CS256: Algorithm Design and Analysis

Syllabus for Spring 2023

General Info

Instructor: Bill Jannen
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Course Web Page: `http://www.cs.williams.edu/~jannen/teaching/s23/cs256`

Texts

We will be using the following textbook in this course:

- *Algorithm Design* (1st edition, 2006) by Jon Kleinberg and Éva Tardos.

This book is available from the college's bookstore. Since it is the same book that has been used during many previous CSCI 256 offerings, you may be able to find a friend who has an extra copy to share.

Supplemental resources, if there are any, may be drawn from various sources, including scribe notes, textbook excerpts, instructional videos, and other digital resources. Any supplemental resources will be made digitally accessible from the course website, although some may only be accessible while connected to the Williams network. If you are ever off-campus, you can always access college resources using the library's proxy server or the college's VPN.

Course Description & Objectives

This course investigates methods for designing efficient and reliable algorithms. By carefully analyzing the structure of a problem within a mathematical framework, it is often possible to dramatically decrease the computational resources needed to find a solution. In addition, analysis provides a method for verifying the correctness of an algorithm and accurately estimating its running time and space requirements. We will study several algorithm design strategies that build on data structures and programming techniques introduced in Computer Science 136. These include greedy, divide-and-conquer, dynamic programming, and network flow algorithms. Additional topics of study include algorithms on graphs, strategies for handling potentially intractable problems, and randomness in algorithms and data structures.

Upon the completion of this course, students will 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.
- Describe contexts in which asymptotic analysis has significant predictive power; also, describe practical factors that must be considered when using asymptotic analysis techniques to reason about an

algorithm's efficiency on physical computing hardware.

Course Structure

Course meetings. There will be three course meetings each week. Course meetings will consist of a combination of lectures, problem solving, and active learning exercises where we explore the material in small groups. It is therefore important that you come prepared and always bring writing materials.

When there are required readings, you may choose to complete those required readings before *or* after their corresponding meeting. Your choice will likely depend on your learning style and preferences.

Attendance and Participation. Attendance is important in this course; students who cannot regularly attend class meetings will need instructor permission in order to complete the course. However, if you cannot attend a particular course meeting, please email your instructor to let them know. Excused absences will not count against your participation grade. So if you are feeling ill, please stay home!

Attendance is only a part of the participation grade. Learning is a collaborative endeavor and class participation is both encouraged and rewarded in this class. Participation can take various forms, including coming to class prepared, being a constructive participant in class exercises, answering and asking questions, attending office hours, engaging on course discussion boards, *completion of in-class collaborative activities*, etc.

Assignments. Problem sets will be an important part of this course. Assignments will be posted on the course's Glow site.

Problem sets will be graded on correctness, clarity, and completeness. Note that complete *does not* mean long; in this course, we will strive to develop complete answers that are concise. In addition, thoughtful attempts at complete solutions will be rewarded: stating your approach and where you got stuck is much better (both grade-wise and for your own learning) than not submitting any answer. Most assignment problems will ask for either a proof or a counter-example.

All assignments must be typeset in 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). 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, e.g., this syllabus was typeset using LaTeX. Resources for getting started with LaTeX can be found in the course's resources webpage.

Assignments must be submitted via gradescope. You will be asked to create a free gradescope account if you do not already have one.

Collaboration. Collaboration is important, and this course will permit a variety of collaboration styles. Each assignment specification will explain the types of collaboration that are permitted for that assignment.

For *problem sets* you may discuss your strategies and ideas for solving problem set questions with other students, but you may not share any *written* solutions (this prohibition includes both typeset and "raw" solutions). You should never view a written solution that you did not write yourself, nor should you offer to show another classmate your own written solutions; sharing digital or printed solutions is *always* a violation of the honor code. After collaborating on problem approaches (if you choose to do so), you must write your solutions on your own. This is the only way to demonstrate *your* grasp of the material. Independently writing your solutions is an important part of your learning.

Deadlines. There are many valid reasons to miss a deadline. However, deadlines play an important part in course administration, and falling behind often negatively impact your other courses. I want to be flexible in a way that promotes your best interests.

Each student may utilize up to three late days for homework assignments throughout the semester, although no more than two late days may be used on any single assignment. Late days are discrete. Using a single late day allows you to submit an assignment up to 24 hours after it is due. Using two late days allows you to submit your assignment 48 hours after it is due. You do not need to provide a reason for using a

late day; Gradescope will automatically have a "late submission" setting enabled. Once your late days have passed, your late work will be penalized 25% per day and must be submitted directly to me via email.

We will always award partial credit for any work that you submit, so factor that into your decisions.

Exams. There will be one midterm exam, which will be administered during a regularly scheduled class meeting. The cumulative final exam will be a scheduled exam during the college's end-of-term exam period.

Grading. I will use the following evaluation criteria when determining final grades:

Problem Sets:	30%
Preparation and participation:	10%
Midterm Exam:	30%
Cumulative Final Exam:	30%

Honor Code

Collaboration is strongly encouraged within the guidelines stated above. However, violations of course collaboration rules will be considered a violation of the honor code and will be forwarded to the honor committee. If in doubt of what is appropriate, do not hesitate to ask your instructor. For a full description of the Computer Science Honor Code, please see
`https://csci.williams.edu/the-cs-honor-code-and-computer-usage-policy/`.

Workload.

At Williams, we operate under the course unit system (rather than the credit hour system). You should expect to spend (on average) at least 13 hours per week on the academic and creative work related to class. This includes time spent meeting as a class and working on assignments. The Office of the Registrar explains the relationship of course units to credit hours in greater detail.

If you find yourself spending significantly more or significantly less time on this course, please let me know.

Course Calendar and Schedule.

The course calendar and schedule can be found on the course webpage, including information about the readings. The course webpage will be regularly updated after each course meeting to make all lecture materials and examples available for review.

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.

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. 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.

Help!!!

Help. We all need it. There are many resources available when *you* need it. You are encouraged to discuss any questions, concerns, difficulties, or thoughts about the course with your instructor. If you find yourself facing challenges beyond the typical, we encourage you to reach out. Talk to your instructor, a friendly face from the Dean's Office, or some of the many professionals across campus who stand ready to help, including:

- The Peer Academic Support Network: For details, go to:

  `https://academic-resources.williams.edu/peer-academic-support/`

- Math & Science Resource Center: Support is available for students grappling with the more quantitative aspects of their coursework. For details, go to:

  `https://academic-resources.williams.edu/peer-academic-support/math-science/`

- Accessible Education and Disability Support Center: Some students with documented disabilities may require accommodations in certain situations. If that's you, take advantage of the options available. Go to

  `https://academic-resources.williams.edu/disabilities/` for details.

- The Health Center: Sometimes your challenges are not course-related. The Health Center provides a range of medical, psychological, and health/wellness services. Go to `https://health.williams.edu` for details.