CSc345 - Analysis of Discrete Structures - Summer 2025

Quick links to syllabus, panopto, piazza, gradescopes

Instructor and Teaching Assistants

Alon Efrat,
alon@cs.arizona.edu
Gould Simpson 742
Office hours Mon Thu 2:30-3:30, or by an appointment.

TA:
Amir Mohammad Esmaieeli Sikaroudi (Amir)
amesmaieeli@arizona.edu
Office hours: Tuesdays Fridays 1:00-2:30pm on zoom (D2L -> UA tools -> Zoom)

Course prerequisite
(CSC 127B or CSC 210) and (CSC 244 or CSC 245 or MATH 243 or MATH 323)

Course Description:

Catalog Description:
Introduction to and analysis of algorithms and characteristics of discret structures. Course topics include

algorithms.

Some of the data structures we will study are stacks, queues, trees, tries, and heaps. Algorithms considered will include sorting, searching, and hashing. We will also learn about graphs, graph algorithms, asymptotic notation, and algorithm analysis.

Expected Learning Outcomes

- Be able to asymptotically analyze iterative and recursive algorithms
- Have an in-depth knowledge of hierarchical structures and graphs
- Understand searching and sorting techniques
- Demonstrate basic skills in algorithm design and analysis

Course Format and Teaching Methods

web-delivered content via zoom

Obtaining Help

- **Academic advising:** If you have questions about your academic progress this semester, or your chosen degree program, consider contacting your department's academic advisor(s). Your academic advisor and the Advising Resource Center can guide you toward university resources to help you succeed. **Computer Science major students** are encouraged to visit https://www.cs.arizona.edu/undergraduate/advising for advisor contact information.

- **Life challenges:** If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office can be reached at 520-621-2057 or DOS-deanofstudents@email.arizona.edu.

- **Physical and mental-health challenges**: If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520-621-9202. For After Hours care, call (520) 570-7898. For the Counseling & Psych Services (CAPS) 24/7 hotline, call (520) 621-3334.

- **UA Ombuds**: The UA Ombuds Office (https://ombuds.arizona.edu/) helps with a wide variety of issues, concerns, questions, conflicts, and challenges. The primary mission of the Ombuds Program is to assist individuals in resolving conflict, facilitating communication, and assisting the University by surfacing issues and providing feedback on emerging or systemic concerns. Communications with the Ombuds Committee are informal and off-the-record. The Ombuds Committee is governed by the following standards: (1) Confidentiality; (2) Impartiality: (3) Informality; and (4) Independence.

Class Recordings For lecture recordings, which are used at the discretion of the instructor, students must access content in D2L only. Students may not modify content or re-use content for any purpose other than personal educational reasons. All recordings are subject to government and university regulations. Therefore, students accessing unauthorized recordings or using them in a manner inconsistent with UArizona values and

- The student will gain the tools to identify, or to cleverly guesstimate, which of the common paradigms used in Algorithms might best fit a problem that the student might face in industry or the academy.
- Be able to articulate clearly the algorithmic solutions (e.g. using pseudo-code), and to provide guarantees for the correctness and asymptotic efficiency of the proposed solutions.
- Demonstrate techniques for algorithmic incorporation of randomness, and will understand basic tools to evaluate its effectiveness.

Illnesses and Emergencies

- If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel.
- Notify your instructor(s) if you will be missing up to one week of course meetings and/or assignment deadlines.
- If you must miss the equivalent of more than one week of class and have an emergency, the Dean of Students is the proper office to contact (DOS-deanofstudents@email.arizona.edu). The Dean of Students considers the following as qualified emergencies: the birth of a child, mental health hospitalization, domestic violence matter, house fire, hospitalization for physical health (concussion/emergency surgery/coma/COVID-19 complications/ICU), death of immediate family, Title IX matters, etc.
- Please understand that there is no guarantee of an extension when you are absent from class and/or miss a deadline.

Statement on compliance with COVID-19 mitigation guidelines: As we enter the semester, our health and safety remain the university's highest priority. To protect the health of everyone in this class, students are required

Course Communications

We use the best of each media: Announcements will be made using Piazza. Homework submission will be performed via Gradescope. The homeworks will be accessible on Overleaf.

