CSE 101: Algorithm Design and Analysis, Spring, 2025 Syllabus

# About the Course

Cutting-edge applications from large language models to bioinformatics to data science to circuit design to internet commerce require efficient use of computational resources. In this course, we will learn how to precisely specify the requirements of applications, and learn the most useful general techniques for designing and analyzing efficient algorithms for these applications. These techniques include graph search, reductions, greedy algorithms, divide-and-conquer, dynamic programming and hill-climbing algorithms such as for network flow. We will also look at inherent limitations of algorithms due to the computational complexity of problems, and how to circumvent some of these limitations, e.g., by designing approximation algorithms.

## Prerequisites

We assume that students will have had exposure to basic discrete mathematics, including graphs, probability, counting techniques, asymptotic notation, recurrence relations, and proof techniques, such as are covered in CSE 20 and CSE 21. We also assume familiarity with basic data structures, such as linked lists, arrays, hash tables, and stacks which are covered in CSE 12. Some assignments will require students to implement algorithms in the programming language of their choice, and measure and plot their performance.

## Learning Outcomes

By the end of this course, students will be able to mathematically specify the correctness properties of algorithms for problems in a variety of applications, design efficient algorithms for these problems, prove the correctness of these algorithms, and analyze these algorithms in terms of asymptotic time and memory use.

# Course Logistics

## Instructor and Course Staff

The instructor, IA’s and tutors will be working for you, to help you succeed and learn.

Feel free to contact the instructor in person or by email if you have any concerns or questions.

Russell is in room 4248 CSE (EBU3b) and his email address is: [russell@cs.ucsd.edu](mailto:russell@cs.ucsd.edu).

Some IA’s and tutors are willing to be contacted by email, but that is not part of their jobs. Please ask them permission to use their email addresses either in office hours or on piazza. Be respectful of their privacy and off-hours.

In-person attendance

This is an in-person class, and attendance is the default. However, lectures will be podcast for you to review, or in case you are not able to attend in person occasionally.

The two midterms will take place during the discussion sections and will only be available in person. If you have an OSD accommodation or a medical or similar excuse, we will be flexible in administering the exams, usually through the Triton Testing Center. Otherwise, we expect you to take the exams in person, and in the time for the section you were assigned. There will be an in-person final exam, Wednesday June 11, 8-11 AM in the usual classroom.

These policies might change if circumstances warrant. We will give as much advanced warning of changes as we can, but conditions often change rapidly.

We have found that some students strongly prefer remote office hours, and some prefer in-person office hours. So we will have a mixture of zoom and in-person office hours for this class. Office hours will not be recorded.

## Course Resources

The main textbook is based on previous sections of this course at UCSD. It is in the form of free pdfs available at https://sites.google.com/view/algobook/home. It was written by myself and visiting 101 instructor Ragesh Jaiswal, but based on co-teaching with Sanjoy Dasgupta and Miles Jones. Being directly based on the class outline for UCSD CSE 101, this textbook is a close match to what will be covered in class. However, students might also want to use supplementary textbooks to get different perspectives on the same topics. Some good examples are : Dasgupta, Papadimitriou and Vazirani, Algorithms; Edmonds, How to Think About Algorithms, or Kleinberg and Tardos, Algorithm Design.

For a general review of discrete mathematics, Rosen’s Discrete Mathematics and Applications is frequently used in CSE 20 and 21, and many used copies should be readily available. For understanding mathematical proofs and the relationship between formal proofs and informal

proof sketches, I highly recommend Solow, How to Read and Do Proofs (although it is more

geared for mathematics than for computer science.)

We will use the following websites as part of our instructional resources: The Canvas site for both sections of the course will have most course materials, including lecture slides, recordings of the lecture sections, assignments, answer keys, and study guides. These will usually be found on the Modules page. You also take a weekly comprehension quizzes on Canvas, and need to complete the financial aid survey there.

Gradescope will be used for submitting and grading all other assignments. Exams will be scanned and uploaded to gradescope for grading and feedback. The gradescope page will be linked from Canvas.

The piazza site is used for discussions, student questions, and announcements, and some materials may also be made available on this site, mirroring Canvas. It is also linked from the Canvas page.

## Time and Location

The lecture time is MWF, 9:00 – 9:50 in Warren Lecture Hall 2001. Discussion sections are Friday afternoons in Pacific Canyon Hall 122. The three discussion sections will cover largely the same material, but may vary due to student questions. Except for the exam days, you may attend any of the three, independently of when you are registered, unless there is a shortage of seats.

