

# CS454 : Theory of Computation

Instructor: Thoshitha Gamage, Ph.D.  
Southern Illinois University at Edwardsville

## Spring 2023 Syllabus

### Course Information:

📖 Title:	CS454 : Theory of Computation (3 Credits)
📍 Location:	SE 1220
🕒 Time:	M & W 12:00 – 01:15 p.m.
🌐 Course Website:	<a href="http://www.cs.siu.edu/~tgamage/courses/454S23">http://www.cs.siu.edu/~tgamage/courses/454S23</a>
📁 Assignment Dropbox:	<a href="https://classes.cs.siu.edu/spring-2023">https://classes.cs.siu.edu/spring-2023</a>

### Contact Information:

🏠 Office:	EB 2045
☎ Phone:	650-2407
✉ Email:	<a href="mailto:tgamage@siue.edu">tgamage@siue.edu</a>
🌐 Web Site:	<a href="http://www.cs.siu.edu/~tgamage">http://www.cs.siu.edu/~tgamage</a>
🕒 Office Hours:	M & W 09:30 – 11:30 a.m. <i>or by appointment</i>

## 1 Course Objectives

This is an upper level undergraduate class in Theory of Computation. The course objectives are:

1. to understand the fundamentals of computational complexity, limitations of efficient computations, and how to reason about them;
2. to introduce formal models of computation and to build on CS330;
3. to develop the skills to formally reason about computational complexity through abstract machines; and
4. to develop essential problem solving and critical thinking skills requisite of a computer scientist.

## 2 Course Prerequisites

MATH224 (Discrete Mathematics) and CS330 (Programming Languages). If you don't meet these prerequisites, you need to contact me immediately **within the first week** and get my approval. I reserve the right to drop you from the course if it becomes obvious that you do not meet the course prerequisites.

## 3 Textbook(s) & Resources

This course has adopted Open Educational Resources (OER) for its reference material needs. The course does not strictly follow any particular textbook. However, to aid your understanding of the course content, the following resources are referred herewith as useful student reference material. All these resources are freely and openly available online. Contact the instructor immediately if you have any difficulties reaching any of these resources.

- **[JS1e]** *Models Of Computation Exploring the Power of Computing* by John E. Savage, <https://cs.brown.edu/people/jsavage/book/>
- **[AM1e]** *Introduction to Theory of Computation* by Anil Maheshwari & Michiel Smid, <https://cglab.ca/~michiel/TheoryOfComputation/TheoryOfComputation.pdf>

- [MIT] MIT OCW: Video Lectures on Theory of Computation by Michael Sipser  
<https://cutt.ly/QXiGVdg> (or <https://bit.ly/3QJyuEE>)
- JFLAP Automata Simulator: <https://www.jflap.org/>

## 4 Assigned Work and Tentative Grading Policy

The following grade allocation breakdown is *tentative*, and may change during the semester. Unless the circumstances change, I am **NOT** planning on curving the final grade.

Grading Allocation	BS	MS	Final Letter Grade	
Exams	60%	55%	[88 ++	A
Midterm 01	15%		[79–88)	B
Midterm 02	15%		[70–79)	C
Final ( <i>comprehensive!!</i> )	30% / 25%(MS)		[60–70)	D
Participation & Scribing	5%	5%	– 60)	F
Problem Solving	35%	25%		
Graduate Standing Project	–	15%		

### 4.1 Exams

All exams and quizzes will be held in the lecture room.

**Midterm 01:** Monday February 13<sup>th</sup> 12:00 – 01:15 p.m. (75 mins)

**Midterm 02:** Wednesday March 22<sup>nd</sup> 12:00 – 01:15 p.m. (75 mins)

**Final:** Tuesday May 02<sup>nd</sup> 10:00 – 11:40 a.m. (100 mins)

### 4.2 Class Participation & Attendance

You are expected to attend all live lectures and **proactively** participate in in-class discussions and Q&A. When applicable recorded video lectures and instructor scribe notes will be made available. However, such material are not meant as a substitute for missing classes, thus, pay attention during live lectures and take your own notes. Constructive and proactive participation in in-class discussions and scribing accounts for 5% of your final grade. In general, you are expected to read the relevant sections from the reference textbook(s) in preparation for each lecture (*see Tentative Schedule below*). I will try my best to direct you to other relevant resources wherever applicable, but I fully expect you to **take the responsibility of your own learning** and come to the class as much prepared as you can.

