CS 3823 - Theory of Computation: Syllabus

Dimitris Diochnos

School of Computer Science
The University of Oklahoma

Fall 2024

Time and Location

Tuesdays & Thursdays, 12:00pm-1:15pm, Nielsen Hall 0170.

Website: https://www.diochnos.com/teaching/CS3823/2024F/index.php

Canvas: Canvas will be used in order to distribute homework assignments and potentially other reading materials.

Instructor

Dimitris Diochnos, 230 Devon Energy Hall (DEH), diochnos@ou.edu .

Teaching Assistants

Our teaching assistants for this course will be: **Pantia-Marina Alchirch** (`marina.alchirch`) and **Tashfeen** (`tashfeen`). Inside the parentheses you can see the username of the student such that if you append `@ou.edu` you can send an email to them directly.

Office Hours

Office hours will be held on:

- **Mondays** between **11:00am-12:00pm** and **5:00am-6:00pm** (Tashfeen, Zoom),
- **Tuesdays** between **10:00am-11:30am** (Marina Alchirch, Hitachi Lab) and **3:00pm-3:50pm** (Dimitris Diochnos),
- **Wednesdays** between **11:00am-12:00pm** (Tashfeen, Zoom), **12:00pm-1:30pm** (Marina Alchirch, Hitachi Lab), and **5:00pm-6:00pm** (Tashfeen, Zoom),
- **Thursdays** between **3:00pm-3:50pm** (Dimitris Diochnos),
- **Fridays** between **1:30pm-2:15pm** (Dimitris Diochnos), or
- **by appointment**.

As I am teaching two courses this semester, please note that while anyone is welcome during my office hours (Dimitris Diochnos), students from CS 4713/5713 will have precedence on Fridays, while students from CS 3823 will have precedence on Tuesdays and Thursdays.

Zoom link for Tashfeen's office hours: https://tashfeen.org/share/oh.md.

Prerequisite Background

The prerequisites for the course are (CS 2413 or CS 2414 and CS 2813 or Math 2513) or CS 5005 or DSA 5005.

Topics and Course Description

(As listed in the undergraduate catalog:) Introduction to abstract machine theory and formal language theory. Topics include Turing machines, finite/pushdown automata, deterministic versus nondeterministic computations, context-free grammars, and mathematical properties of these systems.

Schedule of Classes

The syllabus is continuously updated and subject to change. We will cover the material at a pace that is comforable. Our **first meeting** is on **Tuesday, August 20, 2024** and our **last meeting** is on **Thursday, December 5, 2024**.

We will cover most of the Chapters 1-10 of the textbook well as some topics not covered in the book.

The **final exam** is **in-class** (Nielsen Hall 0170) on **Wednesday, December 11, 2024** between **1:30pm and 3:30pm**. **I will not accommodate rescheduling of the exam because you have a coflict with another course. Be wise and enroll in this class only if you can have the final exam at the above date and time.**

This course is a theory course and our primary focus is on abstract, theoretical ideas, though we may touch on relevant applications at various points (and especially in the topics discussed in the end)

A **rough outline** for the course, which is subject to change slightly depending on our pace, is shown in Table 1.

Textbook, Notes and Related Reading Materials

Textbook

The textbook for the course is ***An Introduction to Formal Languages and Automata (7th Edition)***, by Peter Linz [6].

Other Books of Interest

- *Introduction to the Theory of Computation (3rd Edition)*, by Michael Sipser [9].
- *Computability and Unsolvability*, by Martin Davis [1].
- *Computational Complexity*, by Christos Papadimitriou [7].
- *Computers and Intractability: A Guide to the Theory of NP-Completeness*, by Michael Garey and David Johnson [4].

Another book of interest, which can be inspiring providing patterns for problem-solving strategies, is the one by George Pólya,

- *How to Solve It: A New Aspect of Mathematical Method* [8].

