Computer Science
Dartmouth College

Computer Science 39
Theory of Computation

Winter 2015

Amit Chakrabarti

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Course Description

This course serves as an introduction to formal models of languages and computation. Topics covered include finite automata, regular languages, context-free languages, pushdown automata, Turing machines, computability, and NP-completeness.

This course has substantial mathematical content. It is expected that a student who enrols for this course *already knows how to write mathematical proofs* and is generally mathematically mature. If a student passes this basic criterion and is interested in thinking philosophically about what a computer can or cannot do, then this course should be great fun.

Announcements

- [Jan 5] We will be using Piazza for all class discussion. The system is highly catered to getting you help fast and efficiently from classmates, the TA, and myself. Rather than emailing questions to the teaching staff, I encourage you to post your questions on Piazza. If you have any problems or feedback for the developers, email team@piazza.com. Here is our class page on Piazza.
- [Jan 5] Please send email to the professor (Amit Chakrabarti) with your name (only first and last name, no initials) and a password for accessing your grades in our database.

Administrative Basics

Important! Please also read and familiarize yourself with the administrative details not covered in the outline below. Pay special attention to the section that describes how the honor code applies to this course; violations of the honor code *will* be treated seriously.

Lectures	Sudikoff 115	2 hour	Mon-Wed-Fri 13:45-14:50, X-hr Thu 13:00-13:50
Instructor	Amit Chakrabarti Sudikoff 107	646-1710	Office hours: Mon 15:00-16:00, Tue 13:00-14:00, or by appointment
Teaching Assistants	Jack Holland Sudikoff 152	914-400-9223	Office hours: Wed 15:00-16:00, or by appointment
Textbook	Required: "Introduction to the Theory of Computation," Third Edition. Michael Sipser. Suggested additional reading (not required): "Introduction to Automata Theory, Languages and Computation." J. E. Hopcroft and J. D. Ullman.

Prerequisites Either CS 30 or CS 31, or
a *strong* mathematics backround and permission of the instructor

Work

One homework per week. [35 points]
Two in-class quizzes. [15 points]
One take-home midterm. [20 points]
One take-home final exam. [30 points]

Please take note of the late homework policy. It will be enforced, strictly.

Schedule and Homeworks

This schedule will be updated frequently. Please check back often, and please remember to RELOAD to get the latest schedule.

Any part of the schedule that is greyed out is tentative and subject to change.

Please be sure to read and understand the Homework Grading Guidelines and the Late Submission Policy.

Lecture Number and Date			Reading Due Before Class	Homework Due	Topics Covered in This Lecture
Week 1	1	Jan 5	—	—	Welcome, administrivia, overview; Mathematical notation (slides)
	2	Jan 7	0.1, 0.2, 0.3	—	Types of proof (direct, contradiction, induction) (slides)
	3	Jan 8 x	0.4	—	Strings and languages; Finite automata; Basic DFA examples
	4	Jan 9	1.1 up to p34	—	Further DFA examples; formalization as (Q,Σ,δ,q_0,F)
Week 2	5	Jan 12	1.1	—	Formalization of DFA computations; Closure under union/intersection
	6	Jan 14	1.2	—	The regular operations; Regular expressions
	7	Jan 15 x	—	HW1	Kleene's Theorem; Conversion of RegExp to NFA; (lecture notes);
	8	Jan 16	1.3 up to p69	—	Kleene's Theorem II: Conversion of NFA to DFA;
Week 3		Jan 19	—	—	No class; MLK day
	9	Jan 21	1.3	—	Kleene's Theorem III: of DFA to RegExp (lecture notes); Pumping lemma
	10	Jan 22 x	1.4	HW2	Non-regulartiy via pumping lemma and closure properties

	11	Jan 23	Chapter 1	—	Pushdown automata; Examples of PDAs
	12	Jan 26	—	—	**Quiz 1: closed-notes, in-class**
	13	Jan 28	2.2 up to p116	—	Formal definition of a PDA; More examples; Closure under $\cup$, $\circ$, *
Week 4	14	Jan 29 x	—	HW3	Context-Free Grammars (CFGs); Basic examples
	15	Jan 30	2.1 up to p108	—	Formal definition of a CFG; Ambiguity; CFG for $N_0 = N_1$ (lecture notes)
	16	Feb 2	2.1	—	Chomsky Normal Form; PDA/CFG practice problems (solve these two in advance)
	17	Feb 4	—	—	Equivalence of CFGs and PDAs, I: PDA to CFG
Week 5		Feb 5 x	2.2	HW4	Not used
	18	Feb 6	2.3	—	Equivalence of CFGs and PDAs, II: CFG to PDA (lecture notes)
	19	Feb 9	3.1	—	Pumping lemma for CFLs; Applications; Use of closure properties
	20	Feb 11	—	—	Proof of the CFL pumping lemma; CFL wrap-up; Turing machines (palindromes, adder)
Week 6	21	Feb 12 x	—	**Midterm**	Formal description of TMs; Deciders/recognizers; Implementation Descriptions
	22	Feb 13	3.1	—	Multi-tape TMs; Equivalence with single-tape TMs (slides)
	24	Feb 16	3.2 up to p150	—	Nondeterministic TMs; The RAM model; Church-Turing Thesis (slides)
	25	Feb 18	Chapter 3	—	Decision problems for the major language classes: A_{DFA}, A_{CFG} and A_{TM}
Week 7	26	Feb 19 x	4.1	HW5	Decidability of A_{DFA}, A_{CFG}; (Mapping) reductions; Recognizability of A_{TM}; Undecidability of A_{TM}
		Feb 20	Chapter 4	—	Decidability of E_{DFA}, ALL_{DFA}, EQ_{DFA}; Decidability of E_{CFG}; Unrecognizability of $\overline{A}_{TM}$
	27	Feb 23	5.1 up to p192; 5.3	—	**Quiz 2: closed-notes, in-class**
	28	Feb 25	—	—	Further reductions; Unrecognizability of E_{TM}, EQ_{TM}; Discussion of ALL_{TM}, INT_{TM}
Week 8	29	Feb 26 x	7.1	HW6	Time complexity, P and NP

	30	Feb 27	7.1 – 7.3	—	NP-completeness and polynomial time reductions (slides)
Week 9	31	Mar 2	TBD	—	More NP-completeness proofs: IND-SET, CLIQUE, UHAMCYCLE
	32	Mar 4	TBD	—	Yet more NP-completeness: TSP, 3-COL
	33	Mar 5 x	—	HW7	Tractability of 2-COL, 2-SAT; Computational tableaux
	34	Mar 6	—	—	Undecidability of INT_{CFG}
Week 10		Mar 9	TBD	—	Unrecognizability of ALL_{CFG}; The Cook-Levin Theorem
	35	Mar 10	TBD	HW8 (optional)	Space complexity; Savitch's Theorem
		Deadline Mar 14			**Take-home 48-hour final exam, due at 5:00pm sharp**

Solutions to Homework and Exam Problems

These will be provided in class, when graded homeworks are given out. Hard-copy only.

Grades Database

If you are a registered student, you may verify your grades as entered in our database using the form below.

Your name, without initials or suffixes:

Your CS 39 password:

Check scores