### 4.3 Problem Solving

There will be roughly ~6-7 in-class problem solving sessions. In preparation, students are **required** to review the relevant sections from the reference material. A rough guide to the relevant book sections and videos on the schedule below.

### 4.4 Graduate Standing Project

Graduate students are required to conduct a mini-research project that is worth 15% of their final grade. A typical graduate level research of this scope would include a fairly comprehensive literature survey that refers a minimum of 15-20 *highly cited* research papers, culminating to some preliminary empirical validation. In other words, your objective is to develop a hypothesis based on your readings and see if you can validate your hypothesis (*hence, scientific method*).

You are free to choose a topic of your choice **relevant** to the theme of this course. Places to look for a research topic includes (but not limited to) IEEE Symposium on Foundations of Computer Science (FOCS), ACM Annual Symposium on the Theory of Computing (STOC), ACM-SIAM Symposium on Discrete Algorithms (SODA),

IEEE Conference on Computational Complexity (CCC). Here's a short guide on **How to Read a Paper** : <http://ccr.sigcomm.org/online/files/p83-keshavA.pdf>. Here's a good sample literature review: <https://dl.acm.org/citation.cfm?id=3047307>.

Important milestones for your project are listed below. All assignments are due at the beginning of class through Moodle. You will present your research to the class during weeks 15 and 16, and produce an IEEE conference style minimum 8-page paper as the final report. A template can be found at [http://www.ieee.org/conferences\\_events/conferences/publishing/templates.html](http://www.ieee.org/conferences_events/conferences/publishing/templates.html). You are **highly encouraged** to produce your report using Latex.

- Monday January 23<sup>rd</sup>, 2023 – A one page research proposal and a justification of your proposed research. (M1)
- Wednesday March 15<sup>th</sup> 2023 – A near complete literature review along with a rough empirical validation plan. (M2)
- Wednesday April 26<sup>th</sup> 2023 – Final report (in IEEE conference style) (M4).

While not mandatory, graduate students are highly encouraged to regularly meet and update the instructor on their research progress. I reserve the right to decide which projects meet graduate standing and lower the grade for those who don't; hence, make sure to clearly exchange your research ideas with me, find out about my expectations, and set yourself up for success **early** in the semester.

In addition, graduate students may have additional mandatory questions in exams. Accordingly, graduate students will be graded on separate scale. Please refer Section 4 for the scale.

## 5 COVID-19 Pandemic Policies Related to Classroom Instruction (Spring 2023)

### 5.1 Health and Safety

The measures outlined below are required and any student who does not comply may be in violation of the *COVID-19 People-Focused Health and Safety Policy*, as well as the University's *Student Code of Conduct*.

The full text of the *COVID-19 People-Focused Health and Safety Policy* can be found here: <https://www.siue.edu/policies/Covid.shtml>

### 5.2 Classrooms, Labs, Studios, and Other Academic Spaces

Under current University policy, SIUE will only require masking in campus healthcare settings. See, <https://www.siue.edu/about/announcements/coronavirus/safety-guidelines-support/index.shtml>.

Individual faculty of record may determine that masking will be required in their classrooms and are asked to communicate accordingly with students. Face masks may be required in other campus sites following guidance from governing regulatory agencies.

- Students who forget to wear a face covering when masking is required will be reminded of their obligation to comply with SIUE's *COVID-19 People-Focused Health and Safety Policy* and temporarily asked to leave the class until they are able to conform to the policy. Students who forget or lose their face coverings when masking is required may be able to obtain replacements from a friend, a faculty member, or a nearby departmental office. Face coverings are also available for purchase in the Cougar Store (MUC).
- Students who refuse to wear a face covering when masking is required will be asked to leave the classroom and referred to the Dean of Students for non-compliance with community health and safety protocols. Repeated non-compliance may result in disciplinary actions, including the student being administratively dropped from an on-ground/face-to-face course or courses without refund if no alternative course format is available.
- If a student has a documented health condition which makes wearing a face covering medically intolerable, that student should contact ACCESS to explore options with the understanding that ACCESS will not grant accommodations which excuse the need for a face covering while on campus or in the classroom. ACCESS will work with qualifying individuals to find reasonable alternatives, whenever such solutions are available. Please call or contact the ACCESS Office via email to schedule an online appointment to discuss potential alternatives. ACCESS office (Student Success Center, Room 1203, 618-650-3726, and [myaccess@siue.edu](mailto:myaccess@siue.edu)).