Computing the numeric grade is tricky on D2L. We will use google spreadsheet. We will share with you the template, but you will have to enter your grades yourself. It will look **approximately** like this grades template

Required Texts or Readings

Thomas H. Cormen, Charles E. Leiserson, Ron L. Rivest, and Clifford Stein, Introduction to Algorithms, McGraw-Hill, Boston.

Optional Texts

- Jon Kleinberg and Eva Tardos Algorithm Design, Addison Wesley 2006
- Sanjoy Dasgupta, Christos Papadimitriou, and Umesh Vazirani Algorithms
- Harry R. Lewis, Larry Denenberg Data Structures and Their Algorithms

Assignments and Examinations: Schedule/Due Dates.

Homework: There are six or seven homeworks, which occur roughly after the conclusion of each chapter. The homework with the lowest score will be dropped from the calculation of the final grade.

Homeworks will be graded within a week of the submission.

Midterm and final exams will be graded within four days after the exam day.

Grading Scale and Policies

The course *numeric_final_grade* is computed based on the formula:

32% *Homework grade*
(unless otherwise specified, all homework have the same weight)
28% *MidTerm exam grade*
28% *Final exam grade*
12% *Max{MidTerm_exam_grade, Final_exam}*

*Grade Distribution for this course: (here **n** is your numeric grade of the course).*

A: ***n*** *≥ 91%* ***and a grade of ≥80 at the final***

B*:* ***n*** *≥ 81%* ***and a grade of ≥70 at the final***

C*:* ***n*** *≥ 71%* ***and a grade of ≥60 at the final***

D*:****n*** *≥ 60%* ***and a grade of ≥50 at the final***

E*: ≤ 59%*

Note that these are sufficient conditions. As discussed above, I keep the right to use my overall impression of a student, and to bump up their grade. So for example, a student might have a numerical grade of 88 and still earn an 'A'. Such cases might occur if a student was one of the few that solved the more challenging question, was active in class discussions over piazza, caught glitches in assignments, or submitted exceptionally nice projets.

Incomplete (I) or Withdrawal (W):
Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at https://catalog.arizona.edu/policy/courses-credit/grading/grading-system.

Department of Computer Science Grading Policy:

1. Instructors will explicitly promise when every assignment and exam will be graded and returned to students. These promised dates will appear in the syllabus, associated with the corresponding due dates and exam dates.
2. Graded homework will be returned before the next homework is due.
3. Exams will be returned "promptly", as defined by the instructor (and as promised in the syllabus).
4. Grading delays beyond promised return-by dates will be announced as soon as possible with an explanation for the delay.

Schedule of Topics and Assignments

Midterm: **July 14, 3pm-5pm**
Final: **August 13** 9:00-11:00 in person and online

Syllabus

The course is organized into six parts. After each topic below are the relevant chapter numbers from the text. Note that not all material covered in class will be in the textbook (e.g., Skip Lists). The syllabus below is only an outline and very likely to change.

Lectures: panopto

Jun 16	video video • Algorithms (1, 2): notion of algorithm, measuring time and space • Analysis (3, 4): asymptotics, sums, recurrences. Solving recurrence formulas via iterative method. SwapSort and InsertionSort • Sorting by divide and conquer: ◦ **Merge Sor**t slides, video (CLRS page 11, 28-36) ◦ QuickSort and median selection video slides don't forget the 5-random keys method. CLRS Chapter 6 covers most but not all of the material. ◦ These topics, despite sharing a name, might be different than the way you have seens QuickSort and Median Selection in other places. So make sure to cover the videos. ! • **Heap Sort**. Heaps (priorities queues) is a data structure in its own right, that is very efficient to the operations (Insert(x,H), Extract_Max(H), where H deonte the heap. It is also useful for a moderately efficient O(n log n) sorting, called **HeapSort.** You might prefer this video that only uses a whiteboard, or this video that uses these slides. (if you need a brief introduction to • graphs and trees, check this video.) • *Counting sort and* ***Radix Sort*** (CLRS 8): sorting integers in a bounded range slides video	
	Search trees • Quad Trees video slides.	You might prefer to access on

