

**15-351/15-650/02-613 Algorithms & Advanced Data Structures  
Fall 2023**

**Textbook:** *Algorithm Design* by Jon Kleinberg and Éva Tardos. Addison Wesley, 2005. ISBN: 0-321-29535-8.

**Office hours:** Will be posted on the class webpage. You are encouraged to make use of office hours, and the TAs will be as helpful as possible to explain material and homework questions and solutions.

**Final:** According to the university's schedule

**Course objectives:** The objective of this course is to study general computational problems and their algorithms, with a focus on the principles used to design those algorithms. After passing this class, you should be able to:

1. analyze running time for many kinds of algorithms
2. design divide-and-conquer algorithms
3. design dynamic programming algorithms
4. design network flow-based algorithms
5. write linear / integer programs
6. apply large-scale search / heuristic algorithms
7. efficiently store and answer queries about data
8. prove a problem is NP-complete

**Coursework:** Coursework will consist of near weekly homeworks that will include algorithm design and analysis problems, 2 midterms, and a final. The midterms will be non-cumulative, while the final will cover everything from the class.

**Grading:** The default grading scheme will be as follows:

- 20% for homeworks
- 25% for midterm 1
- 25% for midterm 2
- 30% for the final

However, if you turn in every single homework assignment and achieve a nonzero score on all of them, you will be eligible for the following alternate grading scheme:

- 20% for homeworks
- 25% for the midterm you perform better on
- 15% for the midterm you perform worse on
- 40% for the final

**What about programming?** This course is **not** a programming course. It is an algorithm design and analysis course. Part of the point of the course is to learn to be able to think about

algorithms separately from programming. The course's focus is on being able to understand algorithms theoretically not empirically. You are of course welcome (and encouraged!) to implement any of the discussed algorithms as a way to help yourself understand them, and we can provide starting source code for some of them.

**What's the difference between 02-613, 15-650 and 15-351?** All the courses have the same structure, same lectures, same TAs, etc. Those who are signed up for one of the graduate numbers (02613 or 15650) will have a few additional assignments. The grading curve will also be computed separately in each of the three courses.

**Tentative schedule:** The class has 4 major subunits:

1. Introduction, Minimum Spanning Tree case study (with Heaps, Union Find, Graph data structures), Asymptotic analysis [ $\approx$  1 week]
2. Divide & conquer and graph algorithms [3 weeks]
  - Graph search: Breadth first, depth first, topological sorting
  - Finding closest pair of points
  - Fast Fourier Transform
  - Matrix Multiplication
  - Shortest path algorithms
  - A\* heuristic search
3. Additional Data Structures [ $\approx$  1.5 weeks]
  - Suffix trees & string matching
  - Splay trees & amortized analysis
4. Advanced algorithmic design techniques [2nd half of semester]
  - Dynamic programming (edit distance, RNA folding, chains of matrix multiplication, etc.)
  - Network flow and its use for solving problems (like matching, survey design)
  - Linear and integer programming
  - NP-completeness
  - Randomized algorithms (hashing & global minimum cut)

**Homework policies:**

- Homeworks are due online at the assigned time. Every homework can be submitted up to 1 day late for a 20% penalty. No other late homeworks will be accepted.
- Answers to homework problems should be written concisely and clearly. Homeworks must be handwritten and submitted online (either scanned or written on a tablet). Your midterms and final exam will be handwritten, so we want you to practice in that format. Instructions for submission will be posted on the course webpage.
- Homework problems that ask for an algorithm should present: a clear English description, an argument that the algorithm is correct, and an analysis of the running time. Note: your goal is to explain the algorithm to a human, not a computer — as such detailed pseudocode or source code is usually *not* the best way to explain an algorithm. Do not use pseudocode to obscure your answer.

