CS 4102: Algorithms   **Spring 2020**

M/W 2:00-3:15p,
M/W 5:00-6:15p   **M/W 3:30-4:45**
Instructor: Robbie Hott   **Instructor:** Tom Horton
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Office: Rice Hall 210   Office: Rice Hall 401
Office Hours: M/W 11:00a-12:00p,   Office Hours: M/W 1:30-2:30p,
   Tu 3:00p-4:00p   Tu/Th 10:30-11:30a,
                                           Th 1:00-2:00p

Teaching Assistants: See Collab

Overview

Course Description: Introduces the analysis of algorithms and the effects of data structures on them. Algorithms selected from areas such as sorting, searching, shortest paths, greedy algorithms, backtracking, divide-and-conquer, and dynamic programming. Data structures include heaps and search, splay, and spanning trees. Analysis techniques include asymptotic worst-case, expected time, amortized analysis, and reductions between problems

Availability: It is important to us to be available to our students, and to address their concerns. If you cannot meet with either of us during our office hours, e-mail us and we will find the time to meet. That being said, like everybody else we are quite busy, so it may take a day or more to find a time to meet. And if you have any comments on the course—what is working, what is not working, what can be done better, etc.—we are very interested in hearing about them. Please send Prof. Hott, Prof. Horton, or one of the TAs an e-mail or post privately on Piazza to the instructors. We tend to get bogged down by e-mail as the semester progresses, so seeing us in person (right after lecture, during office hours, etc.) is often a good way to get a more immediate response. If your question could be answered by either professor or even a TA, a post on Piazza to "instructors" may get a faster response.

Prerequisites: CS 2102 and 2150 with grades of C- or higher, and APMA 1090 or MATH 1210 or MATH 1310. (Prerequisites are important to this course and will be enforced!)

Course Objectives: Students who complete the course will:

- Comprehend *fundamental ideas in algorithm analysis*, including: time and space complexity; identifying and counting basic operations; order classes and asymptotic growth; lower bounds; optimal algorithms.

- Apply these fundamental ideas to *analyze and evaluate important problems and algorithms* in computing, including search, sorting, graph problems, and optimization problems.

- *Apply appropriate mathematical techniques in evaluation and analysis*, including limits, logarithms, exponents, summations, recurrence relations, lower-bounds proofs and other proofs.

- *Comprehend, apply and evaluate the use of algorithm design techniques* such as divide and conquer, the greedy approach, dynamic programming, and exhaustive or brute-force solutions.

- Comprehend the fundamental ideas related to the *problem classes NP and NP-complete*, including their definitions, their theoretical implications, Cook's theorem, etc. Be exposed to the design of polynomial reductions used to prove membership in NP-complete.

Textbook: *Introduction to Algorithms, Third Edition* by Cormen, et. al. (ISBN 0262033844). UVA Library makes a digital version of our textbook available online at
`https://search.lib.virginia.edu/catalog/u6757775`
Note: How much we ask you to read from this textbook may vary between instructors. Your instructor will say more about this in class.

Additional Resources: We will make additional optional textbooks and resources available on the course website.

Grading and Assignments

Grades: Grades will be computed by the following formula:

- 60% Assignments

- 20% Midterm

- 20% Final Exam

- 10% Extra Credit

We recognize that we cannot expect to produce assignments which are perfect evaluations of your fluency in course material. As such, grade breakdowns will be determined after all assignments are graded. This adjustment will occur prior to assessing extra credit.

Note: We reserve the right to modify the weighting (changing the curve, adding pop quizzes, etc.), especially if attendance drops off significantly. If this happens, it will be clearly announced in lecture. However, attendance in this class is not mandatory. You can still receive an A if you are not present in lecture, although you will obviously have to find other ways to participate in the course. If you do attend class, then you must agree to limit computer usage to things directly helping you understand the lectures, such as following the slides online, etc. We reserve the right to forbid using laptops/phones in class.

Extra Credit: Extra credit will be awarded for any action which displays *extraordinary engagement* with the course. Actions deserving of extra credit include, but are not limited to, insightful questions/comments in lecture, completing given extra credit assignments, submitting responses to current events which are relevant to algorithms, attending special seminars/colloquia, slide corrections, compelling office-hours conversation. Actions that require more effort to complete will be given a higher weight than those that require little effort. As a general rule, if you have done something that you feel might be deserving of extra credit, just ask for it! Submit extra credit via email to `extracredit.cs4102@gmail.com`. Extra Credit **must** be submitted by the last day of class.

Exams: There will be one midterm exam, as well as a final. The (tentative) exam dates are as follows:

- Midterm: Wednesday, March 4, in-class (with additional take-home component)

- Final (for all sections): Saturday, May 2, 2020, 7-10pm

Assignments: This course will have a heavy emphasis on programming the algorithmic techniques taught. The homeworks will thus be about 1/3 programming and 2/3 traditional pen-and-paper problems. Expect about 10 homework assignments throughout the semester.

Programming assignments may be completed in either **Python** or **Java**.