Table 1: Tentative Course Schedule

Period	Topics
Week 1	Syllabus, expectations, mathematical background
Week 2	Deterministic finite automata (DFAs). Introduction to non-determinism.
Week 3	Non-deterministic finite automata (NFAs). Equivalence between NFAs and DFAs. Discussion on TEX/ LATEX.
Week 4	Closure under the regular operators. Thursday's class is not happening due to career fair.
Week 5	Regular expressions. Equivalence between DFAs and regular expressions.
Week 6	Pumping lemma for regular languages. Examples uses for proving non-regularity of certain languages.
Week 7	More examples on the pumping lemma. **First midterm** to take place on Thursday of this week.
Week 8	Context-free grammars (CFGs), ambiguity, normal forms.
Week 9	Discussion of solutions for first midterm. Introduction to (nondeterministic) push-down automata (PDAs).
Week 10	More on PDAs. MoneyCoach presentation by Cami Sheaffer.
Week 11	Pumping lemma for context-free languages. Proving that certain languages are not context-free.
Week 12	Introduction to Turing machines. Recognizable versus decidable languages. Hilbert's tenth problem.
Week 13	Preparation for the midterm (answering questions, going over homework). **Second midterm**.
Week 14	Equivalence of models for Turing machines. **Thanksgiving**.
Week 15	Chomsky hierarchy. Undecidability. The acceptance problem, the halting problem, and the Post correspondence problem. Complexity classes P and NP.
Week 16	Discussion of solutions for second midterm. The million dollar question of **P vs NP**.

Another interesting book that can give you a good flavor of the other course that I am teaching in computational learning theory, is one by Leslie Valiant that is listed below. With this book you can explore connections between the theory of machine learning and artificial intelligence on one hand, and the theory of computation on the other hand. This book is

- *Probably Approximately Correct: Nature's Algorithms for Learning and Prospering in a Complex World* [10].

Finally, due to the close interaction of modern mathematics and complexity theory, other fun books that revolve around mathematics, or the history of mathematics, also come to mind and one can enjoy in their free time.

- *Logicomix: An epic search for truth*, by Apostolos Doxiadis and Christos Papadimitriou [3].
- *The Parrot's Theorem: A Novel*, by Denis Guedj [5].
- *Uncle Petros and Goldbach's Conjecture: A Novel of Mathematical Obsession*, by Apostolos Doxiadis [2].

Grading

Grading will be based on the following:

- **45% homework assignments**,
- **30% midterm exams (15% each midterm)**,
- **25% final exam**.

Grades may also be adjusted slightly upward or downward depending on class participation. I expect grading to be along the lines shown in the table below:

Percentage	Grade
$\geq 90\%$	A
$\geq 80\%$	B
$\geq 70\%$	C
$\geq 60\%$	D
otherwise	F

Students should submit one assignment per group.

- If a student submits more than one assignment we will take into account the latest one. Please note that there is no way for us to tell if you have submitted additional/other files in your previous submissions as these are overwritten on Canvas. So, you are responsible that you submit all files with your latest submission.
- If more than one student submits the assignment, the TAs are allowed to grade any one of them they like and this may very well mean that you will receive a smaller grade for your group compared to what you could receive with a full/latest submission.
- The TAs are allowed to apply a small penalty (e.g., up to 8% of the maximum grade) for situation where multiple submissions are made per group. So, please make sure that only one person submits what is needed per group and that person should be responsible for making a complete submission each time.

Examinations

- We will have **two midterm exams**, both are going to be in-class.
- The **final exam** is **in-class** on **Wednesday, December 11, 2024** between **1:30pm and 3:30pm**.
- Exams will be closed-book written exams.

Important: You will not be able to take the exam another day because you have a conflict with another course. Make sure you understand this now and choose wisely the courses in which you enroll.

Homework Assignments

There will be 5-6 homework assignments; most likely five, with a tentative schedule as shown in Table 2.

The assignments will be weighted roughly evenly. In other words the contribution for the 50% of your grade based on homework assignments will be computed by adding up all the grades that you receive from the individual assignments and then dividing by the maximum amount of grades that you could gather from all these assignments.

