; Algorithms	Ch. 7.3, 7.1
15	3/11	Chomsky normal form	Ch. 7.1, 7.4
	3/13	Midterm exam in class	
	3/18	Spring Recess	
	3/20	Spring Recess	
16	3/25	CFL Membership Algorithm; Computability	Ch. 7.4, 8.1
17	3/27	Turing machines; Recursive and RE languages	Ch. 8.2
18	4/1	Programming tricks; Multitape TMs; Nondeterministic TMs	Ch. 8.3, 8.4
19	4/3	More variants of TMs, simulations	Ch. 8.5, 8.6
20	4/8	Undecidability; Diagonalization; Properties of Recursive and R.E. languages	Ch. 9.1, 9.2
21	4/10	Universal language and TM, Reductions	Ch. 9.2, 9.3
22	4/15	More reductions, PCP, Undecidable problems	Ch. 9.3-9.5
23	4/17	Complexity classes, the classes P, NP, coNP	Ch. 10.1, 11.1
24	4/22	NP-completeness, Satisfiability	Ch. 10.2, 10.3
25	4/24	Reductions, NP-complete problems	Ch. 10.3, 10.4
26	4/29	Lambda calculus	
27	5/1	Lambda calculus	
	5/15	Final exam	

3 Grading

There will be several homework assignments throughout the semester. Homeworks will be posted on courseworks and announced in class and via email. They will be due at the beginning of class on their due date.

Collaboration Policy Students are allowed to work together on the homework assignments but must write up their solutions individually (while alone, not looking at anyone else's writeup). It will be considered an honor code violation to consult solutions from previous years, from the web or elsewhere, in the event that homework problems have been previously assigned or solu-

tions are available elsewhere. The CS department web page,
http://www.cs.columbia.edu/education/honesty, lists the department's academic honesty policies. All students are expected to abide by these policies.

Late Homework Policy Late homework will penalized by 10% for each day late. If a homework is > 0 but ≤ 24 hours late, it is penalized as one day. If it is > 24 but ≤ 48 hours late, it is penalized as two days, etc.

The course grade will be based on:

- 30% homework assignments
- 35% midterm exam
- 35% final exam

4 Textbook

Required Textbook Introduction to Automata Theory, Languages and Computation, by John Hopcroft, Rajeev Motwani, and Jeffrey Ullman.

Additional Reference (optional) Introduction to the Theory of Computation, by Michael Sipser.