

CSE 5311-001: Advanced Algorithms - Spring 2020

MW 4:00 - 5:20, Woolf Hall 402

- Instructor: Bob Weems, Associate Professor
Office: ERB 627 (weems@uta.edu, <http://ranger.uta.edu/~weems>)
Hours: MW 11:30 a.m. - 12:30 p.m. and MW 2:30 - 3:30 p.m.
- GTA: Contact information will be on my personal webpage
- Prerequisites: Algorithms & Data Structures (CSE 2320)
Theoretical Computer Science (CSE 3315)
- Objectives: Deeper study of algorithms, data structures, and complexity classes.
- Outcomes:
 1. Exposure to more sophisticated analysis techniques, e.g. amortized complexity.
 2. Exposure to specialized data structures and algorithms.
 3. Exposure to models of algorithm design.
- Textbook: Cormen, Leiserson, Rivest, Stein, *Introduction to Algorithms, 3rd ed.*, MIT Press, 2009. (Henceforth known as CLRS)
- References: S. Baase and A. Van Gelder, *Computer Algorithms, Introduction to Design and Analysis, 3rd ed.*, Addison-Wesley, 2000.
- M. de Berg et.al., *Computational Geometry: Algorithms and Applications, 3rd ed.*, Springer-Verlag, 2010. <http://dx.doi.org.ezproxy.uta.edu/10.1007/978-3-540-77974-2>
- A. Borodin and R. El-Yaniv, *Online Computation and Competitive Analysis*, Cambridge Univ. Press, 1998.
- E.D. Demaine and J. O'Rourke, *Geometric Folding Algorithms: Linkages, Origami, Polyhedra*, Cambridge Univ. Press, 2007.
- P. Flajolet and R. Sedgewick, *Analytic Combinatorics*, Cambridge Univ. Press, 2009, <http://algo.inria.fr/flajolet/Publications/AnaCombi/>
- L. Fortnow, *The Golden Ticket: P, NP, and the Search for the Impossible*, Princeton Univ. Press, 2013.
- M.R. Garey and D.S. Johnson, *Computers and Intractability: A Guide to the Theory of NP-Completeness*, Freeman, 1979.
- G. Gonnet and R. Baeza-Yates, *Handbook of Algorithms and Data Structures, 2nd. ed.*, Addison-Wesley, 1991.
- R.L. Graham, D.E. Knuth, and O. Patashnik, *Concrete Mathematics*, Addison-Wesley, 1989.

C.M. Grinstead and J.L. Snell, *Introduction to Probability*,

http://www.dartmouth.edu/~chance/teaching_aids/books_articles/probability_book/book.html

D. Gusfield, *Algorithms on Strings, Trees, and Sequences: Computer Science and Computational Biology*, Cambridge Univ. Press, 1997.

D. Gusfield and R. Irving, *The Stable Marriage Problem: Structure and Algorithms*, MIT Press, 1989.

D.S. Hochbaum, ed., *Approximation Algorithms for NP-Hard Problems*, PWS, 1997.

E. Horowitz and S. Sahni, *Fundamentals of Computer Algorithms*, Computer Science Press, 1978.

J. Kleinberg and E. Tardos, *Algorithm Design*, Addison-Wesley, 2006.

D.E. Knuth, *The Art of Computer Programming*, Vols. 1-4, Addison-Wesley.

V. Lifschitz, *Answer Set Programming*, Springer-Verlag,

<https://www.cs.utexas.edu/users/vl/teaching/378/ASP.pdf>

D. Manlove, *Algorithmics of Matching Under Preferences*, World Scientific, 2013,

<https://ebookcentral-proquest-com.ezproxy.uta.edu/lib/utar1/detail.action?docID=1168176>

M. Mitzenmacher and E. Upfal, *Probability and Computing: Randomized Algorithms and Probabilistic Analysis, 2nd ed.*, Cambridge, 2017.

C. Moore and S. Mertens, *The Nature of Computation*, Oxford, 2011.

R. Motwani and P. Raghavan, *Randomized Algorithms*, Cambridge Univ. Press, 1995.

J. O'Rourke, *Computational Geometry in C, 2nd ed.*, Cambridge Univ. Press, 1998.

C.H. Papadimitriou, *Computational Complexity*, Addison-Wesley, 1994.

