

CS 6161: Algorithms (Grad) Fall 2018

Instructor: Mohammad Mahmoody

Credit Units: 3

Time and Location: Tues Thurs 5pm-6:15pm, Mechanical Eng 205

Instructor: Mohammad Mahmoody (Rice 511) mohammad@cs.virginia.edu

TAs:

- Ahmadreza Rahimi ar7bc@Virginia.EDU
- Caleb Smith cns5za@virginia.edu

Office Hours:

- Mohammad's: Tues Thurs 6:15pm-7pm (after class) in Rice 511.
- Ahmadreza's and Caleb's office hours will be posted after getting your preferred dates.

Goals and Objectives: The aim of the course is to provide a good atmosphere for learning advanced topics in the design and analysis of algorithms. Ideally, students who are interested in research in this area, will find this course useful as well.

Prerequisites: No prerequisites are enforced, but being familiar with concepts of CS 3102 (theory of computation), CS 2102 (Discrete Math), and particularly Algorithms (CS 4102) will be extremely useful. The key is to be comfortable with math concepts and proofs.

Assignments and Grading: There will be a mid-term exam (Oct 16, 5:00-7:00pm in class) and a final exam (December 11, 9:00AM-11:00PM). There will be bi-weekly problem sets posted, and there will be bi-weekly problem solving sessions run by the TAs, but only *some* of the problem sets will be returned by you for grading. Exams will be 30% each, and the problem sets will be 40% total. The submitted assignments (for grading) should be written *individually*. You can collaborate on solving the problems

together, and you are even encouraged to do so, but (1) you should explicitly list the name and computing ID of your collaborators on top of the submitted drafts (which will be submitted as PDF in collab) and (2) you are *not* allowed to share *any* written material, so make sure you write the solutions on your own. This way you notice if there is anything that you have not fully understood, so you can come to the office hours and discuss them with us. If person X collaborates with person Y, they both have to mention this on top of their submission, and if either of them fails to do so, it means getting no grade for the submission by the person failing to do so.

Honor Policy: All are subject to the UVa's honor policy. <https://honor.virginia.edu/statement>

Syllabus: Quoted from catalog: *Analyzes concepts in algorithm design, problem solving strategies, proof techniques, complexity analysis, upper and lower bounds, sorting and searching, graph algorithms, geometric algorithms, probabilistic algorithms, intractability and NP-completeness, transformations, and approximation algorithms.*

This is the general broad description, but the topics will be diverse. Depending on time, we will go over the following topics and more, *not* necessarily in the order listed below. (The starred item are more advanced/optional, and more likely to be skipped). The plan for going over the material during the classes will be posted in a separate Google sheet. But, at a high level, the first half of the course will cover the more standard basic tools and notions from the CLRS book (see below) and the 2nd half will cover more advanced topics from various sources.

- Using randomization and probabilistic method in computation (as well as “derandomizing” probabilistic algorithms).
- Graph notions and algorithms. For example
 - Reachability algorithms (e.g., DFS, BFS).
 - Matching algorithms.
 - Max Flow, Min Cut.
 - Various forms of shortest path(s)
 - Finding (Eulerian) Tours.
- Various data structures supporting search, update, delete, etc.

- Classical algorithmic techniques: Greedy (e.g., minimum spanning tree), Dynamic (e.g., triangulation), and Divide and Conquer (e.g., matrix multiplication, merge sort).
- Beyond “standard” analysis techniques:
 - Amortized analysis.
 - Competitive analyses.
 - Average-case analysis.
- Approximation Algorithms (e.g., as a way to deal with NP-hardness).
- More powerful optimization techniques:
 - Linear Programming, rounding and randomized rounding.
 - Duality theorem and Von Neuman’s min-max theorem.
 - * Ellipsoid method.
 - * Semi-definite programming.
- Number theory and cryptographic algorithms:
 - Finding prime numbers.
 - RSA cryptosystem.
- Geometric Algorithms (e.g., convex hull, minimum triangulation).
- Online and streaming algorithms:
- Sub-linear algorithms for large data sets.
- Lower bounds, NP-hardness and hardness of approximation:
 - Cook-Levin Theorem and basic NP-hardness results.
 - Reductions

Textbook and other Resources: There will be no particular text book for the class, but there are several suggested books:

- *Algorithm Design* by Jon Kleinberg and Eva Tardos.
- *Algorithms* by S. Dasgupta, C. H. Papadimitriou, and U. V. Vazirani.

- *Algorithms* by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein.

The first half of the course will cover materials mostly from the 3rd book above (referred to as CLRS) and the 2nd half of the course will cover more advanced material from various sources.

Suggested readings will be posted to Piazza and course's page.

Course's Pages: Piazza: <https://piazza.com/virginia/fall2018/cs6161/>

Main page: <https://www.cs.virginia.edu/~mohammad/courses/algo/fall18/>

There you can find the class notes as well as suggested readings.

Collabe page:

<https://collab.its.virginia.edu/portal/site/a89d9ad2-8fdf-4d24-8db9-90e2c39ab753>

Mailing list: algorithms-fall-2018@collab.its.virginia.edu it is assumed that you check the piazza page for announcements, etc, but the mailing list might be used as well.

Disabilities accommodation. The University of Virginia strives to provide accessibility to all students. If you require an accommodation to fully access this course, please contact the Student Disability Access Center (SDAC) at (434) 243-5180 or sdac@virginia.edu. If you are unsure if you require an accommodation, or to learn more about their services, you may contact the SDAC at the number above or by visiting their website at <http://studenthealth.virginia.edu/student-disability-access-center/faculty-staff>

Sexual assault prevention. The University of Virginia is dedicated to providing a safe and equitable learning environment for all students. To that end, it is vital that you know two values that I and the University hold as critically important: (1) Power-based personal violence will not be tolerated. (2) Everyone has a responsibility to do their part to maintain a safe community on Grounds. If you or someone you know has been affected by power-based personal violence, I urge you to check this link that describes reporting options and resources available: <http://eocr.virginia.edu/>

Religious accommodation. It is the University's long-standing policy and practice to reasonably accommodate students so that they do not experience an adverse academic consequence when sincerely held religious beliefs

or observances conflict with academic requirements. Students who wish to request academic accommodation for a religious observance should submit their request in writing directly to me (Mohammad) by email as far in advance as possible. Students and instructors who have questions or concerns about academic accommodations for religious observance or religious beliefs may contact the University's Office for Equal Opportunity and Civil Rights (EOCR) at UVAEOCR@virginia.edu or 434-924-3200. Accommodations do not relieve you of the responsibility for completion of any part of the course-work missed as the result of a religious observance.