### 5.3 General Health Measures

Students and employees are expected to review the siue.edu/coronavirus website (<https://www.siue.edu/about/announcements/coronavirus/>) to better understand prevention strategies and safety expectations.

- Students and employees are expected to maintain healthy hygiene practices.
- Students and employees are expected to follow COVID-related guidelines and directions.
- Students and employees are expected to conduct a daily health self-assessment and isolate themselves if COVID-related symptoms are present. COVID-related symptoms include:
  - Fever (100.4 degrees or above) or chills
  - Cough
  - Shortness of breath or difficulty breathing
  - Fatigue
  - Muscle or body aches
  - Headache
  - New loss of taste or smell
  - Sore throat
  - Congestion or runny nose
  - Nausea or vomiting
  - Diarrhea

### 5.4 Academic Integrity

Students are reminded that the expectations and academic standards outlined in the Student Academic Code (3C2) apply to all courses, field experiences and educational experiences at the University, regardless of modality or location. The full text of the policy can be found here: <https://www.siue.edu/policies/3c2.shtml>.

### 5.5 Recordings of Class Content

Faculty recordings of lectures and/or other course materials are meant to facilitate student learning and to help facilitate a student catching up who has missed class due to illness or quarantine. As such, students are reminded that the recording, as well as replicating or sharing of any course content and/or course materials without the express permission of the instructor of record, is not permitted, and may be considered a violation of the University's Student Conduct Code (3C1), linked here: <https://www.siue.edu/policies/3c1.shtml>.

### 5.6 Potential for Changes in Course Schedule or Modality

As the COVID-19 pandemic continues, there remains a possibility that planned classroom activities will need to be adjusted. Depending on circumstances and following state-issued recommendations, potential changes include alterations to distancing requirements, course modality (e.g., transition from face-to-face to online, hybrid, or hy-flex, mask wearing, in-course activities, etc). These changes would be implemented to ensure the successful completion of the course while preserving health and safety. In these cases, students may be provided with an addendum to the class syllabus that will supersede the original version. If the course schedule or modifications significantly alter expectations, a new syllabus will be issued.

## 6 Responsible Learning Policy

There is a no tolerance policy with regards to cheating. **Anyone caught cheating will fail the course.** Do your own work. Your exams, homework, and programming projects are subject to the academic honor code. You are expected to know and observe the **SIUE Student Conduct Code (3C1)** and **Student Academic Code (3C2)** found at <http://www.siue.edu/policies>. If you are unsure about what constitutes as plagiarism, check this website: <https://www.siue.edu/education/psychology/plagiarism.shtml>.

### 6.1 Online Repositories

If you intend to keep any project source code in online repositories, ensure those repositories are **private** and **only accessible to you**. By making source code publicly available to others, you might be involuntarily participating in plagiarism.

### 6.1.1 Advice

This course will require a substantial amount of time reading and solving problems outside of class time. It is imperative that you keep up with the assigned reading and other tasks as much as possible. If you do not, it will be very difficult to be successful in this course.

Know the information, how to approach the problem/solution, and present it in a clear and organized manner. On exams and in programming projects, you are attempting to demonstrate understanding of concepts and the ability to solve problems. If I have to try to determine **how** you came up with your answer, then you will **not** receive full credit.

The following conditions are subject to loss of some or all credit for a given problem:

- Illegible work/answers
- work/answers that cannot be easily located
- no work
- missing/incorrect units
- compile-time and/or run-time errors

Solutions which clearly demonstrate understanding of the material, but have a minor error may receive partial credit. The final score for such problems is at the discretion of the grader and/or the instructor.

- a. Don't wait until the last minute to do homework or projects. Labs get busy, computers break down, and people get sick. These are not sufficient excuses for an extension.
- b. Save early; save often!
- c. Contact me if you are confused. Don't wait for office hours; send a Discord DM or an email.
- d. I strongly discourage you from getting into discussions with me about grades and how you can get a better one. This includes emailing me about possible ways to "bump" your grade. Such requests only mean one thing; that you have already fallen behind on your own expectations.

