CSCI 256: Algorithm Design and Analysis

Spring 2025

Instructor:	Sam McCauley	**Time:**	MR 1:10–2:25, 2:35–3:50
Email:	sam@cs.williams.edu	**Place:**	Schow 30B

Webpage: https://williams-cs.github.io/cs256-s25/index.html

Office Hours: Tuesday 2–4PM, Wednesday 2–4PM, Friday 1:30–2:30PM

Textbooks: The primary text for the course is *Algorithm Design* by Jon Kleinberg and Éva Tardos, Addison-Wesley 2006. This will be supplemented by readings from the *Algorithms* textbook by Jeff Erickson available at http://jeffe.cs.illinois.edu/teaching/algorithms/book/Algorithms-JeffE.pdf

Objectives: This course is about mathematical modeling of computational problems, developing common algorithmic techniques to solve them, and about analyzing the correctness and running time of the algorithms. By clearly formulating and carefully analyzing the structure of a problem, it is often possible to dramatically decrease the computational resources needed to solve it. In addition, by analyzing algorithms you can provide provable guarantees of their performance. We will study several algorithm design strategies that build on data structures and programming techniques introduced in CS 136 and mathematical tools introduced in MATH 200. The course will roughly cover the following topics in order: graph algorithms, greedy algorithms, divide-and-conquer, dynamic programming, NP completeness and problem reductions, approximation algorithms and randomized algorithms. At the end of the course, the students should be able to:

- Analyze worst-case running time and space usage of algorithms using asymptotic analysis.
- Formulate real-world optimization problems mathematically (using concepts like sets and graphs) and apply algorithmic paradigms such as divide-and-conquer and dynamic programming to solve them.
- Identify and prove that certain computational problems are NP-hard or NP-complete, that is, show that they are unlikely to admit an efficient solution.
- Design and analyze simple randomized algorithms for computational problems.

Prerequisites: CSCI 136 and the Discrete Math Proficiency Requirement

Course Outline:

- Part 1: Graph Algorithms and Greedy Algorithms
- Part 2: Divide & Conquer, Dynamic Programming, Network Flows
- Part 3: Reductions, NP Hardness, Randomized and Approximation Algorithms

Grading Policy: Daily Homeworks (10%), Problem Sets (10%), Midterm 1 (25%), Midterm 2 (25%), Final (30%)

The exams will be slightly reweighted based on performance: the lowest score will be worth 5% less, and the highest will be worth 5% more.

Academic Honesty: For a full description of the Computer Science Honor Code, please see: https://csci.williams.edu/the-cs-honor-code-and-computer-usage-policy/. If you have any doubt about what is appropriate, please email me at sam@cs.williams.edu.

Midterm and final exams are to be the sole work of each student. No collaboration or discussion is allowed.

On problem sets and daily homeworks, students should not use online resources except for Latex debugging. Students should never look up answers to assignment questions, or to similar assignment questions.

Students are encouraged to use course materials—textbooks, notes from lectures, and slides—as a reference when answering questions, as well as the TAs and instructor in office hours.

Problem Sets: This course will have problem sets, released (approximately) weekly. Problem Sets are graded largely on completion: while a correct answer is required to get full credit, there will be considerable partial credit given for an attempt at a solution.

All problem sets must be typeset using Latex using the template provided. Latex is free and available on all lab computers; it can also be installed on your personal computer, or accessed via a web interface (Overleaf). The goal of Latex is to allow users to focus on content, rather than typesetting concerns, while still allowing flexibility and the ability to make beautiful documents. Latex has many useful tools—in this course we will often be using the tools for mathematical typesetting, but Latex can be used in a wide variety of circumstances. This syllabus was typeset using Latex.

A (small) portion of the grade for each problem set will be based on correctly using Latex. We will provide resources to help students get up to speed with effective Latex typesetting.

Problem sets will be done in pairs; the pairs will be randomly assigned for each problem set.

Problem sets are intended to be challenging and to explore the material more deeply. Students are particularly encouraged to get help from the instructor and TAs if they find themselves stuck on a problem set.

Daily Homeworks: Most lectures will be accompanied by a daily homework. Each is due at the beginning of the next lecture. These homeworks should be completed and submitted on paper; Latex is not required. The homeworks will be handed out during each lecture, and will also be available on the Glow page for the course. Daily homeworks will be graded coarsely: students will get a check mark for full credit, a check minus if significant parts are mising, or will get no credit if ther assignment was not submitted or the solution is almost entirely missing. Solutions to each homework will be released immediately after they are due.

The daily homeworks focus more on how algorithms work mechanically, rather than the deeper proofs of problem sets. The TAs and instructor are great resources for reinforcing the underlying topics of daily homeworks, but they will generally not directly give information about daily homework solutions.

Grading and Late Policy: All grading will be done anonymously.

All problem sets will be weighted equally toward the final grade. Each student's lowest problem set grade will be dropped. Late problem sets will have a penalty of 10% per day late.

Late daily homeworks will not be accepted; however, the lowest 4 daily homework grades will be dropped.

Midterms: We will have two in-class midterms. The first will be on March 10, and the second will be on ~~April 24~~ April 28 during the normal lecture period.

Final Exam: We will have a 2.5 hour scheduled exam on Sunday May 25th at 1:30pm.

Accommodations: Students with disabilities of any kind who may need accommodations for this course are encouraged to contact Katy Evans (Interim Director of Accessible Education) at 597–4672. I am happy to discuss accommodations personally as well. Also, students experiencing mental or physical health challenges that are significantly affecting their academic work or well-being are encouraged to contact me and/or speak with a dean so we can help you find the right resources. The deans can be reached at 597-4171.

The college generally reaches out to professors about accommodations. If any of your accommodations affect how you interact with the course (e.g. by changing a due date), I will reach out to you with these changes. If you have not heard from me about accommodations you should have, please let me know as soon as possible so that we can make sure any resources are prepared in time.

Health and Accessibility Resources: Students with disabilities or disabling conditions who experience barriers in this course are encouraged to contact me to discuss options for access and full course participation. The Office of Accessible Education is also available to facilitate the removal of barriers and to ensure access and reasonable accommodations. Students with documented disabilities or disabling conditions of any kind

who may need accommodations for this course or who have questions about appropriate resources are encouraged to contact the Office of Accessible Education at oaestaff@williams.edu

Inclusion and Classroom Culture: The Williams community embraces diversity of age, background, beliefs, ethnicity, gender, gender identity, gender expression, national origin, religious affiliation, sexual orientation, and other visible and non visible categories. I welcome all students in this course and expect that all students contribute to a respectful, welcoming and inclusive environment. If you have any concerns about classroom climate, please come to me to share your concern.

Addressing Each Other: In this class, we use the name and gender pronouns that individuals ask us to use as a sign of mutual respect. I will use the pronouns you have indicated on GLOW unless you alert me to a different pronoun (I'll also ask in the intro form, as a part of Problem Set 0). That said, everyone makes mistakes—in general, should you use an incorrect pronoun or name, the best course of action is to make a quick correction and move on, rather than dwelling on it.