CSCI 341: Theory of Computation
Syllabus

Prof. Edward Talmage

Fall 2024
Note that this syllabus is subject to change.

Course Information

Instructor: Edward Talmage

- Office Hours (Dana 329): Monday 10AM-12PM, Wednesday, 9:30-11:30AM,3-4:30PM, Thursday 10:30-11:30AM, or by appointment.
- Email: [first].[last] [at] bucknell.edu

  Please include the text "CSCI 341" in the subject line, as well as a title indicating the email's subject. Example: "CSCI 341: DFA Initial States".
- Discord: etalmage (Prof. Talmage)

Schedule:

- Lecture: Monday, Wednesday, Friday, 2-2:50PM, Dana 227
- Recitation: Thursday, 3-3:50PM, Dana 303

Textbook: I recommend the 3rd edition of Sipser's text, as the most up-to-date version, but I don't anticipate activities which distinguish between the two. You do *not* need both editions.

- *Introduction to the Theory of Computation, 3rd Edition*, Sipser, CEngage 2013, ISBN 9781133187790
- *Introduction to the Theory of Computation, 2nd Edition*, Sipser, CEngage 2006, ISBN 9780534950972
- *Book of Proof, 3rd Edition*, Hammack, ISBN 978-0-9894721-2-8/978-0-9894721-3-5, `https://richardhammack.github.io/BookOfProof/`
  - This is an **optional** resource, but may be very useful if you are not super comfortable with proofs.
  - This book is available in print, or freely from the author's website, linked above.

Course Goals: This course considers the meaning of computation by exploring how we model computation mathematically. We will explore how these formal models allow us to conclusively prove results relating to the computability of different problems, and how these techniques can be applied to various practical problems in Computer Science.

After taking this course, you will be able to approach a new problem and determine what, if any, type of computing device is necessary and sufficient to compute it. You will then be able to describe how to construct such a computing device. Finally, you will also be able to analyze an existing computing machine to determine what problem it solves.

The course's specific learning goals are to be able to

- construct finite automata, regular expressions, and context-free grammars,

- analyze finite automata, regular expression, and context-free grammars,
- determine whether a problem is solvable, and
- determine whether a problem is efficiently solvable.

In addition, you will develop skills in presenting solutions to problems, particularly typesetting in LaTeX.

Tools: We will use the following online systems for this course:

- **Course Webpage**: `https://csci.courses.bucknell.edu/341/csci-341-fall-24` I will post course resources (syllabus, notes, etc.) here.
- **Moodle**: Learning Management System: `moodle.bucknell.edu`. I will post assignments (homeworks, recitations) here.
- **Gradescope**: Assignment submission and grading system. Using gradescope makes grading *vastly* more manageable for me. You'll submit assignments and take quizzes here. `gradescope.com`. Your login will be your Bucknell email, and you should go to `https://gradescope.com/reset_password` initially to set up your password if you have not used gradescope before.
- **Overleaf** [optional]: Online, collaborative LaTeX editor. `overleaf.com` I recommend you use this for writing documents (e.g. hw solutions) for this class, as you can collaborate with a group and give me access to your code for debugging.
- **Discord** [optional]: Online chat client, freely available at `https://discordapp.com/`. This is one way to reach me and connect with other students in the department.

Class Culture: Having stated the course's learning goals, I want to clarify that the intent of this class is for every student to achieve them all. To that end, this class is a shared effort. I commit to working with you to help you achieve the course's learning goals. But I am also learning from you, whether new approaches to a solution or the limitations of my personal style and perspectives. Similarly, you are here to help each other learn. Every member of the class has a contribution, whether because you grasp something quickly or, more often, when you don't. I expect you to support every one of your classmates, both in assigned groups and informally. Seek out opportunities to help and be helped by your classmates. While I would be the first to feel awkward reaching out to someone I don't know, in this class you are invited and expected to form connections with every member.

Every human is inherently valuable, and I expect you to treat all others, in this course and outside in light of that reality. There are many aspects of our lives, both small enough to hardly notice and large enough we don't recognize them as abnormal, with which we put others down and treat than as valueless. As part of our education, we need to practice being cognizant of the effects our words, actions, and inactions have on those around us, both directly and indirectly. This is hard, but we can teach each other. If you feel I have offended or mistreated you, I promise to listen to your concern and do my best to correct it. I expect you to extend similar grace to each other, and ask that you seek to improve yourself and your classmates. Remember, gentleness and humility go a long way!

Health Concerns: If you are sick, please **do not attend class**. When you miss class, you are expected to communicate with me to answer any questions you may have and ensure you have a complete understanding.

The question will naturally arise: "How sick is too sick to come to class?" This is not an easy question to answer and you will need to use your best judgement, but I encoursage you to err on the side of safety. At a minimum, if you have a fever ($\geq 100^\circ$ F), please do not attend. If you have a minor illness, please wait until you have been fever-free for 24 hours before returning to in-person class (`https://www.cdc.gov/flu/business/stay-home-when-sick.htm`). If you are missing class because you are ill, please notify me by email as soon as is reasonably possible.