The pen-and-paper (a.k.a. "written") assignments are not really pen-and-paper: they must be typeset with LaTeX, a professional formatting system. Tutorials on how to use LaTeX will be made available when the first written problem set is released. LaTeX is easily installable on many computers:

- Overleaf, `http://overleaf.com`: a Web-hosted LaTeX editor which behaves much like Google Docs.

- Cygwin (which you saw in CS 2150) has LaTeX packages that can be installed

- MiKTeX provides a stand-alone installer for Windows and Mac, `miktex.org`

- Ubuntu and CentOS provide TeXLive packages in their repos

- LyX, TexShop, and TeXStudio are GUI editors available either through the MiKTeX and TeXLive repos or available as separate downloads.

We strongly recommend using Overleaf, `http://overleaf.com`, since it contains all the necessary packages and works in-browser. We generally will not accept LaTeX documents with images of text or formulas; **you must typeset the formulas in LaTeX**, not in another program and have them exported as images.

Submission System: All homeworks will be submitted via Collab. For written assignments, you must submit both a PDF of your write up as well as a zip file containing your `.tex` markup files (as two separate attachments). For programming assignments, you must submit your modified `.java` or `.py` files containing all of your code. In both cases, you must include a

list of your collaborator's computing IDs and cited sources in the file headers. Remember, submit extra credit via email to `extracredit.cs4102@gmail.com`.

Late Policy: $grade = grade_{earned}e^{-\frac{days}{2\varphi}}$.

Your grade for each assignment is given by the above formula (this is an exponential decay formula). To calculate your grade, let $grade_{earned}$ be your earned grade (the remaining grade after scoring), let $days$ be the (fractional) number of days late, let $\varphi = \frac{1+\sqrt{5}}{2}$ be the golden ratio, and e be Euler's number. To give you an idea of the result of this scheme, submitting an assignment 4 hours late ($days = 1/6$) will result in a grade penalty of 5%, submitting 1 day late will result in an $\approx 27\%$ penalty, and submitting 2 days late will result in an $\approx 46\%$ penalty.

Regrades: Regrades on assignments are limited to *2 weeks* after the grades for that assignment have been returned. All regrades are conducted in person. Regrade office hours will be posted on the course website, please attend these office hours to discuss your assignments. If you are unable to make this time, then please schedule an appointment.

Collaboration Policy

Exams: Exams are always individual assignments; collaboration with others is not allowed for the midterm and final. Any solutions that share similar text or code will be considered in breach of this policy.

Homeworks: You are encouraged to collaborate with up to 4 other students in the course on each homework, but all work submitted must be your own independently written solution. While you may discuss techniques and collectively solve the problems in your group, you may **not** share any written notes, documents, or code. For instance, shared Overleaf or Google Docs are **not** allowed. Likewise, pair programming or sharing the debugging of code are **not** allowed. Any solutions that share similar text or code will be considered in breach of this policy. You **must** list the names and computing IDs of all of your collaborators in your submitted `tex`, `py`, and `java` files.

Do not seek published or online solutions for any assignment or exam. Any submission which is discovered to be similar to a published solution or one found online will be considered in breach of this policy. If you use any published or online resources (they must not include solutions) when completing your assignments, be sure to cite them.

Note that it is a violation of this policy to submit a problem solution that you are unable to explain orally to a member of the course staff, and we reserve the right to spot-check for this requirement.

Penalty: Assignments or exams where violations of this policy occur will receive a **zero** grade for that entire assignment or exam, as well as a **full letter-grade** penalty on the course grade. Second infractions will result in a **failing (F)** grade in the course. Any infractions will also be submitted to the Honor Committee if deemed appropriate.

Additional Information

Special Circumstances: 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 `http://studenthealth.virginia.edu/sdac`.

For this course, we ask that students with special circumstances let us know as soon as possible, preferrably during the **first week of class**.

Religious Accommodations: 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 to Prof. Hott or Prof. Horton as far in advance as possible. If you have questions or concerns about academic accommodations for religious observance or religious beliefs, visit

> `https://eocr.virginia.edu/accommodations-religious-observance`

or 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.

Safe Environment: 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 we 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, more information can be found on the UVA Sexual Violence website that describes reporting options and resources available – `www.virginia.edu/sexualviolence`.

As your professor and as a person, know that we each care about you and your well-being and stand ready to provide support and resources as we can. As a faculty member, we are responsible employees, which means that we are required by University policy and federal law to report what you tell us to the University's Title IX Coordinator. The Title IX Coordinator's job is to ensure that the reporting student receives the resources and support that they need, while also reviewing the information presented to determine whether further action is necessary to ensure survivor safety and the safety of the University community. If you would rather keep this information confidential, there are Confidential Employees you can talk to on Grounds (See `http://www.virginia.edu/justreportit/confidential_`

`resources.pdf`). The worst possible situation would be for you or your friend to remain silent when there are so many here willing and able to help.

Well-being: If you are feeling overwhelmed, stressed, or isolated, there are many individuals here who are ready and wanting to help. The Student Health Center offers Counseling and Psychological Services (CAPS) for all UVA students. Call 434-243-5150 (or 434-972-7004 for after hours and weekend crisis assistance) to get started and schedule an appointment. If you prefer to speak anonymously and confidentially over the phone, Madison House provides a HELP Line at any hour of any day: 434-295-8255.