CS 4510B Syllabus (8/22/22)

Automata and Complexity, 3 Credits
TR, 3:30-4:45pm, Paper Tricentennial 109 (Zoom ID: 935 7991 8859, Code: 101635)

Instructor Information
Instructor: Joseph Jaeger (he/him)  
Email: josephjaeger+4510@gatech.edu

Teaching Assistants
Jesse Corzine  
Email: jcorzine3@gatech.edu
Hamna Khan  
Email: hamna@gatech.edu
Harshvardhan Maheshwari  
Email: hmaheshwari31@gatech.edu
Rohith Sudheer  
Email: rsudheer3@gatech.edu
Jiahao Sun  
Email: jiahaosun@gatech.edu
Ziteng Yang  
Email: ziteng.yang+4510@gatech.edu

Office hours will start the second week of classes. We will announce their times and locations soon and update the syllabus to reflect this. We strongly encourage the use of “4510” in subject lines when emailing course instructors.

General Information

Description
This course serves as an introduction to the fascinating world of Theoretical Computer Science. We will discuss various models of computing and classify problems by the strength of the model needed to solve them (if possible; some problems are too difficult for any computer!).

Pre-Requisites
The single most important prerequisite for this course is CS2050 Intro to Discrete Math or similar. (Technically I think it is a prerequisite for one of the prerequisites.) This is a math course! We expect you to be comfortable with mathematical notation as well as with reading and understanding proofs and then writing your own in clear and thorough language.
If you want to refresh your mathematical knowledge, we suggest reading chapter 0 of the textbook.

Course Goals and Learning Outcomes

By the end of the course, you should be able to:

- Design and manipulate deterministic and nondeterministic finite automata and regular expressions, convert between them, and use them to prove that a language is regular
- Design and manipulate pushdown automata and context-free grammars, convert between them, and use them to prove that a language is context-free
- Use the appropriate pumping lemma to prove that a language is not regular/context-free
- Design Turing machines and use them to prove that a language is decidable
- Use reductions from undecidable problems to show that a language is undecidable
- Use reductions from NP-complete problems to show that a problem is NP-complete
- Understand the implications that NP-complete problems have for secure computing
- Analyze the time and space complexity of a decision problem
Course Requirements & Grading

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Date</th>
<th>Weight</th>
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</thead>
<tbody>
<tr>
<td>Homework</td>
<td>Weekly (Thursdays)</td>
<td>40%</td>
</tr>
<tr>
<td>Exams (x3)</td>
<td>9/20, 10/25, 12/13</td>
<td>60% (15% + 20% + 25%)</td>
</tr>
</tbody>
</table>

Homework policies

Homework assignments will typically be weekly, released on Thursday and due the following Thursday. We expect ~10 homework assignments and will replace your lowest homework grade with your highest homework grade. You may collaborate with your classmates, but all written work should be your own. Write the names of the students you collaborate with at the top of your assignment.

For homework assignments submitted on time, there is a ~3% extra credit bonus! However, sometimes life gets in the way, and that’s okay. You may submit your homework one day late for no penalty, or two days late with a ~10% penalty. Submissions more than two days after the deadline will NOT be graded.

Exams

There will be three exams, two midterms and one final. The “final” exam is not cumulative; it is effectively just a third midterm. Of the three exams, your lowest scoring exam will count for 15% of your final grade, your highest scoring exam will count for 25% of your final grade, and your remaining exam will count for 20%.

Piazza Extra Credit

You can earn up to 2% extra credit on each exam by asking and answering questions on Piazza!

Therefore, to get the full 2%, you may ask one question and answer another, or you may answer two questions. For your question to count, it must be about the course material. (“When is homework 3 due?” doesn’t count.) Try not to repeat questions asked by other students.

For your answer to count, provide a succinct but thorough answer or elaborate on the answer of another student. In other words, an “answer” can either be a direct answer to a question or discussion of another student’s answer. This can either be in the “Student Answer” section or in the comment section underneath. (Your answer should involve some amount of explanation: just saying “Yes” or “12” doesn’t count. Repeating the answer of another student, re-answering a question that has already been answered without providing any new information, or editing another student’s answer doesn’t count.)

In either case, the deadline to ask or answer is the day BEFORE the exam. After the exam, send me an email with the screenshots of your contributions including your name; this email must contain [Exam X Extra Credit] in the title, including the brackets but replacing the X by 1, 2, or 3 as appropriate. Ex. [Exam 1 Extra Credit]

Grading Scale

Your final grade will be assigned as a letter grade according to the following scale:

- A 90-100%
- B 80-89%
- C 70-79%
- D 60-69%
- F 0-59%

We reserve the right to round or not at our discretion, on a student-by-student basis. If we recognize you as someone who is active in class (by participating in lecture, generating discussion on Piazza, coming to office hours, etc.), we are significantly more likely to round up.
Make-up Exams

If you have an institute-approved absence, you may request a make-up exam. As such things are typically scheduled well in advance, please do not wait until the last minute to request a make-up exam.

