Lamar University

COSC 5315, Spring 2004

Foundations of Computer Science

TTH 11:00 AM ∼ 12:15 PM, Maes 111

Instructor: Dr. Chung-Chih Li
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Office Hours: MWF 9:30 ∼ 10:30 AM or by appointment

Course Description and Topics:

This course is designed to give you a general picture of the underlying theory of computation. Topics to be covered extend across three major areas in theoretical computer science, which are Automata, Computability, and Complexity. Since the topics in the three areas form indispensable foundations of computer science from both applicative and theoretical aspects, we therefore believe that a master student majoring in computer science should be familiar with the topics in a certain depth.

Each area puts different emphases on the notion of computation. The theory of automata deals with the relations between formal languages and computing machines, which directly benefits many applications in computer science such as compilers and natural language processing. We will discuss finite state machines and examine a few language families in the standard hierarch of formal language. In particular, we will have a close look at regular languages and context-free languages.

The theory of computability is a century-long study meant to define problems that can be solved by mechanical procedures. The notions and methods used by mathematicians in defining computable problems turned out to be the idea that led to the invention of the modern computer. We will use the Truing Machine as our standard computing formalism to explain the well-known Church-Turing thesis. Then, some important concepts of decidability and reducibility and the recursion theorem will also be introduced.

A theoretical reflection on the study of algorithm analysis gave birth to this relatively new research area called computational complexity theory. A problem that cannot be solved efficiently by the computer in many cases is not because of the lack of programming skill, but because of the inherited nature of the problem. Thus, we need to provide a theoretical framework to characterize computable problems in terms of their "natural difficulties". Some typical complexity classes such as **P**, **NP**, **PSPACE** and **NP**-complete will be introduced. We will also discuss the meaning and impact of the possible solutions to the famous query: whether $\mathbf{P} = \mathbf{NP}$, which is one of the 7 mathematical problems proposed to be solved in this century.

Prerequisites: Discrete Mathematics

Textbook:

Introduction to the Theory of Computation
by Michael Sipser, PWS Publishing Company, 1997.

NOTE: No Xerox copy of the textbook is allowed to bring to the class and tests.

Reference Books:

1. *Models of Computation and Formal Languages*
   by R. Gregory Taylor, Oxford University Express, 1998.
2. *An Introduction to Formal Languages and Automata*
   by Peter Linz, Jones and Bartlett Publishers, 3rd Edition 2000.
3. *Introduction to Automata Theory, Languages and Computation*
   by John E. Hopcroft and Jeffrey D. Ullman, Addison-Wesley Publishing Company, 1979.
4. *Computability, Complexity, and Languages*
   by Martin Davis and Elaine J. Weyuker, Academic Press, 1983.

Tests: (400 points)

Two midterms (100 points for each) and one final (200 points). All tests are open book and accumulative. You will receive 0 point for any absent test. No makeup test will be given. These rules also apply to quizzes.

Tentative dates:

Midterm I	100 points	Feb. 17 (6th week, Tuesday)
Midterm II	100 points	Mar. 23 (11th week, Tuesday)
Final Exam	200 points	May 6 (17th week, Thursday)

NOTE: No early or late final exam will be given for any personal travelling plan.

Pop quizzes: (200 points)

Ten pop quizzes will be given impulsively. Each quiz carries 20 points towards your tally. The coverage of every quiz is also accumulative, including the materials covered in the class right before the quiz. A typical quiz takes about 10 minutes.

Attendance: (50 points)

About ten attendances will be taken randomly. An attendance on a day when the roll is checked contributes 5 points towards the tally. In other words, an absence may cost 5 points if attendance is taken, or cost as many as 20 points if a quiz is given.

Grading Policy: Based on 650 points, your grade will be given according to the following table.

Points	Grade	
$540 \sim 650$	A	Excellent
$420 \sim 539$	B	Good
$300 \sim 419$	C	Satisfactory
$200 \sim 299$	D	Passing
$0 \sim 199$	F	Failure

Academic Honesty:

Cheating, plagiarism, collusion, abuse of resource materials, and their consequences are defined and described under the section of Academic Affairs in the *Student Handbook*.

Students giving away academic works for assignment offered for credit to other students working on the same assignment will be considered as guilty as academic dishonesty, and will receive the same penalty.

Tentative Topics and Schedules for COSC 5315

Week	Topics	Reading
1: Jan. 12	(01/14, semester begins, 01/15 1st class), introduction and mathematical preliminaries	syllabus, chapter 0
2: Jan. 19	(01/19 Monday, MLK's birthday, no class), mathematical preliminaries, finite automata, regular languages	1.1, 1.2
3: Jan. 26	Nondeterminism, regular and non-regular languages, pumping lemma	1.2 ∼ 1.4
4: Feb. 2	Context free languages and pushdown automata	2.1, 2.2
5: Feb. 9	Non-context free languages, pumping lemma, Turing machines	2.3, 3.1, 3.2
6: Feb. 16	**(Midterm 1, 02/17 Tuesday)**, more on Turing machines, Hilbert's problems	3.2, 3.3
7: Feb. 23	Decidability, halting problems and diagonalization	4.1, 4.2
8: Mar. 1	Undecidable problems, Reducibility, many-one reduction	5.1 ∼ 5.3
9: Mar. 8	(Spring break, no class)	6.1 ∼ 6.4
10: Mar. 15	The recursion theorem, Gödel's incompleteness theorem, Turing reduction, Kolmogorov complexity	6.1 ∼ 6.4
11: Mar. 22	**(Midterm 2, 03/23 Tuesday),** Complexity measure, Blum's axioms, complexity classes, asymptotic notations	7.1, 7.2
12: Mar. 29	**P** v.s. **NP**, complete problem, **NP**-completeness	7.3 ∼ 7.5
13: Apr. 5	Space complexity, Savitch's theorem, **PSPACE**, **NPSPACE**, **PSPACE**-completeness, **L** and **NL**, (04/09, Good Friday, no class)	8.1 ∼ 8.6
14: Apr. 12	Intractability, hierarchy theorem, oracle Turing machines, circuite complexity	9.1 ∼ 9.3
15: Apr. 19	Probabilistic algorithms, primality test, alternating Turing machines, polynomial hierarchy	10.1 ∼ 10.3
16: Apr. 27	Interactive proof system, zero-knowledge proof, parallel computation, one-way functions	10.4 ∼ 10.6
17: May 3	**Final Examination, May 6, Thursday, 11:00 AM ∼ 1:30 PM**	