Table 2: Tentative Homework Schedule

Homework	Assigned	Due
1	Week 2 (end)	Week 3 (end)
2	Week 5 (beginning)	Week 6 (end)
3	Week 9 (beginning)	Week 10 (beginning)
4	Week 11 (beginning)	Week 12 (end)
5	Week 15 (beginning)	Week 16 (beginning)

Course Policies

Collaboration Policy

Students **must** form **groups of 4 to 5 people** and work together on the homework assignments. You cannot work alone. You cannot work in a group of less than 4 people.

- Collaborators must be named (together with their university IDs) at the top of every assignment.
- The study groups are intended to foster collaborations, encourage brainstorming, create excitement, and make the learning process more fun. Each study group should meet regularly (say once or twice per week throughout the semester). Everyone in the study group should contribute fairly to the overall group effort. Ideally, equal group effort should be put by everyone in the group in each assignment. Please form your study groups early in the semester (by the second week) and meet regularly.
- Students are allowed to leave their group once and move to a different group, as long as the group that they are leaving does not end up with less than 4 members. Therefore, from the point in time where one leaves from the initial group they were members of, then they cannot move to another group. Of course the consistency of one's group may change because other members may flow in/out of the group – this does not count as a group change for the person who has not requested a group change as they remain in the group with the same groupID throughout the entire time.

  An exception to this rule is if you are asked by a TA or an instructor to change to a different group; but most likely this will not happen to any one of you during the course.
- Form groups before you submit the first homework assignment.

General Remarks. Please note the following two.

- **If you are unsure if something is permitted, consult with me before doing it.**
- **For exams** (whether midterms or final), **students are required to work alone** and follow the stated rules exactly.

Late Work Policy

You can postpone once your homework submission by 24 hours without any penalty. After the first time that you have a late submission, a 10% (of the maximum possible grade) penalty will be applied for every day that is late – the maximum delay can be 3 days (including the first time that you have a late submission). This penalty is applied of course to every member of the group where you belong to.

We will be using an electronic system (Canvas) for the students' submissions and therefore it is your responsibility to turn in your homework (or an exam, should this be the case) on time. **Please**

coordinate within your group and make one submission per group. Apart from electronic submissions (Canvas), you can turn-in homework sets also in-class, by the end of the class on the day they are due.

Chegg and Other Online Tutoring Sources

There are a wide variety of tutoring resources available through paid websites. Many of these sites have students upload assignments and solutions and surreptitiously provide these documents to other students. What appears to be a session with a tutor may be, behind the scenes, the tutor doing a search of their company database of solutions to share. By using these sites you risk being charged with academic misconduct, either by supplying other students with answers they did not author or by receiving someone else's answer that you did not author. Since these companies are not open with students about their practices, you cannot know whether a tutor is providing meaningful support (for example, identifying misunderstandings of content and explaining them) or simply feeding you someone else's solution a bit at a time. The tutor's actions can result in different students submitting answers that are identical, which may be flagged as academic misconduct during grading.

Make-Up Midterms

In some rare cases I can offer a makeup midterm to a student (subject to my schedule and availability as well). However, if the student misses their rescheduled midterm, the percentage points of the midterm as a contribution towards their final grade will transfer to their final exam. For example, if in a class each of two midterms contributes 15% to the total final grade and the final exam contributes 25% of the total final grade, then missing one midterm would cause the final exam to contribute 40% towards the final (overall) grade that the student will receive in the class.

Furthermore, for every midterm that a student misses beyond one (e.g., a student misses both makeup midterms), then for every such midterm apart from one, the student will receive a zero.

Final Exam Rescheduling

The final exam cannot be rescheduled. If you miss it you will get a zero (0).