Tentative Schedule

<table>
<thead>
<tr>
<th>Date/Topic</th>
<th>Lec. Notes</th>
<th>Homeworks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 23, T: Intro to DFAs</td>
<td>Lec. 1</td>
<td></td>
</tr>
<tr>
<td>Aug. 25, R: DFAs, cont.</td>
<td>Lec. 2</td>
<td>HW1 out</td>
</tr>
<tr>
<td>Aug 30, T: Nondeterminism</td>
<td>Lec. 3</td>
<td></td>
</tr>
<tr>
<td>Sept. 1, R: Nondeterminism cont.</td>
<td>Lec. 4</td>
<td>HW2 out, HW1 due</td>
</tr>
<tr>
<td>Sept. 6, T: Regular Expressions</td>
<td>Lec. 5</td>
<td></td>
</tr>
<tr>
<td>Sept. 8, R: Pumping Lemma</td>
<td>Lec. 6</td>
<td>HW3 out, HW2 due, Practice exam out</td>
</tr>
<tr>
<td>Sept: 13, T: Pumping Lemma cont.</td>
<td></td>
<td></td>
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<tr>
<td>Sept. 15, R: Review for exam 1</td>
<td>-</td>
<td>HW3 due, Discuss practice exam</td>
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<tr>
<td>Sept. 20, T: Exam 1</td>
<td>-</td>
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<tr>
<td>Sept. 22, R: Intro to Context-Free Grammars (CFGs)</td>
<td>Lec. 7</td>
<td></td>
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<tr>
<td>Sept. 27, T: CFGs cont., Ambiguity, CNF</td>
<td>Lec. 8</td>
<td></td>
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<tr>
<td>Sept. 29, R: Pushdown Automata (PDA)</td>
<td>Lec. 9</td>
<td>HW4 out</td>
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<tr>
<td>Oct. 4, T: PDA cont., Equivalence of PDA and CFG</td>
<td>Lec. 11</td>
<td></td>
</tr>
<tr>
<td>Oct. 6, R: Context-Free Pumping Lemma</td>
<td>Lec. 10</td>
<td>HW5 out, HW4 due</td>
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<tr>
<td>Oct. 11, T: TBD</td>
<td></td>
<td></td>
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<tr>
<td>Oct. 13, R: TBD</td>
<td></td>
<td>HW5 due, Practice exam out</td>
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<tr>
<td>Oct. 18, T: ---Fall Break---</td>
<td>-</td>
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<tr>
<td>Oct. 20, R: Review for exam 2</td>
<td>-</td>
<td>Discuss practice exam</td>
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<tr>
<td>Oct. 25, T: Exam 2</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Oct. 27, R: Introduction to Turing machines</td>
<td>Lec. 13</td>
<td>HW 6 out</td>
</tr>
<tr>
<td>Nov. 1, T: Equivalence of models</td>
<td>Lec. 14</td>
<td></td>
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<tr>
<td>Nov. 3, R: Counting</td>
<td>Lec. 15</td>
<td>HW7 out, HW6 due</td>
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<tr>
<td>Nov. 8, T: An Undecidable Problem</td>
<td>Lec. 16</td>
<td></td>
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<tr>
<td>Nov. 10, R: Undecidability Reductions</td>
<td>Lec. 17</td>
<td>HW8 out, HW7 due</td>
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<tr>
<td>Nov. 15, T: Even more undecidability</td>
<td>Lec. 18</td>
<td></td>
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<tr>
<td>Nov. 17, R: Time Complexity, P and NP</td>
<td>Lec. 19</td>
<td>HW9 out, HW8 due</td>
</tr>
<tr>
<td>Nov. 22, T: NP-completeness Reductions</td>
<td>Lec. 20</td>
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Attendance
This is an in-person class. In particular, exams are in-person and mandatory. Attendance at lectures is not mandatory, but is strongly encouraged. To accommodate those with public health concerns a best-effort attempt will be made to stream lectures live using the zoom url linked at the top of the page. We cannot guarantee that this will happen or will continue to happen throughout the semester.

Course Materials
Course Text
The textbook for this course is Michael Sipser’s Introduction to the Theory of Computation (Any edition). It is not required, but it is strongly recommended. It is clear, thorough, appropriately paced, and contains a wealth of examples and extra practice problems. It is, in our opinion, one of the best textbooks ever written.

Additionally, for most topics discussed we will share lecture notes written by Prof. Frederic Faulkner.

Course Website and Other Classroom Management Tools
Will use make use of the university-provided Canvas site for course organization. Homework will be released and due through Gradescope. Ask questions on Piazza, where other students and the TA’s can see and discuss them (https://piazza.com/gatech/fall2022/cs4510b).

