CS 6161: Algorithms (Grad) Spring 2022

Instructor: Mohammad Mahmoody

Credit Units: 3

Time and Location: Mon and Wed 3:30pm - 4:45pm, Thornton Hall E316. The class will be live streamed, and you can also join by Zoom. The link will be available in course's Collab page.

Instructor: Mohammad Mahmoody `mohammad@virginia.edu`

TAs: Abtin (Nima) Afshar `na6xg@virginia.edu` and Zakaria Mehrab `zm8bh@virginia.edu`

Office Hours: Virtual at Class's Zoom link

- Mohammad's: Tuesdays 1pm-2pm.
- TAs' office hours are Thursdays 2:45pm-4pm.
- There will also be problem-solving sessions after each problem set is graded, in which we go into the details of the problems. The time of the problem solving sessions will be posted later.

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.

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

Assignments and Grading: There will be a mid-term exam and a final exam. The goal is to have them in person, but depending on the COVID situation, we might have them take home as well. There will be 3 or 4 problem sets. Exams will be 20% of the final grade each, and the problem sets each will be 15% or 20% of the grade. The grades will be curved, so if your numbers are low, you should not (necessarily) be worried. 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.

How to submit solutions. You will have to write your solutions using pre-filled templates available on Overleaf using Latex, and then you need to submit them through GradeScope. You don't need to know Latex know to be able to write solutions easily. The templates can be compiled, and you basically just have to learn how to write basic math formulas in Latex.

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.
- 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: TThere are several suggested books:

- *Algorithm Design* by Jon Kleinberg and Eva Tardos.
- *Algorithms* by S. Dasgupta, C. H. Papadimitriou, and U. V. Vazirani.
- **Introduction to Algorithms, 3rd Edition** by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein.

But we will mostly use the last option (referred to as CLRS).
Suggested readings will be posted the course's page.

Course's Pages:

- Web: https://www.cs.virginia.edu/~mohammad/courses/algo/sp22/
- Piazza: https://piazza.com/virginia/spring2022/cs6161/
- Collab: https://collab.its.virginia.edu/portal/site/5debab7f-8447-47d3-9d3a-3ce727d10d19
- Dates: https://docs.google.com/spreadsheets/d/1P8p56urXZA5CHYZmyuBORv5Dcn_pMfWsusgeKV2V2iA/

Live streaming the class: Due to COVID-19, the class will be live streamed. You can attend the class virtually and ask questions just like those in the class. The lectures will also be recorded and you can find them through the Collab page of the class right after the class.

Mailing list: @collab.its.virginia.edu it is assumed that you check the piazza page as well as the mailing list for the announcements.

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 coursework missed as the result of a religious observance.