Classroom Conduct

Disruptions of class will not be permitted. Examples of disruptive behavior include:

- Allowing a cell phone or pager to repeatedly beep audibly.
- Playing music or computer games during class in such a way that they are visible or audible to other class members.
- Exhibiting erratic or irrational behavior.
- Behavior that distracts the class from the subject matter or discussion.
- Making physical or verbal threats to a faculty member, teaching assistant, or class member.
- Refusal to comply with faculty direction.

In the case of disruptive behavior, I may ask that you leave the classroom and may charge you with a violation of the Student Code of Responsibilities and Conduct.

Class Web Page

The main web page for the class is

https://www.diochnos.com/teaching/CS3823/2024F/index.php

Login to the Canvas website using your 4+4 (first four letters of your last name followed by the last four digits of your student number), using your standard OU password. If you have difficulty logging in, call 325-HELP. This software provides a number of useful features, including a list of assignments and announcements, an electronic mailing list, newsgroups, and grade book. All handouts are available from Canvas. You should check the site daily. When I update the site, I will post an announcement telling you what has been added and where it is located.You are responsible for things posted on the site with a 24 hour delay.

Student's Feedback for the Course

The College of Engineering utilizes students' feedback as one of the bases for evaluating the teaching effectiveness of each of its faculty members. The results of these forms are important data used in the process of awarding tenure, making promotions, and giving salary increases. In addition, the faculty uses these forms to improve their own teaching effectiveness. The original request for the use of these forms came from students, and it is students who eventually benefit most from their use. Please take this task seriously and respond as honestly and precisely as possible, both to the machine-scored items and to the open-ended questions.

Class Email Alias

Urgent announcements will be sent through email. It is your responsibility to:

- Have your university supplied email account properly forwarded to the location where you read email.
- Make sure that your email address in Canvas is correct, and forwards email to the place where you read it. I'll send out a test message during the first week of class. If you do not receive this message, it is your responsibility to get the problem resolved immediately.
- Have your email program set up properly so that replying to your email will work correctly the first time. You can send email to yourself and reply to yourself to test this.

If you need assistance in accomplishing any of these tasks, contact 325-HELP.

Newsgroups and Email

The newsgroup on Canvas should be the primary method of communication, outside of class. This allows everyone in the class to benefit from the answer to your question. If you email me a question of general interest, I may post your question and my answer to the newsgroup. Matters of personal interest should be directed to email instead of to the newsgroup, e.g. informing me of an extended personal illness. Posting guidelines for the newsgroup are available on Canvas.

Incompletes

The grade of I is intended for the rare circumstance when a student who has been successful in a class has an unexpected event occur shortly before the end of the class. I will not consider giving a student a grade of I unless the following three conditions have been met.

1. It is within two weeks of the end of the semester.
2. The student has a grade of C or better in the class.
3. The reason that the student cannot complete the class is properly documented and compelling.

Add/Drop/Withdrawal Deadlines. Please consult the OU academic calendar (as well as the policies of the School of Engineering) for the following deadlines:

- **Add a course**
- **Drop a course without penalty (course removed from transcript)**
- **Drop a course with a W on transcript**

University Policies

The instructor reserves the right to add, remove, or change any element of class policy at any time and for any reason, within the limits of University policy.

OU is committed to creating a learning environment that meets the needs of its diverse student body. If you anticipate or experience any barriers to learning in this course, please feel welcome to discuss your concerns with me.

Academic Integrity

Academic misconduct hurts everyone but particularly the student who does not learn the material. All work submitted for an individual grade should be the work of that single individual and not his/her friends. It is fine to ask a fellow student for help as long as that help does not consist of copying any computer code, or solutions to other assignments. Students working on joint projects (e.g., the groups you form for homework) may certainly help one another and are expected to share ideas, code, and solutions within their group. However, they may not share beyond their group.

1. Collaboration is encouraged for homework where you will work within your groups. For the homework, you may form study groups so long as each homework is in your own words. Write your study partners' names on your homework when you turn it in. **Please return only one writeup for each group of people.**
2. Do not show another student (or group) a copy of your homework before the submission deadline. The penalties for permitting your work to be copied are the same as the penalties for copying someone else's work.
3. Make sure that your computer account is properly protected. Use a good password, and do not give your friends access to your account or your computer system. Do not leave printouts or thumb drives around a laboratory where others might access them.