A single person's actions and decisions may have small or no consequences for themselves, but may cause immeasurable harm to others in our community. Please, be safe and care even more for those around you than for yourself.

Assignments: Their Purpose and Grading:

- Problem Sets (15% of course grade): Weekly. Exercise and develop a deep understanding of the material and your problem-solving skills. **Submissions must be typeset with LaTeX**.
- Quizzes (15% of course grade): Weekly. Validate your understanding of definitions and basic concepts. If you miss a question, you will have a chance to make it up the next week.
- Exams (15/15/20% of course grade): Two "midterm" exams, one final. Cumulative evaluation of your total comprehension of the material.
- Participation (10% of course grade): Class discussion, group exercise, demonstrating solutions to in-class problems, etc. Be **actively** engaged, in the classroom, in office hours, and/or in other discussions.
- Recitations (10% of course grade): Interactive and group work to reinforce understanding and explore applications.

Participation: Merely showing up to class does *not* count as full participation. You do not need to speak in every class, but you should regularly ask or answer a question, make an observation, participate in discussion, etc. You are required to participate in classroom activities.

Homework Format: Solutions must be typeset in LaTeX and uploaded as a PDF to gradescope. If you are unfamiliar with LaTeX, please see the resources on moodle and ask the professor for help.

Cooperation: No cooperation or communication of any sort is allowed on quizzes or exams. Cooperation on problem sets is permitted, but you should first attempt to solve them on your own, as that gives the greatest value. The harder you work to solve the problem, the more you will learn. You should never see anyone outside your group's final writeup, nor show yours to anyone outside your group, before submitting the assignment. Your writeup should come from your own head and reflect your understanding. Do not write from someone else's notes or dictation.

When you have worked with other students, provide detailed citations (by footnote, highlighting, etc.) of what ideas came from others, and from whom they came. The LaTeX `\footnote{}` command will serve you well.

You may look up **definitions of terms** online, though you are are almost guaranteed to be better served by using the textbook or asking the professor. You *may not* ever look up a problem's solution online.

Late Policy: Problem sets will lose 10% per 24 hours, rounded up, that pass after the due date. If you will be turning in an assignment late, you MUST email me before the due date to inform me it will be late. Quizzes may not be submitted late.

If you have a conflict with an exam, please inform me at the beginning of the semester and remind me at least one week in advance. There is no guarantee that you will be able to make up an exam missed without prior permission.

Quizzes: There will be weekly quizzes (except during exam weeks). A quiz will typically have four questions, on topics from lecture that week. The following week, in addition to a new quiz on the new material, there will be an opportunity to retake any missed quiz questions. Retake *only* those questions you got wrong on the original quiz. For example, if in Quiz 3 you get questions 1 and 4 correct, but 2 and 3 incorrect, then complete questions 2 and 3 in Quiz 3 - Retake, leaving questions 1 and 4 blank. Each of the four questions is worth the same amount on the original and retake quiz, so utilize the feedback to re-study any topics you got wrong and get the points on the retake. There is historically a very strong correlation between quiz grades (particularly retake grades) and final grades.

Accommodations:

If you need accommodations for any form of disability, please speak to Bucknell's Office of Accessibility Resources (OAR) **first**, and then **also** the instructor ASAP so that we can provide appropriate accommodations. We want to provide the best learning environment possible for every student, but need your input to know how best to do so. If you need a schedule adjustment for religious observance, athletic competition, etc., please speak to me ASAP to work that out.

Tentative Schedule

Topics: This is an approximate list of the topics for the semester and the order in which I intend we will progress through them. This **will** change without further notice depending on the pacing of class.

- Math Review: Sets, functions, graphs, strings, logic, proofs
- Deterministic and Non-Deterministic Finite Automata
- Regular Expressions
- Context-Free Languages and Grammars
- Pushdown Automata
- Turing Machines
- Decidability and reductions
- Complexity Classes
- Space Complexity

#	Date	Topic	Chapters	Notes
1	8/26	Introduction & Math Review	0	
2	9/2	Finish Review, DFAs	1.1	
3	9/9	DFA Closure,NFAs	1.2	
4	9/16	NFA-DFA Equiv., RegEx	1.3	
5	9/23	Pumping Lemma for Regular Languages	1.4	
6	9/30	CFLs, CFGs	2.1	Exam 1 Monday
7	10/7	Pushdown Automata	2.2	
8	10/14	Pumping CFLs	2.3	Fall Break Mon, Prof. Meng Wed-Fri
9	10/21	Turing Machines	3.1-2	
10	10/28	Decidability	4	
11	11/4	Reductions	5	Exam 2 Monday
12	11/11	Undecidability, Complexity	7.1-3	
13	11/18	Poly-Time Reductions	7.4	
14	11/25	—NO CLASS—	—	Thanksgiving Break
15	12/2	NP-Complete Problems	7.4-5	Topic dependent on progress
16	12/9	Space Complexity	8.1-3	Topic dependent on progress