CSE 5311-005: ADVANCED ALGORITHMS

Fall 2015: TR 9:30 - 10:50, Science Hall 105

Instructor:	Bob Weems, Associate Professor
Office:	627 ERB (weems@uta.edu, http://ranger.uta.edu/~weems)
Hours:	T 11:15 a.m - 1:15 p.m., R 1:00 - 3:00 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.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.

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

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

Exams:	80% (Test 1: 40%; Test 2: 40%, Thursday, December 17, 8:00 - 10:30 a.m)
Labs:	20% (Three labs, equal weight, submitted on Blackboard)

Policies:

1. Attendance is not required, but is highly encouraged.

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. Homeworks, with solutions, are available from the web page.

4. 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/`

5. Any request for special consideration must be appropriately documented **in advance**. (Special consideration does not include giving a higher grade than has been earned.)

6. Late labs are penalized 30% per day, i.e. up to 9:15 a.m. After the due date neither I, nor the GTA, will provide assistance.

7. Each student will have available *one* 48-hour no-penalty extension that may be applied to *one* of the lab assignments. To use your extension you must send an email to the grader *before* the due time.

8. 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/`

9. 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 (CSE 2320 notes 7)
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)
    - Fibonacci Heaps (19)
4.b. van Emde Boas Trees (20)
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)
8. Minimum Spanning Trees (23)
    - Brief review of Prim
    - Review of Kruskal's Algorithm and extension to detecting non-unique MST

- Boruvka's Algorithm*

TEST 1

9. Max-Flow/Bipartite Matching (26)
   - Ford-Fulkerson - review, maximum capacity paths*
   - Push-relabel methods
   - Vertex and edge connectivity*
   - Optimal Hashing*
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
   - Sweepline Algorithms
   - Plane Partitions and Point Location
   - Euclidean MST/Voronoi Diagram/Delaunay Triangulation
14. Sequences
   - Pattern Preprocessing Search
     - Rabin-Karp Algorithm (32.2)
     - Gusfield's Z Algorithm*
     - 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

August		September		October	
27	Syllabus	1	0.	3	1.
		8		10	2.
		15		17	3.
		22	4.	24	
		29	5.		

						1	6.
6	7.					8	8.
13						15	9.
20	Exam 1					22	
27	10.					29	

November				December			
3	11.	5		1	14.	3	
10		12	12.	8			
17	13.	19				17	Exam 2
24		26	Holiday				

November 4 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/).

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.

Only those students who have officially documented a need for an accommodation will have their request honored. Information regarding diagnostic criteria and policies for obtaining disability-based academic accommodations can be found at www.uta.edu/disability or by calling the Office for Students with Disabilities at (817) 272-3364.

Title IX: *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. For information regarding Title IX, visit* www.uta.edu/titleIX.

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.

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, go left then right. 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.