Jun 25	successor worst-case efficiency through height balancing, Note how we delete a key that is not a leaf. Dont forget the proof of the height. This video covers this topic, and contains an introduction to the next topic (AVL) AVL trees slides video1 (or on whiteboard video2). After the basic definitions, we proved that the height of an AVL tree is O(log n). Insertions are performed as in a binary balanced search tree, and then we traverse the tree upward, update height fields, and if needed, use one of the 4 rotations (LL, LR, RL or LL) to fix the balance. Deletions are handled as in an unbalanced BST. However, we do not cover the re-balancing that might be needed.	
Jun 30	**More trees** • **Level-of-details**: We store something - no matter what. Should we store a crowd approximation or a fine approximation of this thing? Answer: Store both. The quadtree will tell you how. • A quick glance to **R-trees.** Note the similarity between R-trees (for segments vs B-trees (for keys) slides, lecture • Augmenting Data Structure ------- Material for Summer 2025 Final Starts Here ---------- **Hashing** Basic hashing techniques,(you will see more in cs445) Hashing (i) and Hashing ii. slides (CLRS). Don't forget the application of hashing to distributed Data Bases	
	• Graphs: *Representation* basic concepts: adjacency matrix,	

	• Huffman codes (CLRS 16.3) Slides, video (older videos: video1, video 2)	
July 13	Union/Find DS. Using Induction to prove logarithmic. slides lecture. Kruskal Alg for MST slides lecture Project 2 lecture. Video (link to project) Tries and Suffix Trees	
Week ending at ***July 19***	Midterm Finish tries and suffix trees. I remastered the lectures, so sounds is decent. Part 1 slides video (remastered) Part 2 slides video (remastered) Dont forget the lemma about Children-blessed families, and how this lemma provides linear-size suffix trees *BFS* lecture (contains Prim)	*T*his material is included in Chapter 23 of CLRS. We will only show that the time per operation is O(log n). (CLRS proves much better bounds) Make sure to understand how we prove a bound of O(log n) per each U/F operation.
Week ending at ***July 26***	DFS lecture (contains Prim) slides Maximum cardinalities and matching in a Bipartite Graphs video Slides. Don't forget the proof of optimality Persistent Data Structures slides video	

On homework, you are expected to think about and try to solve the problem for yourself. You may discuss general ideas with friends, but your solutions must be written up separately and represent individual work, and if ideas were developed during a collaborative discussion, list clearly with whom you brainstormed ideas. Use of solutions from previous offerings of the course (at UofA or any other university) is not permitted. Five points will be deducted per day for lateness, and late homework cannot be turned in after solutions have been discussed in class.

Use D2L to submit your homework. They should be .pdf files. You could use LaTeX, Word, Google Doc, etc, or you could write using your handwriting, scan and submit. It is your responsibility to verify that homework is legible. Please do not submit paper solutions. Neatness, and especially conciseness, is required to earn the highest marks. If you cannot solve a problem, state this in your write-up, and write down only what you know to be correct; rambling at length about ideas that don't quite work may cause additional points to be deducted.

- The purpose of assignments is to help you solidify your own understanding of the material. They are meant to cover the main ideas, but by no means are they meant to cover every aspect of the course materials. It is your responsibility to make sure you understand all concepts covered.

- All homework assignments should be turned as a single **PDF** file through gradescope.
- Make sure that your homework is clean and easy to follow. It is strongly recommended to print them, but hand-written is allowed. If it is not legible, then it may be marked as incorrect. It is up to the grader's courtesy to determine that your answer is unreadable *within reasonable effort*, either due to bad handwriting or incoherent explanation. The grader might opt to give you another chance in submitting these homework questions, if they have not been addressed in the classroom yet. A minimum penalty of 5 points will be in effect.
- The LaTeX code of the assignment will be shared using overleaf.com. You will need an overleaf account to access it.

- You may use programs such as Word, OpenOffice Writer, or LaTeX (e.g. overleaf) to write your solutions, but the file you turn in should be a **pdf**.

practice intellectual honesty.

Disruptive behaviors (such as physical or emotional harassment, dismissive attitudes, and abuse of department resources) will not be tolerated. The complete Code of Conduct is available on our department web site. We expect that you will adhere to this code, as well as the UA Student Code of Conduct, while you are a member of this class.

Classroom Behavior Policy

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.)