R. Sedgewick, *Algorithms in C, Parts 1-5, 3rd ed.*, Addison-Wesley, 2003.

R. Sedgewick and P. Flajolet, *An Introduction to the Analysis of Algorithms, 2nd ed.*, Addison-Wesley, 2013.

A. Stepanov and P. McJones, *Elements of Programming*, Addison-Wesley, 2009.

A. Stepanov and D. Rose, *From Mathematics to Generic Programming*, Addison-Wesley, 2014.

Homework: Two assignments - NOT GRADED (solutions are available from the web page)

Grade: Your grade will be based on the following weights:

Exams:	80% (Test 1: 40%; Test 2: 40%, Friday, May 15, 2:00 - 4:30 p.m.)
Labs:	20% (Three labs, equal weight, submitted on Canvas)

Policies:

1. Regular attendance is expected. The lectures are being recorded and will have a link from Canvas, but no availability guarantee is made (e.g. this is not a “distance” course).
2. You are expected to have at least skimmed the new material by the day we start that material in class. The material will be covered in the order given later.
3. **CHEATING - YOU ARE EXPECTED TO KNOW UNIVERSITY POLICIES.** All cases of plagiarism will be processed through University channels outside the CSE department.
<http://www.uta.edu/conduct/>
4. Any request for special consideration must be appropriately documented **in advance**. (Special consideration does not include giving a higher grade than has been earned.)
5. Late programs are penalized according to the following schedule. Labs will be due at 3:45 PM on the due date. After the due time, assistance will be limited.

<u>Degree of lateness</u>	<u>Penalty</u>
Up to 3:45 next day	10 pts
Up to 3:45 two days	20 pts
Up to 3:45 three days	40 pts
Up to 3:45 four days	80 pts

6. If you require a reasonable accomodation for a disability, please contact me no later than the second week of this semester. Further details are available at <http://www.uta.edu/disability/>
7. Occasional class-wide email messages (e.g. weather situations, clarifications) may be sent to the addresses recorded by MyMav.

Course Outline

Starred (*) topics are not in CLRS

0. Selective review of dynamic programming
 1. Mathematical Preliminaries
 - Recurrences - Master Method (4.5-4.6.1)
 - Probability and Randomized Algorithms (5)
 2. Binary Search Trees
 - Red-Black Trees - Review (13)
 - AVL Trees*
 - Treaps (problem 13-4)
 - Augmenting Data Structures (14)
 - Optimal Binary Search Trees (15.5)
 - Self-Organizing Linear Search (Computing Surveys*, problem 17-5)

Self-Adjusting Binary Search Trees (Splay trees/amortized analysis) (JACM)*

3. Amortized Analysis (17)
 - 4.a. Priority Queues - Review (6.5)
 - Binary Trees, Binary Heaps, d-heaps*, Leftist Heaps*
 - Binomial Heaps (problem 19-2)
 - Pairing Heaps*
5. Hashing
 - Review (11.2-11.4)
 - Brent's Rehash*, Cuckoo Hashing*
 - Perfect Hashing (11.5)
 - Bloom Filters*
6. Medians/Selection (9.3)
7. Disjoint Sets (union-find trees) (21)
- TEST 1
8. Minimum Spanning Trees (23)
 - Brief review of Prim
 - Review of Kruskal's Algorithm and extension to detecting non-unique MST
 - Boruvka's Algorithm*
9. Max-Flow/Bipartite Matching (26)
 - Ford-Fulkerson - review, maximum capacity paths*
 - Push-relabel methods
 - Vertex and edge connectivity*
 - Hopcroft-Karp matching (problem 26-6)
10. Matching Under Preferences*
 - Bipartite with Two-Sided Preferences (stable marriages, hospitals/residents)
 - Bipartite with One-Sided Preferences (house allocation)
 - Non-Bipartite with Preferences (stable roommates)
11. Intractability (34, 35)
 - Sample Intractable Problems
 - Complexity Classes
 - Reductions
 - Polynomial-Time Approximation
12. Matrices
 - Strassen's Matrix Multiplication (4.2)
 - Binary Matrix Multiplication and Four Russians Trick*
13. Computational Geometry (33)
 - Fundamental Predicates
 - Closest Pairs
 - Convex Hulls
 - Sweep-line Algorithms
 - Plane Partitions and Point Location*
 - Smallest Enclosing Disk*
 - Euclidean MST/Voronoi Diagram/Delaunay Triangulation*
14. Sequences
 - Pattern Preprocessing Search
 - Rabin-Karp Algorithm (32.2)
 - Knuth-Morris-Pratt Algorithm (32.4)
 - Text Preprocessing - Suffix Arrays*
 - Longest Common Subsequences

