CSC381: Theory of Computation (Revised for Online Meeting)

Dr. Robert Lowe

Spring (March 30 – May), 2020

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Office Phone: N/A
Office Hours:
MWF 1:00PM – 2:00PM
TR 3:00PM – 4:00PM
Synchronous Hour: F 11:00 – 11:50
Office: Zoom Room (See Blackboard)
Primary Contact Point: The Tartan

Syllabus Revisions

Normally, a syllabus cannot be revised in any substantial way. Schedules and activities may adjust, but the overall layout of a course should be settled by the first day of classes. This semester, however, is anything but normal. We are shifting from a traditional in-person class format to an online course for our final few weeks of this semester. As such, this requires a more substantial change to the syllabus. This document contains the revised format of the class. Grading and expectations for the period prior to March 30, 2020 remain in full force. The grading categories will not change, but the requirements to receive credit from this time forward will change. The end result is a hybrid course that met in person for the most of the semester and is now online.

Please read this syllabus carefully. This document specifies how we will proceed for the remainder of the semester.

Course Description

A study of theoretical models of computing, including finite state machines, pushdown automata, context-free grammars, and Turing machines. The concepts of decidability, complexity theory, and NP-Completeness will be studied in depth.

Required Materials

- Various papers, which will be distributed in class.

Prerequisites

- CSC2310 Discrete Structures
- Courage

Course Goals

The big-picture goal of this course is for you to become well acquainted with abstract mathematical literature and learn how to treat mathematics as a participatory subject. We will be reading the papers which started our field, and along the way we will cultivate an appreciation for the literature, and we will also learn about the authors of these papers.

A successful student will:

1. Gain an appreciation for mathematical literature.
2. Learn to see the beauty of a well formed proof.
3. Learn to write beautiful proofs yourself.
4. Classify problems into decidable and undecidable problems.
5. Understand how computational theory relates to mathematics, the universe, and human beings.
6. Get a taste of the peer-review process.
7. Understand the underlying theory of computation.
8. View computer science as a mathematical discipline.
9. Realize that mathematicians are not divine beings who hand wisdom down from on high.
10. Learn to participate in making mathematical discoveries.

The more ambitious among you may even try to produce publishable results.

Course Structure

Methods of Instruction

Synchronous Instruction

Synchronous instruction activities are activities where the entire class meets at the same time and performs the activity together. This is, of course, difficult in an online environment. We will therefore rely more on asynchronous activities, which are outlined in the next section. However, synchronous instruction is needed because it affords you with the best ability to ask questions, and it gives me the best feed back and discussions. **We will have one weekly synchronous session**

during our normal class time (11:00 – 11:50) every Friday, beginning April 3. These sessions will take place via Zoom. With the exception of the final presentations, these sessions will likely be shorter than a normal class period. Synchronous activities will include:

- Weekly discussions of the readings
- Online Presentations (During the final exam period.)

Asynchronous Instruction

Asynchronous instruction is what makes online learning desirable to so many students! However, it is also the biggest disadvantage. These are course materials which will be posted online, which you can explore at your own pace on your own schedule. That last bit is the key, for if you do not schedule time to actually avail yourself of these things, you will not look at them and you will perform poorly on the final portion of the course. My recommendation is to use these during the normal class periods, and to help you along I have strict due dates on completing asynchronous activities. These activities and materials include:

- Assigned Readings
- Brief Recorded Lectures (introducing and highlighting elements of the papers)
- Homework Assignments
- Online Discussion via Tartan Forums

Grading

Let A be a sequence $A = \langle \epsilon, \Sigma, \alpha, \phi, \rho, \sigma \rangle$ where

- $\epsilon :=$ Sequence of grades $\langle \epsilon_1, \epsilon_2, \ldots, \epsilon_{|\epsilon|} \rangle$ pertaining to grades on easy problems
- $\Sigma :=$ Sequence of grades $\langle \Sigma_1, \Sigma_2, \ldots, \Sigma_{|\Sigma|} \rangle$ pertaining to grades on harder problems
- $\alpha := \dfrac{|\epsilon| + |\Sigma| + |X|}{|P|}$ where X is a set of attempted but not solved problems and P is the set of all problems presented to the class.
- $\phi :=$ A sequence of grades $\langle \phi_1, \phi_2 \rangle$ pertaining to two peer reviewed papers
- $\rho :=$ The set of all contributions made to the class, either through posing problems, peer review, or discussion.
- $\sigma :=$ Is the grade of your final research presentation.

We define a function $g : A \mapsto x \in \mathbb{R} | 0 \leq x \leq 1$. Futhermore, we construct a Turing machine Z_g which computes the function g.

In order to arrive at the sought after function, Z_g first computes A' where $A' = \langle e, s, \alpha, p, f, r, \sigma \rangle$ where each $x \in A'$ corresponds to the like term in A, and where every $x \in A'$ satisfies the constraints $x \in \mathbb{R} | 0 \leq x \leq 1$. The simplest of these transformations are α and σ, which are simply a

direct transcriptions from A. The transformations for e, s, f are accomplished through simple averaging of their corresponding sequences. This leaves the computation of p and r. Unfortunately, these mappings require a qualitative analysis which is not readily obtainable via conventional means due to the ambiguity of its definition and must be approximated by a stochastic process (your professor). Of course, this establishes that your grades are not strictly computable, and the proceeding can only therefore be an approximation of g, but as it is the best we can do we must proceed! Having established that Z_g cannot exist, we replace it with $\hat{Z}_g$ which approximates g via the means described above and with the addition of the approximate terms.