Upon the first documented occurrence of academic misconduct, I will report it to the Campus Judicial Coordinator. The procedure to be followed is documented in the University of Oklahoma Academic Misconduct Code. In the unlikely event that I elect to admonish the student, the appeals process is described in `http://www.ou.edu/integrity`. For specific definitions on what constitutes cheating, review the Student's Guide to Academic Integrity (https://www.ou.edu/integrity/students).

Religious Observance

It is the policy of the University to excuse the absences of students that result from religious observances and to reschedule examinations and additional required classwork that may fall on religious holidays, without penalty. [See Faculty Handbook 3.15.2]
(https://apps.hr.ou.edu/FacultyHandbook/#3.15.2).

Reasonable Accommodation Policy

The Accessibility and Disability Resource Center is committed to supporting students with disabilities to ensure that they are able to enjoy equal access to all components of their education. This includes your academics, housing, and community events. If you are experiencing a disability, a mental/medical health condition that has a significant impact on one or more life functions, you can receive accommodations to provide equal access. Possible disabilities include, but are not limited to, learning disabilities, AD(H)D, mental health, and chronic health. Additionally, we support students with temporary medical conditions (broken wrist, shoulder surgery, etc.) and pregnancy. To discuss potential accommodations, please contact the ADRC at 730 College Avenue, (ph.) 405.325.3852, or adrc@ou.edu.

Title IX Resources and Reporting Requirement

Anyone who has been impacted by gender-based violence, including dating violence, domestic violence, stalking, harassment, and sexual assault, deserves access to resources so that they are supported personally and academically. The University of Oklahoma is committed to offering resources to those impacted, including: speaking with someone confidentially about your options, medical attention, counseling, reporting, academic support, and safety plans. If you would like to speak with someone confidentially, please contact OU Advocates (available 24/7 at 405-615-0013; see
https://www.ou.edu/gec/gender-based-violence/advocates) or another confidential resource (see "Can I make an anonymous report?"; https://www.ou.edu/gec/gender-based-violence/learn-more). You may also choose to report gender-based violence and discrimination through other means, including by contacting the Institutional Equity Office (ieo@ou.edu, 405-325-3546; https://www.ou.edu/eoo) or police (911). Because the University of Oklahoma is committed to the safety of you and other students, I, as well as other faculty, Graduate Assistants, and Teaching Assistants, are mandatory reporters. This means that we are obligated to report gender-based violence that has been disclosed to us to the Institutional Equity Office. This includes disclosures that occur in: class discussion, writing assignments, discussion boards, emails and during Student/Office Hours. For more information, please visit the Institutional Equity Office (https://www.ou.edu/eoo).

Adjustments for Pregnancy/Childbirth Related Issues

Should you need modifications or adjustments to your course requirements because of documented pregnancy-related or childbirth-related issues, please contact your professor or the Accessibility and Disability Resource Center at 405/325-3852 as soon as possible. Also, see the Institutional Equity Office FAQ on Pregnant and Parenting Students' Rights
(https://www.ou.edu/content/dam/eoo/documents/faqs/faqs-pregnant-and-parenting-students.pdf)
for answers to commonly asked questions.

Final Exam Preparation Period

Pre-finals week will be defined as the seven calendar days before the first day of finals. Faculty may cover new course material throughout this week. For specific provisions of the policy please refer to

OU's Final Exam Preparation Period policy.
Please see https://apps.hr.ou.edu/FacultyHandbook#4.10

Emergency Protocol

During an emergency, there are official university procedures (https://www.ou.edu/campussafety/policy-and-procedures) that will maximize your safety.

Severe Weather: If you receive an OU Alert to seek refuge or hear a tornado siren that signals severe weather.