Dynamic Programming - Review and Linear Space* Version
 Four Russians for LCS*
 By Reduction to Longest Strictly Increasing Subsequence*

TEST 2

Calendar - with subject numbers from course content

January		February		March							
20	MLK	22	Syllabus	3	5 2.	2	7.	4	8.		
27	0.	29	1.	10	3.	12		9	SPRING	11	BREAK
				17	4.a	19		16	Exam 1	18	
				24	5.	26	6.	23	9.	25	
								30	10.		
April			May								
		1		4		6					
6	11.	8						15	Exam 2		
13		15	12.								
20	13.	22									
27		29	14.								

April 3 is last day to drop; submit requests to major advisor prior to 4:00 p.m.

Messages/disclaimers/fine print from our sponsor:

Drop Policy: Students may drop or swap (adding and dropping a class concurrently) classes through self-service in MyMav from the beginning of the registration period through the late registration period. After the late registration period, students must see their academic advisor to drop a class or withdraw. Undeclared students must see an advisor in the University Advising Center. Drops can continue through a point two-thirds of the way through the term or session. It is the student's responsibility to officially withdraw if they do not plan to attend after registering. **Students will not be automatically dropped for non-attendance.** Repayment of certain types of financial aid administered through the University may be required as the result of dropping classes or withdrawing. For more information, contact the Office of Financial Aid and Scholarships (<http://wweb.uta.edu/aao/fao/>).

Attendance: At The University of Texas at Arlington, taking attendance is not required but attendance is a critical indicator in student success. Each faculty member is free to develop his or her own methods of evaluating students' academic performance, which includes establishing course-specific policies on attendance. As the instructor of this section, I expect regular attendance. However, while UT Arlington does not require instructors to take attendance in their courses, the U.S. Department of Education requires that the University have a mechanism in place to mark when Federal Student Aid recipients "begin attendance in a course." UT Arlington instructors will report when students begin attendance in a course as part of the final grading process. Specifically, when assigning a student a grade of F, faculty report the last date a student attended their class based on evidence such as a test, participation in a class project or presentation, or an engagement online via Canvas. This date is reported to the Department of Education for federal financial aid recipients.

Disability Accommodations: UT Arlington is on record as being committed to both the spirit and letter of all federal equal opportunity legislation, including *The Americans with Disabilities Act (ADA)*, *The Americans with Disabilities Amendments Act (ADAAA)*, and *Section 504 of the Rehabilitation Act*. All instructors at UT Arlington are required by law to provide "reasonable accommodations" to students with disabilities, so as not to discriminate on the basis of disability. Students are responsible for providing the instructor with official notification in the form of a letter certified by the **Office for Students with Disabilities (OSD)**. Students experiencing a range of conditions (Physical, Learning, Chronic Health, Mental Health, and Sensory) that may cause diminished academic performance or other barriers to learning may seek services and/or accommodations by contacting:

The Office for Students with Disabilities, (OSD) www.uta.edu/disability or calling 817-272-3364.

Counseling and Psychological Services, (CAPS) www.uta.edu/caps/ or calling 817-272-3671.

Non-Discrimination Policy: The University of Texas at Arlington does not discriminate on the basis of race, color, national origin, religion, age, gender, sexual orientation, disabilities, genetic information, and/or veteran status in its educational programs or activities it operates. For more information, visit uta.edu/eos.

Title IX Policy: The University of Texas at Arlington ("University") is committed to maintaining a learning and working environment that is free from discrimination based on sex in accordance with Title IX of the Higher Education Amendments of 1972 (Title IX), which prohibits

discrimination on the basis of sex in educational programs or activities; Title VII of the Civil Rights Act of 1964 (Title VII), which prohibits sex discrimination in employment; and the Campus Sexual Violence Elimination Act (SaVE Act). Sexual misconduct is a form of sex discrimination and will not be tolerated. *For information regarding Title IX, visit www.uta.edu/titleIX or contact Ms. Jean Hood, Vice President and Title IX Coordinator at (817) 272-7091 or jmhood@uta.edu.*

Academic Integrity: Students enrolled all UT Arlington courses are expected to adhere to the UT Arlington Honor Code:

I pledge, on my honor, to uphold UT Arlington's tradition of academic integrity, a tradition that values hard work and honest effort in the pursuit of academic excellence.

