CPSC 450: Theory of Computation

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Fall, 2019

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Office Hours: MTWTh 12:00-1:00pm, or by appointment

Class Hours: TTh 10:10-11:40pm

Office: Trexler 365B

Class Room: Trexler 363

Course Description

This course addresses one of the most fundamental questions in computer science:

Which problems can be solved on a computer?

To answer this question, we will study the following types of computational models:

- **Finite-state automata:** computational models with extremely limited memory. These computational models are equivalent in power to *regular expressions*. (Chapter 1)
- **Pushdown automata:** computational models that have access to a stack data structure. These computational models are equivalent in power to *context-free grammars*. (Chapter 2)
- **Turing machines:** any algorithm can be implemented on a Turing machine according to the *Church-Turing thesis*. We will study the *halting problem* and *undecidability*. Many fundamental algorithmic problems cannot be solved by any computer – no matter how much time is allowed. (Chapters 3-5)
- **Polynomial-time algorithms:** efficient computation. We will study *computational complexity* and *NP-completeness*. We will show that many optimization problems are unlikely to solved efficiently on a computer. (Chapter 7)

Required Materials

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

Prerequisites

CPSC 250, MATH 131.

Course Objectives

Successful students will be able to:

1. determine whether or not a language is regular,
2. determine whether or not a language is context free or not,
3. determine whether or not a language is turning recognizable or not,
4. understand whether or not a language is in NP,
5. understand NP-completeness.

Course Structure

The course will meet in class for 3 hours during the week. In case of scheduling conflicts, makeup tests will be available by pre-arrangement only. Make-ups will also be available in case of documented medical emergencies. There will be two exams, about 10 homework assignments, and a co-curricular requirement. This course expects you to spend at least 12 hours of work each week inside and outside of class.

Co-curricular Requirement: The Mathematics, Computer Science and Physics department offers a series of discussions that appeal to a broad range of interests related to these fields of study. These co-curricular sessions will engage the community to think about ongoing research, novel applications and other issues that face these disciplines. Each student is required to attend at least three of these sessions, and turn in a short paper describing the contents of the session, and his/her critical reflections about the topic and content. **These papers are due in class within a week of the session**. A paper submitted beyond a week from the event being discussed in the paper will NOT be accepted. The MCSP Conversation Series website has the schedule of talks in the series.

Homework: On all assignments, your name must be written clearly as it appears on Inquire. Your homework must be neat and legible, you will lose points for submitting rough work.

Grading Policy

The final grade will be computed based on the following weights:

- **4%**: Co-curricular **56%**: Homework **20%**: Midterm **20%**: Final exam

The final course grade will be calculated as follows:

- **> 92%**: A **90-92%**: A- **86-89%**: B+ **83-85%**: B **80-82%**: B- **76-79%**: C+
- **73-75%**: C **70-72%**: C- **66-69%**: D+ **63-65%**: D **60-62%**: D- **< 60%**: F

Course Policies

During Class

If you use an electronic device such as a tablet or a laptop for note-taking or to read the textbook, the content that is open on the screen should be strictly restricted to documents and pages of relevance to the class. For example, you should not have any social media websites open in your browser window, even if it is in a tab that is not currently in focus.

Phones are prohibited as they are rarely useful for anything in the course. Eating and drinking are allowed in class but please refrain from it affecting the course. Try not to eat your lunch in class as the classes are typically active.

Attendance Policy

Regular attendance in class is highly recommended. Regardless of attendance, students are responsible for all material covered or assigned in class.

Policies on Incomplete Grades and Late Assignments

Late assignments will be accepted for no penalty if a valid excuse is communicated to the instructor before the deadline. **Late assignments will receive no credit.**

Academic Integrity and Honesty

Students are expected to adhere to the Academic Integrity policies of Roanoke College. All work submitted for a grade is to be strictly the work of the student unless otherwise specified by the instructor. The policies as outlined in the Academic Integrity handbook will be enforced in the course.

Graded programs are subject to the Roanoke College Academic Integrity policies. Copying a program or a portion of a program (even a single line) or reading another person's program to obtain ideas for solving a problem is plagiarism. Other examples of integrity violation include writing code for someone else, using code written by someone else, telling someone else how to solve a problem or having someone tell you how to solve a problem (and using his/her method). These cases apply to any work that is handed in for a grade under the instructor's assumption that the work is your own. Unless specified otherwise by the instructor, discussion among students should be limited to general discussion of concepts and language details, not specific aspects of a solution to the assigned problem

Schedule and weekly learning goals

The schedule is tentative and subject to change. The learning goals below should be viewed as the key concepts you should grasp after each week, and also as a study guide before each exam.

Week 1 Regular Languages

- Mathematical Review (Chapter 0)
- Finite Automata (Section 1.1)

Week 2 Regular Languages

- Nondeterminism (Section 1.2)
- Regular Expressions (Section 1.3)

Week 3 Regular Languages

- Regular Expressions (Section 1.3)
- Nonregular Languages (Section 1.4)

Week 4 Context-Free Languages

- Context-Free Languages (Section 2.1)

Week 5 Context-Free Languages

- Pushdown Automata (Section 2.2)
- Non-Context-Free Languages

Midterm: 10:10-11:40, Thursday, October 10

Week 6 Fall Break

Week 7 The Church-Turing Thesis

- Turing Machines (Section 3.1)
- Variants of Truing Machines (Section 3.2)

Week 8 Decidability

- Decidable Languages (Section 4.1)

Week 9 Decidability

- Undecidablity (Section 4.2)

Week 10 Reducibility

- Undecibable Problems from Language Theory (Section 5.1)
- Mapping Reducibility

Week 11 P & NP

- Measuring Complexity (Section 7.1)
- The Class P (Section 7.2)
- The Class NP (Section 7.3)

Week 12-13 P & NP

- NP-Completeness (Section 7.4)
- Additional NP-Complete Problems (Section 7.5) **Final: 8:30-11:30, Thursday, December, 12**