CSC 341: Automata, Formal Languages, and Computational Complexity

Fall 2018

Department of Computer Science
Grinnell College

I. Instructor

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II. Class

- CSCI 341: MWF (1:00 PM - 1:50 PM) Room #Noyce-1245

III. Textbook

Introduction to the Theory of Computation, third edition, Michael Sipser.
CENGAGE Learning. ISBN-13: 978-1-133-18779-0, ISBN-10: 1-133-18779-X.

IV. Prerequisite

CSC 207 and either MAT 218, CSC 208 or MAT 208.

V. Course Overview

In your journey through computation, you likely have noticed that many problems can be solved with the same solution through a skill you have honed called abstraction. Through this process, you may have noticed more nuanced connections between problems. Some problems require some translation before being solved using the solution to another problem. Some problems are immune this sort of transformation and feel fundamentally more difficult than others. Some problems feel downright impossible: are they actually impossible?

In this course, we study the theory of computation where we use mathematics to model problems of increasing complexity and study their relationships with each other. Although some applications may be discussed from time to time, this course will emphasize the formal underpinnings and theory of computer science.

By going through this modeling process, we can:

- Deeply understand a problem and its potential corner cases.
- Prove properties of a problem, e.g., the correctness of potential solutions or whether said problem has a solution at all.

- Reduce one problem to others of similar complexity.
- Categorize this problem as easier or harder than other problems in a precise way.

By the end of the course, we will explore the limits of computation.

- Are there problems that are intractable in practice?
- Are there problems that can provably never have a solution?

After this course, you will be able to:

- Manipulate and reason about mathematical definitions like computer programs.
- Model problems using mathematics and use these models to perform the techniques described above.
- Understand when a problem is intractable or undecidable.

VI. Communication

Course website You will find the course website here: http://www.cs.grinnell.edu/~hamidfah/courses/csc341fall2018/. The website will give you the detailed schedule of the class. I may need to update it from time to time.

Pioneerweb We will use the pioneer-web system for submitting homework and keeping track of your grades. A course account (CSC-341-01) is created and you all are added to it. You will find the course materials (syllabus, lecture notes, homework problems, etc.) posted in this account.

Email You are encouraged to email me if you need to set up a meeting beyond the dedicated office hours. You are also welcome to ask any question through email. I will try to get back to you within next 24 hours. If your question is of interest to others in the class, we can discuss it in the class or I can send a message to all using the pioneerweb course account.

VII. Activities

Readings For every day of class, I will give you a short reading to prepare you for the topic-of-the-day. You are expected to finish this reading before class begins.

Class Meetings Most of our class meetings will feature in-class activities, e.g., discussion and group exercises, designed to help you play and explore the various mathematical definitions we study in this course.

Homework The bulk of your practice comes from the weekly homework which contain problems that test your knowledge of the material as well as give you the opportunity to apply your knowledge to in different contexts. We will accept typed as well as hand-written submissions. If hand-written, scan your work, compile it as a single pdf (or any sort of image file) and upload on the pioneer-web course account.

Class Presentation By 11/14/2018, you will form a group of two (your choice) and pick an NP-Complete problem to study. You will have to notify me as each group should work on different problems. We will dedicate two classes (12/03 and 12/05) when you will be presenting the problem that you and your group member studied.

Exams Finally, to ensure that you have adequately mastered the core concepts of the class, I will conduct two in-class examinations as well as a final.

VIII. Attendance

Attendance at all lectures is expected. While attendance won't always be taken, instructors appreciate knowing why students are absent. If you miss a class for some personal reason/sickness, please send me a quick note. Also, please let me know in advance of planned absences. Note that regularly missing class is one of the potential special circumstances that could lead to a discretionary reduction in grade.

IX. Homework Submission Policy

All assigned work is due on the date and at the time specified. For homework, we will use a late day policy to help you manage your work load throughout the semester. This policy works as follows:

- You have six late days to use in the semester.
- You may use one late day to turn in one homework up to 24 hours after the due date, no questions asked.
- You do not need to tell us that you are using a late day.
- Late days are automatically noted and tracked by the instructor.
- You may use up to two late days on a given homework.
- If you are working in a group, each member must use a late day in order to extend the deadline by 24 hours.
- As homework may be handwritten, exceptions will not be granted for computer system malfunctions.
- The lowest grade in homework will be dropped. For example, if you miss one homework and you are past due date, then you get a zero in that homework. But it will be dropped at the end of the semester.

Beyond late days, homework may not be turned in after the due date. This is a strict policy in order to help us get your feedback to you in a timely manner. Only the most exceptional of circumstances discussed well in advance with the instructor (as much as the situation allows) will be entertained. In case of medical emergencies, written medical excuses from a medical practitioner (or a responsible person from student affairs) may be grounds for granting an extension.

X. Grading Policy

My goal in the course is for everyone to be proficient in the big concepts outlined in the Overview. While this is a lot of content, I firmly believe that everyone is capable of mastering this material — earning an A in the process-with enough time, dedication, and proper study skills. My initial plan is to start with the following breakdown:

- Homework: 40%
- Hour Tests: 30%
- Class Presentation: 10%
- Final Exam: 20%

Percentages may be adjusted upwards or downwards at the discretion of the instructor.