I promise that I will submit only work that I personally create or contribute to group collaborations, and I will appropriately reference any work from other sources. I will follow the highest standards of integrity and uphold the spirit of the Honor Code.

UT Arlington faculty members may employ the Honor Code as they see fit in their courses, including (but not limited to) having students acknowledge the honor code as part of an examination or requiring students to incorporate the honor code into any work submitted. Per UT System *Regents' Rule* 50101, §2.2, suspected violations of university's standards for academic integrity (including the Honor Code) will be referred to the Office of Student Conduct. Violators will be disciplined in accordance with University policy, which may result in the student's suspension or expulsion from the University.

Electronic Communication: UT Arlington has adopted MavMail as its official means to communicate with students about important deadlines and events, as well as to transact university-related business regarding financial aid, tuition, grades, graduation, etc. All students are assigned a MavMail account and are responsible for checking the inbox regularly. There is no additional charge to students for using this account, which remains active even after graduation. Information about activating and using MavMail is available at <http://www.uta.edu/oit/cs/email/mavmail.php>.

Campus Carry: Effective August 1, 2016, the Campus Carry law (Senate Bill 11) allows those licensed individuals to carry a concealed handgun in buildings on public university campuses, except in locations the University establishes as prohibited. Under the new law, openly carrying handguns is not allowed on college campuses. For more information, visit <http://www.uta.edu/news/info/campus-carry/>

Active Shooter: The safety and security of our campus is the responsibility of everyone in our community. Each of us has an obligation to be prepared to appropriately respond to threats to our campus, such as an active aggressor. Please review the information provided by UTA Police regarding the options and strategies we can all use to stay safe during difficult situations. For more information, visit <https://police.uta.edu/activeshooter>

Student Feedback Survey: At the end of each term, students enrolled in classes categorized as "lecture," "seminar," or "laboratory" shall be directed to complete an online Student Feedback Survey (SFS). Instructions on how to access the SFS for this course will be sent directly to each student through MavMail approximately 10 days before the end of the term. Each student's feedback enters the SFS database anonymously and is aggregated with that of other students enrolled in the course. UT Arlington's effort to solicit, gather, tabulate, and publish student feedback is required by state law; students are strongly urged to participate. For more information, visit <http://www.uta.edu/sfs>.

Final Review Week: A period of five class days prior to the first day of final examinations in the long sessions shall be designated as Final Review Week. The purpose of this week is to allow students sufficient time to prepare for final examinations. During this week, there shall be no scheduled activities such as required field trips or performances; and no instructor shall assign any themes, research problems or exercises of similar scope that have a completion date during or following this week *unless specified in the class syllabus*. During Final Review Week, an instructor shall not give any examinations constituting 10% or more of the final grade, except makeup tests and laboratory examinations. In addition, no instructor shall give any portion of the final examination during Final Review Week. During this week, classes are held as scheduled. In addition, instructors are not required to limit content to topics that have been previously covered; they may introduce new concepts as appropriate.

Emergency Exit Procedures: Should we experience an emergency event that requires us to vacate the building, students should exit the room and move toward the nearest exit. When exiting the building during an emergency, one should never take an elevator but should use the stairwells. Faculty members and instructional staff will assist students in selecting the safest route for evacuation and will make arrangements to assist individuals with disabilities.

Student Support Services: UT Arlington provides a variety of resources and programs designed to help students develop academic skills, deal with personal situations, and better understand concepts and information related to their courses. Resources include tutoring, major-based learning centers, developmental education, advising and mentoring, personal counseling, and federally funded programs. For individualized referrals, students may visit the reception desk at University College (Ransom Hall), call the Maverick Resource Hotline at 817-272-6107, send a message to resources@uta.edu, or view the information at <http://www.uta.edu/studentsuccess/success-programs/programs/resource-hotline.php>