- Solutions should be as short, clear, and concise as possible. We will be taking marks off for long, meandering solutions to otherwise short problems, even if all of the reasoning is technically correct. Brevity is the soul of wit.
- Regrade requests should be made **in writing** within 1 week of the homework being returned. The entire homework or exam in question will be regraded, which may result in a higher or lower grade than originally returned.
- You may discuss homework problems with classmates. You must list the names of the class members with whom you worked at the top of each solution (if you worked with Jane Doe on problems 1 and 2, you should write down her name as a collaborator in the solution for both problems). **You must write up your own solution independently!** “Independently” means — at least — that you cannot look at another person’s homework, you cannot have them look at yours to see if it is correct, you cannot take detailed notes from a discussion and edit them into your homework, and you cannot sit in a group and continue discussing the homework while writing it up. The intent of this rule is: you can gather around a chalkboard with your fellow students and discuss how to solve the problems. Then you must all walk away and write the answers up separately.  
Unfortunately, each semester, we find some people who have copied each other’s homeworks. Such instances are referred to the University according to the academic integrity violation policy.
- You may *never* use, look at, study, or copy any answers or exams from previous semesters of this course.

**Class format:** All lectures will be entirely in-person; there will not be recordings made available. We will generally try to point to relevant readings for each lecture however.

Online questions and discussions will be conducted via Piazza. You should post questions there, though please be careful not to give away any answers to problems. General questions should be public to the rest of the class, but you may also use private notes to communicate with just the teaching staff.

**Classroom etiquette:** To minimize disruptions and in consideration of your classmates, I ask that you please arrive on time and do not leave early. If you must do either, please do so quietly. Laptop use is discouraged; their use detracts significantly from the benefit of coming to class (wouldn’t it have been more fun to spend an hour surfing Tiktok at home?) and also provides a distraction for other students. If you must use your laptop, please turn the sound off, type quietly, and sit as far towards the back of the room as possible.

**Excused absences:** Students claiming an excused absence for an exam or midterm must supply documentation (such as a doctor’s note) justifying the absence. Absences for religious observances must be submitted by email to the instructor during the first two weeks of the semester.

**Academic honesty:** All class work should be done independently unless explicitly indicated on the assignment handout. You may *discuss* homework problems with classmates, but must write your solution by yourself. If you do discuss assignments with other classmates, you must supply their names at the top of your homework / source code. No excuses will be accepted for copying others’ work (from the current or past semesters), and violations will be dealt with harshly. (Getting a bad grade is much preferable to cheating.)

The university's policy on academic integrity can be found here: <https://www.cmu.edu/policies/student-and-student-life/academic-integrity.html>. In part it reads "Unauthorized assistance refers to the use of sources of support that have not been specifically authorized in this policy statement or by the course instructor(s) in the completion of academic work to be graded. Such sources of support may include but are not limited to advice or help provided by another individual, published or unpublished written sources, and electronic sources." You should be familiar with the policy in its entirety.

**In particular: use of a previous semester's answer keys or online solution manuals for graded work is absolutely forbidden. Generative artificial intelligence tools are also strictly forbidden. Any use of such material will be dealt with as an academic integrity violation.**

**Accommodations for students with disabilities:** If you have a disability and have an accommodations letter from the Disability Resources office, we encourage you to discuss your accommodations and needs with us as early in the semester as possible. We will work with you to ensure that accommodations are provided as appropriate. If you suspect that you may have a disability and would benefit from accommodations but are not yet registered with the Office of Disability Resources, we encourage you to contact them at [access@andrew.cmu.edu](mailto:access@andrew.cmu.edu).

## Frequently Asked Questions

**Is there some extra work I can do to improve my grade?**

No, we cannot make exceptions to the course work and grading policy. If you are concerned about your grade, please see me or one of the TAs ASAP. There will be no exceptions to this policy during or after the class has completed.

**I have to be out of town, and I would like an extension on my homework. Can I have one?**

No. This is a very large class, and it is not possible to accommodate individualized deadlines for everyone. You can always turn your homework in early (if the link is not available, please ask a TA). You can also always turn your homework in remotely.

## Provost's Statement on Student Well-Being

**Take care of yourself.** Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress.

All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful.

If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at <http://www.cmu.edu/counseling/>. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.

If you or someone you know is feeling suicidal or in danger of self-harm, call someone immediately, day or night:

- **CaPS: 412-268-2922**
- **Re:solve Crisis Network: 888-796-8226**

If the situation is life threatening, call the police:

- **On campus: CMU Police: 412-268-2323**
- **Off campus: 911**

If you have questions about this or your coursework, please let us know.