1. Look for severe weather refuge location maps located inside most OU buildings near the entrances.
2. Seek refuge inside a building. Do not leave one building to seek shelter in another building that you deem safer. If outside, get into the nearest building.
3. Go to the building's severe weather refuge location. If you do not know where that is, go to the lowest level possible and seek refuge in an innermost room. Avoid outside doors and windows.
4. Get in, Get Down, Cover Up
5. Wait for official notice to resume normal activities.

Additional Weather Safety Information is available through the Department of Campus Safety.

Armed Subject/Campus Intruder

If you receive an OU Alert to shelter-in-place due to an active shooter or armed intruder situation or you hear what you perceive to be gunshots: 1. Avoid: If you believe you can get out of the area WITHOUT encountering the armed individual, move quickly towards the nearest building exit, move away from the building, and call 911. 2. Deny: If you cannot flee, move to an area that can be locked or barricaded, turn off lights, silence devices, spread out, and formulate a plan of attack if the shooter enters the room. 3. Defend: As a last resort fight to defend yourself. For more information, visit OU's Active Shooter page (https://ou.edu/police/psafe/active-shooter-training). Shots Fired on Campus Procedure – Video: https://www.youtube.com/watch?v=BsEOhGJIdI8

Fire Alarm/General Emergency

If you receive an OU Alert that there is danger inside or near the building, or the fire alarm inside the building activates: 1. LEAVE the building. Do not use the elevators. 2. KNOW at least two building exits 3. ASSIST those that may need help 4. PROCEED to the emergency assembly area 5 ONCE safely outside, NOTIFY first responders of anyone that may still be inside building due to mobility issues. 6. WAIT for official notice before attempting to re-enter the building. OU Fire Safety on Campus: https://vimeo.com/125093634

Mental Health Support Services

If you are experiencing any mental health issues that are impacting your academic performance, counseling is available at the University Counseling Center (UCC). The Center is located on the second floor of the Goddard Health Center, at 620 Elm Rm. 201, Norman, OK 73019. To schedule an appointment call (405) 325-2911. For more information, please visit University Counseling Center (https://www.ou.edu/ucc).

Pre-Finals Week Policies

During pre-finals week, all normal class activities will continue; however, no assignment, test, or examination accounting for more than 3% of the course grade may be assigned, unless it is assigned in advance of pre-finals week and worth less than 10%, or scheduled at least 30 days prior if worth more than 10%. No activity or field trip may be scheduled that conflicts with another class. There are some exceptions and nuances, so please review the Final Exam Policies (https://www.ou.edu/registrar/academic-records/academic-calendars/final-exam-schedule/final-exam-policies) prior to designing your course schedule.

References

[1] Martin D. Davis. *Computability and Unsolvability*. Dover, 1982.

[2] Apostolos Doxiadis. *Uncle Petros and Goldbach's Conjecture: A Novel of Mathematical Obsession*. Bloomsbury USA, 2001.

[3] Apostolos Doxiadis and Christos Papadimitriou. *Logicomix: An epic search for truth*. Bloomsbury USA, 2009.

[4] Michael R. Garey and David S. Johnson. *Computers and Intractability: A Guide to the Theory of NP-Completeness*. W. H. Freeman & Co., New York, NY, USA, 1979.

[5] Denis Guedj. *The Parrot's Theorem: A Novel*. St. Martin's Griffin, 2002.

[6] Peter Linz. *An Introduction to Formal Languages and Automata*. Jones & Bartlett Learning, sixth edition, 2017.

[7] Christos H. Papadimitriou. *Computational Complexity*. Addison-Wesley, 1994.

[8] George Pólya. *How to Solve It: A New Aspect of Mathematical Method*. Princeton University Press, 1971.

[9] Michael Sipser. *Introduction to the Theory of Computation*. Cengage Learning, third edition, 2012.

[10] Leslie Valiant. *Probably Approximately Correct: Nature's Algorithms for Learning and Prospering in a Complex World*. Basic Books (AZ), 2013.