Course Expectations & Guidelines
How to Succeed
Historically, this class can be challenging (it is, after all, a math class); however, we know that every student can succeed and thrive in this class! To that end, we suggest the following five pieces of advice:

1. Come to class! Attendance is not mandatory, but there is a high correlation between attendance and performance in this class. More than that, participate actively in class: work on the challenge problems with the people around you, and ask questions to the TA’s, who have come to class with the express purpose of answering your questions.

2. Come to office hours! The TA’s are both passionate and knowledgeable, and they want to help you. Even if you do not have a question, consider working on the homework during office hours, which has two benefits: you will not procrastinate, and if you end up having a question, you can get it answered very quickly! Plus, you will be able to listen to the questions of other students.

3. Participate on Piazza! If you are at a loss for where to begin on the homework, start by checking to see what questions other students have asked. Also, one of the best ways to check if you are, say, ready for the exam is to try explaining the material to another student, by answering their question on Piazza. (Not to mention that you can get some extra credit this way as well.)
4. Try extra problems! If there is a topic you are not comfortable with, do the additional practice problems we provide or try the additional ones in the book. You can bring these problems to the TA’s as well (or Piazza), not just homework questions.

5. Explore multiple sources! Sometimes it can help to utilize multiple avenues to learn the course content: consider reading the textbook, reading the lecture notes, or watching additional videos on Youtube.

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Student-Faculty Expectations Agreement

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See http://www.catalog.gatech.edu/rules/22/ for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Intent for Inclusivity

As a member of the Georgia Tech community, I am committed to creating a learning environment in which all of my students feel safe and included. Because we are individuals with varying needs, I am reliant on your feedback to achieve this goal. To that end, I invite you to enter into dialogue with me about the things I can stop, start, and continue doing to make my classroom an environment in which every student feels valued and can engage actively in our learning community.

Resources for Students

In your time at Georgia Tech, you may find yourself in need of support. Below you will find some resources to support you both as a student and as a person. (See also the GT Student Resources section on Canvas.)

Academic Support

- Center for Academic Success (http://success.gatech.edu)
  - 1-to-1 tutoring (https://tutoring.gatech.edu/tutoring/)
  - Peer-Led Undergraduate Study (PLUS) (https://tutoring.gatech.edu/plus-sessions/)
- OMED: Educational Services (http://omed.gatech.edu/programs/academic-support)
  - Group study sessions and tutoring programs
- Communication Center (http://www.communicationcenter.gatech.edu)
  - Individualized help with writing and multimedia projects
- Advising and Transition (https://advising.gatech.edu)
Study Strategies Seminar course
(https://advising.gatech.edu/gt2801-study-strategies-seminar)

Academic coaching (https://advising.gatech.edu/academic-coaching)

Advising in your major (http://advising.gatech.edu/)

Personal Support

Georgia Tech Resources

- The Office of the Dean of Students (http://studentlife.gatech.edu/)
  404-894-6367; Smithgall Student Services Building 2nd floor
  - You also may request assistance at
- Center for Assessment, Referral and Education (CARE) 404-894-3498; (https://care.gatech.edu/)
  - Smithgall Student Services Building 1st floor
  - Students seeking assistance from the Counseling Center or Stamps Psychiatry need to visit
    CARE first for a primary assessment and referral to on and off campus mental health and
    well-being resources.
  - Students in crisis may walk in during business hours (8am-4pm, Monday through Friday) or
    contact the counselor on call after hours at 404-894-2575 or 404-894-3498.
    Other crisis resources: (https://counseling.gatech.edu/content/students-crisis)
- Students’ Temporary Assistance and Resources (STAR) (https://star.studentlife.gatech.edu/)
  - Can assist with interview clothing, food, and housing needs.
- Stamps Health Services: https://health.gatech.edu; 404-894-1420
  - Primary care, pharmacy, women’s health, psychiatry, immunization and allergy, health
    promotion, and nutrition
- OMED: Educational Services (https://omed.gatech.edu/)
- Women’s Resource Center (https://womenscenter.gatech.edu/); 404-385-0230
- LGBTQIA Resource Center (https://lgbtqia.gatech.edu/); 404-385-2679
- Veteran’s Resource Center (https://veterans.gatech.edu/); 404-385-2067
- Georgia Tech Police: 404-894-250 (https://police.gatech.edu/)

National Resources

- The National Suicide Prevention Lifeline | 1-800-273-8255
  - Free and confidential support 24/7 to those in suicidal or emotional distress
- The Trevor Project (https://www.thetrevorproject.org/)
  - Crisis intervention and suicide prevention support to members of the LGBTQ+ community
    and their friends
  - Telephone | 1-866-488-7386 | 24 hours a day, 7 days a week
  - Online chat (https://www.thetrevorproject.org/get-help-now/) | 24 hours a day, 7 days a week
  - Text message | Text “START” to 687687 | 24hrs day, 7 days a week

Acknowledgements

Many thanks to Frederic Faulkner for allowing me the use of the material from their Spring 2022 instance of
4510. Much of the structure of this class (and indeed this syllabus) has been copied from that material.

Thanks to Christopher Jaeger for scheduling advice.