XI. Grading Scale

We will use the following scale to determine your final grade in the course:

- A: 93-100%
- A-: 90-93%
- B+: 86-90%
- B: 82-86%
- B-: 78-82%
- C+: 74-78%
- C: 68-74%
- D: 55-68%
- F: 0-55%

If you obtain the (weighted) percentages of points listed above, you are guaranteed at least the corresponding grade.

XII. Access Statement

If you have specific physical, psychiatric, or learning disabilities and require accommodations, please let me know early in the semester so that your learning needs may be appropriately met. Note that you will also need to provide documentation of your disability to the Dean for Student Academic Support and Advising, Autumn Wilke, located on the 3rd floor of the Rosenfield Center (x3702).

XIII. Academic Responsibility

Students are expected to read and abide by the principles clearly explained in the Student Handbook. When in doubt, talk to your professor.

XIV. Academic Honesty

All academic work at Grinnell College must follow standard academic practice regarding quotation, paraphrase, and citation. Grinnell's Student Handbook provides basic guidelines.

Homework: Homework exercises should be entirely your own individual work, not done in collaboration with other students in the class, and not quoted or paraphrased, in whole or in part, from external sources. [Note: Although the Web can be useful for reference, much material on the Web is of poor quality. You are responsible for the quality of what you turn in, regardless of the source of the material.]

Class Participation: In many sessions of the class, we will prepare solutions or partial solutions to certain problems taken from the textbook, to be discussed in class rather than to be written up and submitted for credit. The constraint mentioned in the preceding paragraph does not apply to these problems.

Group Presentation: If a group of two or three people work together on a presentation, the group should turn in one written report, and all names in the group must appear at the top of the first page. A sample template will be provided later for the written report.

Plagiarism: If I encounter clear indications of plagiarism or academic dishonesty, the Committee on Academic Standing with deal with them. I will impose penalties for academic dishonesty only as directed by the committee.

XV. Exams

There will be two one-hour exams and a comprehensive final. The one-hour exams will be **Friday 05 October** and **Monday 05 November**. The final examination will be on **Thursday December 20 (2:00 pm - 5:00 pm)**.

Missing exams because of illness will require an excuse from a medical practioner. Make-up exams for excuses other than illness will be given only in extraordinary circumstances and only at the discretion of the instructor. If you expect that you will need a make-up exam, contact your lecture instructor at least one week in advance. All the exams will be closed-book unless I decide it to be otherwise.

XVI. Tentative Schedule

Weeks	Topic	Reading	Assignments
8/31	Introduction & Preliminaries		
9/03	Proofs/Proof Techniques	Sipser 0.1-0.4	
9/05	Proofs (Cont..)		
9/07	Deterministic Finite Automata	Sipser 1.1	Assignment 01
9/10	Nondeterministic Finite Automata	Sipser 1.2	
9/12	Finite Automata (Cont...)		
9/14	Regular Expressions	Sipser 1.3	Assignment 02
9/17	Nonregular Languages	Sipser 1.4	
9/19	Context Free Grammar	Sipser 2.1	
9/21	Context Free Grammar (Cont...)		Assignment 03
9/24	Context Free Languages	Sipser 2.2 - 2.3	
9/26	Turing Machines	Sipser 3.1	
9/28	Turing Machines (Cont...)		Assignment 04
10/01	Turing Machine Variants	Sipser 3.2	
10/03	Pause for breath		
10/05	**Hour-Exam 01**		
10/08	Algorithms	Sipser 3.3	
10/10	Decidability	Sipser 4.1	
10/12	Undecidability	Sipser 4.2	Assignment 05
10/15	The Halting Problem		
10/17	Turing-Recognizable Languages		
10/19	Recursion Theorem	Sipser 6.1	
10/22	Fall Break		
10/24	Fall Break		
10/26	Fall Break		
10/29	Reducibility	Sipser 5.1 - 5.2	
10/31	Mapping Reducibility	Sipser 5.3	Assignment 06
11/02	Review (so far ...)		
11/05	**Hour-Exam 02**		
11/07	Measuring Complexity	Section 7.1	
11/09	Class P	Sipser 7.2	

Weeks	Topic	Reading	Assignments
11/12	Class NP	Sipser 7.3	
11/14	NP-Completeness	Sipser 7.4	
11/16	NP-Complete Problems	Sipser 7.5	Assignment 07
11/19	Pause for breath		
11/21	Number Theory		
11/23	**Thanksgiving Break**		
11/26	Cryptography	Sipser 10.6	
11/28	Cryptography		Assignment 08
11/30	PSPACE & Savitch's Theorem	Sipser 8.1 - 8.3	
12/03	Class Presentations on NP-Complete Problems		Assignment 09
12/05	Class Presentations on NP-Complete Problems		(class presentation)
12/07	PSPACE Completeness	Sipser 8.4	
12/10	Open Problems in Automata Theory		
12/12	Review		
12/14	Review		
12/20	**Final Exam**		

XVII. More ...

Syllabus This syllabus may be modified as the course progresses. Notice of such changes will be announced in class or through course website.

Talk I will be delighted to talk to you about anything related to the course. Feel free to email me or stop by my office.

Have a Great Semester!