Having approximated A', we introduce $W = \langle 10, 20, 10, 30, 10, 20 \rangle$. Because W is a sequence of constants, it may be encoded into the internal configuration of $\hat{Z}_g$. The final computation in this approximation is performed by arithmetic and is well defined as:

$$\frac{\sum_{i=1}^{7} A'_i W_i}{100}$$

The real number obtained by this computation will be converted into one of the arbitrary elements in the grade alphabet using the well-known method.

Remaining Schedule

This is the tentative schedule for the remainder of our course. Papers are introduced on the days bearing their full title, and discussions follow.

March 30 – May 2020

Su	Mo	Tu	We	Th	Fr	Sa
29	30	31	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	1	2
3	4	5	6	7	8	9

- **March 30 – April 3**
  - Read all of *Three Models for the Description of Language* by Noam Chomsky
  - Read the first section of *On Certain Formal Properties of Grammars* by Noam Chomsky
  - Video: Introduction to Languages and Computability
  - **Synchronous Discussion April 3 –** Chomsky's Theory of Languages
  - **Final Version of Peer Review Paper 1 is Due April 3**
  - **Homework**: Church Turing Problem Set *(Due April 10)*
- **April 6 – April 10**
  - Read the rest of *On Certain Formal Properties of Grammars* by Noam Chomsky

  - Video: Chomsky Hierarchy
  - Video: Language, Complexity, and Proof
  - **Homework:** Computational Languages Problem Set *(Due April 17)*
  - **Synchronous Discussion April 10 –** Computation and Language

- **April 13 – April 17**
  - Read *The Complexity of Theorem-Proving Procedures* by Stephen Cook
  - Read *Universal Sequential Search Problems* by Leonid Levin
  - Video: The Cook-Levin Theorem
  - Video: Exploring NP Problems
  - **Homework:** NP-Complete and Universal Limit Problems *(Due April 29)*
  - **Peer Review Paper Number 2 is Due April 17**
  - **Synchronous Discussion April 17 –** Computation and NP-Completeness

- **April 20 – April 24**
  - Video: More NP-Complete Problems
  - Video: Other Complexity Classes
  - **Synchronous Discussion April 24 –** NP-Complete Problems
  - **Peer Reviews Due April 24**

- **April 27 – April 29**
  - Video: Sub-Turing and Super-Turing Computation
  - **Synchronous Discussion April 29** – Universal Limits on Knowledge
  - **Final Version Peer Review Paper Number 2 Due May 1**

- **May 5, 2020 Synchronous Session**– Final Presentations 9:00 AM – 11:00 AM

Course Policies

Late Policy

No late work will be accepted under any circumstances (except as mercy and decency may dictate in extremely rare events).

Extra Credit

No extra credit will be given under any circumstances.

Excused Absences

In some cases, absences may be excused. These include:

- School Sanctioned Events (Sports, Concerts, etc.)
- Severe Illness
- Family Emergencies
- Court Appearance / Jury Duty

In the case of a school event, notice must be given at least one week prior to the absence. The notice must include a signed note from the faculty or staff member in charge of the event. This note must be given in physical form, electronic notes will not be accepted. In the case of illness, a doctor's note is required. Note that except in extreme circumstances, doctor's appointments do not qualify as a valid reason to miss a class. Please be respectful of the other students, and schedule appointments during your free time.

Family emergencies will require some form of proof. Where possible, you must give advance notice of missing a class. The exception to this would need to be fairly severe, and hopefully it will not come up. For court appearances and/or jury duty, you must provide a copy of your summons. You may redact any details you wish, save for the actual date and time of your appearance. Court appearances must be cleared at least one week in advance.

Communication and Extra Help

You are always welcome at office hours for help with any questions you may have about the course. For help at other times during the day, stop by or call my office to see if I'm available. You can also contact me by email, but often I can better help you face to face and may respond with a request that you come to see me. Note that I do not typically respond to email between 5 p.m. and 8 a.m. You may make appointments to see me at other times if your schedule does not permit you to attend my office hours.

Plagiarism and Cheating

You are expected to do your own work. Never submit the work of others, never give unauthorized assistance to others, do not use unauthorized aids during exams, and do not ask for help from other faculty members without the approval of your professor. Plagiarism and cheating are serious offenses that will not be tolerated. Explanations regarding these offenses and how they are handled can be found in the MC Student Handbook at
https://www.maryvillecollege.edu/academics/catalog/handbook/section-nine/.
You are expected to read and understand these policies. Offenses on specific assignments, quizzes, or exams will result in a score of 0 on the relevant assignment, and a letter of censure will be placed in your college file. Repeat offenses will result in further disciplinary action, including the possibility of failing the course.

Students with Disabilities

Any student who feels s/he may need learning or physical accommodation(s) based on the impact of a disability should contact Services for Students with Disabilities to discuss your specific needs. Please contact 981-8124 to coordinate reasonable accommodations for students with documented disabilities. The Disability Services office is located in the Learning Center in the basement of Thaw Hall. Undocumented disabilities will not be accommodated.