## 7 Accessible Campus Community & Equitable Student Support

Students needing accommodations because of medical diagnosis or major life impairment will need to register with Accessible Campus Community & Equitable Student Support (ACCESS) and complete an intake process before accommodations will be given. Students who believe they have a diagnosis but do not have documentation should contact ACCESS for assistance and/or appropriate referral. The ACCESS office is located in the Student Success Center, Room 1270. You can also reach the office by e-mail at [myaccess@siue.edu](mailto:myaccess@siue.edu) or by calling 618.650.3726. For more information on policies, procedures, or necessary forms, please visit the ACCESS website at [www.siue.edu/access](http://www.siue.edu/access).

## 8 Tentative Schedule\*

\*Subject to adjustment and change. I reserve the right to change topics, add items of related interest, or adjust the schedule. All changes will be announced in class.

### 8.1 CS454 in a Nutshell

1	2	3	4	5	6	7	8	BREAK	10	11	12	13	14	15	16	
	MLK	S1		S2		S3		S4	S5			S6			S7	
		M1							M2							M4
					E1					E2						FE

S# – Problem Solving Session  
E# – Mid-Term Exams

M# – Graduate Standing Project Milestones  
FE – Final Exam

### 8.2 Outline

Week	Topics	Reference Video	Assignments/Exams
01	Introduction and Course Overview <b>Regular Languages:</b>	<a href="#">JS1e/1.2-1.3</a> <a href="#">JS1e/4.1</a> , <a href="#">AM1e/2.2</a> , <a href="#">MIT/1</a>	
02	<b>MLK Day</b> Deterministic Finite State Automata (DFA)		S1 (in-class)
03	Non-Deterministic Finite State Automata (NFA) Regular Expressions and Regular Grammars	<a href="#">JS1e/4.2</a> , <a href="#">AM1e/2.4</a> <a href="#">JS1e/4.3-4.4</a> , <a href="#">AM1e/2.7</a>	M1 < in
04	Closure Properties Non-Regular Languages, Pumping Lemma	<a href="#">JS1e/4.6</a> , <a href="#">AM1e/2.6</a> or <a href="#">MIT/3</a> <a href="#">JS1e/4.5</a> , <a href="#">AM1e/2.9</a>	S2 (in-class)
05	<b>Context-Free Languages (CFL) :</b> Context-Free Grammars	<a href="#">JS1e/4.8</a> <a href="#">JS1e/4.7</a> , <a href="#">AM1e/3.1-3.3</a> , <a href="#">MIT/4</a>	
06	‡ <b>Midterm Exam I: Monday February 13<sup>th</sup> 12:00 – 01:15 p.m.</b> Push-Down Automata, Normal Forms	<a href="#">JS1e/4.11</a> , <a href="#">AM1e/3.4-3.6</a>	S3 (in-class)
07	Pumping Lemma for CFL CFL Properties and Equivalence	<a href="#">JS1e/4.13</a> , <a href="#">AM1e/3.8</a> <a href="#">JS1e/4.13.2</a> , <a href="#">MIT/5</a>	
08	<b>Recursively-Enumerable Languages (REL):</b> Recursive vs. REL	<a href="#">AM1e/4.1-4.4</a> <a href="#">JS1e/5.1</a> or <a href="#">MIT/5</a>	S4 (in-class)
09	<b>Spring Break</b>		
10	Turing Machines (TM)	<a href="#">JS1e/5.7</a>	S5 (in-class) M2 < in
11	Halting Problem ‡ <b>Midterm Exam II: Wednesday March 22<sup>nd</sup> 12:00 – 01:15 p.m.</b>	<a href="#">JS1e/5.8.2</a> , <a href="#">AM1e/5.1</a>	
12	<b>Computational Complexity:</b> Undecidability	<a href="#">MIT/7-8</a> , <a href="#">AM1e/5.2</a>	
13	Reducibility, Rice Theorem	<a href="#">JS1e/5.8</a> , <a href="#">AM1e/5.3</a>	S6 (in-class)
14	Complexity Classes: P, NP, NP-C P vs. NP	<a href="#">MIT/14-15</a>	
15	Satisfiability, Cook’s Theorem Church-Turing Thesis	<a href="#">MIT/16</a>	S7 (in-class)
16	<i>MS Presentations: Topic TBA</i>		M4 < in
17	<b>Final Exam: Tuesday May 02<sup>nd</sup> 10:00 – 11:40 a.m.</b>		