Inclusive Excellence is a fundamental part of the University of Arizona's strategic plan and culture. As part of this initiative, the institution embraces and practices diversity and inclusiveness. These values are expected, respected and welcomed in this course.

Threatening Behavior Policy

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students.

Elective Name and Pronoun Usage

This course supports elective gender pronoun use and self-identification; rosters indicating such choices will be updated throughout the semester, upon student request. As the course includes group work and in-class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect.

Accessibility and Accommodations

At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See https://deanofstudents.arizona.edu/policies/code-academic-integrity.

Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA email to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

UA Nondiscrimination and Anti-harassment Policy

The University of Arizona is committed to creating and maintaining an environment free of discrimination. In support of this commitment, the University prohibits discrimination, including harassment and retaliation, based on a protected classification, including race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, or genetic information. For more information, including how to report a concern, please see http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Additional Resources for Students

UA Academic policies and procedures are available at http://catalog.arizona.edu/policies

Visit the UArizona COVID-19 page for regular updates.

Campus Health
http://www.health.arizona.edu/
Campus Health provides quality medical and mental health care services through virtual and in-person care. Voluntary, free, and convenient COVID-19 testing is

Phone: 520-621-5554

The Dean of Students Office's Student Assistance Program
https://deanofstudents.arizona.edu/support/student-assistance
Student Assistance helps students manage crises, life traumas, and other barriers that impede success. The staff addresses the needs of students who experience issues related to social adjustment, academic challenges, psychological health, physical health, victimization, and relationship issues, through a variety of interventions, referrals, and follow up services.
Email: DOS-deanofstudents@email.arizona.edu
Phone: 520-621-7057

Survivor Advocacy Program
https://survivoradvocacy.arizona.edu/
The Survivor Advocacy Program provides confidential support and advocacy services to student survivors of sexual and gender-based violence. The Program can also advise students about relevant non-UA resources available within the local community for support.
Email: survivoradvocacy@email.arizona.edu
Phone: 520-621-5767

Campus Pantry

Any student who has difficulty affording groceries or accessing sufficient food to eat every day, or who lacks a safe and stable place to live and believes this may affect their performance in the course, is urged to contact the Dean of Students for support. In addition, the University of Arizona Campus Pantry is open for students to receive supplemental groceries at no cost. Please see their website at: *campuspantry.arizona.edu* for open times.

Furthermore, please notify me if you are comfortable in doing so. This will enable me to provide any resources that I may possess.

Title IX (recommended)

trained to support you in navigating campus life, accessing health and counseling services, providing academic and housing accommodations, helping with legal protective orders, and more.

Please be aware that UA faculty and instructors who work with students are required to report allegations of sex discrimination to the Title IX Office. This means that if you tell me about a situation involving sexual harassment, sexual assault, dating violence, domestic violence, or stalking that involves another student or employee, or that happens on campus or in a UA program, I **must** share that information with the Title IX Coordinator. Although I have to make that notification, you will have choices regarding whether or not you want to pursue a formal complaint against anyone on campus. Our goal is to make sure you are aware of the range of options available to you and have access to the resources you need.

If you wish to speak to someone privately, you can contact any of the following on-campus resources:

- Counseling & Psych Services (CAPS), https://health.arizona.edu/counseling-psych-services, 520-621-6490, 520-570-7898 (after hours)
- Oasis Sexual Assault, Relationship Violence, and Trauma Services, https://caps.arizona.edu/oasis (same phone as CAPS)
- Campus Health, https://health.arizona.edu/home, (520) 621-6490
- University of Arizona Ombuds, https://ombuds.arizona.edu/, (520)-626-5589

Safety on Campus and in the Classroom

For a list of emergency procedures for all types of incidents, please visit the website of the Critical Incident Response Team (CIRT): **https://cirt.arizona.edu/case-emergency/overview**

Also watch the video available at

https://arizona.sabacloud.com/Saba/Web_spf/NA7P1PRD161/app/me/ledetail;spf-url=common%2Flearningeventdetail%2Fcrtfy000000000003841

Confidentiality of Student Records

https://www.registrar.arizona.edu/personal-information/family-educational-rights-and-privacy-act-1974-ferpa

Subject to Change Statement

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.