ArsDigita University
Month 8: Theory of Computation
Professor Shai Simonson

Syllabus

General information about our text and readings:

Our text is Introduction to the Theory of Computation by Sipser. It is a classical introduction to automata theory, formal grammars and complexity theory known collectively as the theory of computation. Like many theoretical computer science texts, it begins with a review of the relevant discrete mathematics in Chapter 0. I will assign only 0.1 from this chapter that serves as an overview of the subject, but you are expected to be familiar with the other sections and use them for reference when necessary. We will use recitations for reviewing these topics if needed.

We will cover chapters 1-5 in detail, comprising the core of the course. Chapter 7 on NP-Complete theory has been covered in the Algorithms course (month 5), but we will cover it again from a slightly different point of view. The basics of chapter 8 (section 1-3) and selections from chapter 10 will be covered as time allows.

A detailed syllabus with readings follows below:

Week 1: Introduction and Regular Sets.

General Introduction: Languages, Grammars, Automata (Machines), The Chomsky Hierarchy, Applications. Finite State Machines, Regular Expressions, Regular Grammars, Non-determinism, Non-regular sets, The Pumping Lemma, Decision Algorithms for Regular Sets.

Reading: Chapters 0.1, 1, 4.1a.

Lecture 1: Finite State Machines, Design, Non-Determinism. (Reading: 1.1-1.2)

Lecture 2: Closure Properties, Regular Expressions, Equivalence with Finite State Machines. (Reading: 1.3).

Lecture 3: The Pumping Lemma – Proving a Language is Non-Regular, The Adversary Game, Using Closure Properties. (Reading 1.4).

Lecture 4: Regular Grammars, Equivalence to FSMs, Other FSM Variations, Minimization of FSM's.

Lecture 5: Decision Algorithms for Regular Sets and Undecidability. (Reading 4.1a).

Week 2: Context-Free Languages.

Context-Free Grammars, Chomsky Normal Form, Pushdown Machines, Non-Context-Free Languages, Another Pumping Lemma, Decision Algorithms for Context Free Sets.

Reading: Chapter 2, 4.1b.

Lecture 1: Context-Free Grammars, Semantic and Inductive Design, Examples, Applications. (Reading 2.1).

Lecture 2: Chomsky Normal Form. Three Applications. (Reading 2.1).

Lecture 3: Pushdown Machines, Non-Determinism Adds Power, Equivalence to CFG's. (Reading 2.2).

Lecture 4: The Pumping Lemma and Non-Context-Free Sets. (Reading 2.3).

Lecture 5: Closure Properties, DCFL's and Decision Algorithms. (Reading 4.1b).

Week 3: Turing Machines.

Reading: Chapter 3, 4.2, 5.1, 5.2.

Lecture 1: Turing Machines, Design. (Reading 3.1).

Lecture 2: Variations and Equivalence: Non-Determinism, MultiTape, Two-Way. (Reading 3.2).

Lecture 3: Recursive and Recursively Enumerable Sets, Undecidability. (Reading 4.2)

Lecture 4: Diagonalization, The Halting Problem. (Reading 4.2).

Lecture 5: Other Undecidable Problems, PCP. (Reading 5.1, 5.2).

Week 4: Complexity Theory. NP-Completeness theory. Reductions.

Reading: 5.3, 7, 8.1-8.3, 10 (If time allows).

Lecture 1: Reductions: Many-One (Mapping) Reducibility, Rice's Theorem. (Reading: 5.3).

Lecture 2: What is NP? What is NP-Complete? What are reductions? Examples. (Reading: 7).

Lecture 3: What is PSPACE? Savitch's Theorem. (Reading 8.1-8.2).

Lecture 4: PSPACE-Complete Problems. (Reading 8.3).

Lecture 5: Advanced Topics: Alternation, IP. (Reading 10.3-10.4).