Office hours are available

throughout the week at a variety of times, and will be a combination of in-person and zoom meetings. Locations and/or zoom links for all of the above and an office hour schedule will be available on the piazza and Canvas pages.

# Coursework and Grades

## Assignments/Coursework

Most weeks will have a homework assignment due on Tuesdays. (See the tentative assignment schedule at the end of this syllabus for more details). The homework assignments can be completed in groups of 1-5, and a single answer should be submitted for each group.

In addition, there will be either a separate assignment or a section of the homework assignment marked ``Ungraded problems’’. These are optional problems similar to the graded problems. Answers for the ungraded problems will be provided before the due date for the graded problems, to give students an example of what we are looking for in terms of length and style. (The ungraded problems will frequently be the graded problem sets from a previous year, and so might just be labeled as such.)

The first homework is based on prerequisite material rather than things we’ll cover in class. This homework will be graded out of 101 points, with 100 being based on effort and 1 based on correctness. Your grade on this should be interpreted as follows. Most students will have grades of the form : 100.XY. The 100 represents your good-faith attempt to solve each problem. The XY represents the fraction of points your group gets for correctness for the assignment, which is how subsequent assignments will be graded. So you can interpret

this fraction as the grade you would have gotten if this were graded by the standard procedures. The main purpose of this assignment is to review material needed for the class, and to calibrate expectations for assignments for the remainder of the course.

While all homework can be completed in groups, the best way to do this is to discuss all problems as a group. **All students in the group must be able to vouch for the academic integrity and correctness of answers for all problems.** If you can’t do that, write a note that removes you from specific problems that you weren’t involved in answering. Note that brainstorming ideas or proof-reading an answer is a form of involvement, even if your ideas aren’t used in the end.

Starting with the third homework, there will be a choice of two ``review’’ questions on each assignment. The purpose of the review questions is to reinforce ideas from previous assignments and to allow students who struggled with something on previous assignments to catch up. The two review questions will be associated with the two previous homework assignments. Each group should pick one of the two review questions to answer. If their grade

on the previous homework associated with it was less than 80 % , the score for that question will also be added to the previous homework grade, up to a maximum of 80%. So it is advantageous to pick the review question for your worst assignment so far.

The best 6 out of the 7 total homework assignments will count for a total of 24% of the class grade.

Each week, you should take an on-line comprehension quiz found on Canvas. You can retake this quiz as many times as you like until you pass, and get 1% of the grade for each pass, with a maximum total of 7%. (So passing 7 out of 10 quizzes gives you full credit.) The comprehension quizzes are meant to ensure that students are staying engaged and conversant with the material for that week, and so **will not be available after the week is over.** The first two might be available longer because some students add the class in second week.

We will have six **participation surveys** each worth 1 % of the grade, but capped at 4 % (so answering 4 of the 6 gives you maximum credit). The financial aid survey counts as the first participation survey. The survey will ask you to list ways you’ve participated in the class, such as coming to lecture, discussion section, or office hours; or asking a question on piazza. This will serve as a reminder to you about your level of participation, and also a way for us to devote more resources to the most utilized formats. There will also be general questions for you to give us feedback about the direction of the class and your progress in the class.

There will be two 45 minute mid-terms , covering most of the major topics except for the last few weeks of class. These are meant to be similar to the homework on the topics and to make sure students are all participating in homework solutions. Midterms must be taken in person in discussion section (see previous note). See the schedule at the end for more details. Each midterm is worth 12.5% of the course grade, or 25% total.

There will be a 3 hour final exam at the end of the course, worth 40% of the total course average.

So the total breakdown is: Homework: 24%; comprehension quizzes: 7%; surveys: 4%; midterms: 25%; and final: 40%. = 100% total, I hope.

## Standards for assignments and grading policies

Most questions on the homework will be algorithm design questions. These will be graded based on clarity and rigor as well as correctness and efficiency. Unless otherwise noted, an algorithm design question requires:

1. a clear statement of the problem to be solved;
2. a clear and unambiguous description of your algorithm, either in unambiguous English or in well-documented pseudo-code (or both);
3. a proof of correctness, possibly informal;
4. and a time analysis in asymptotic notation.

This is the default, but some problems will explicitly give some more particular instructions.

There will be a few implementation and experiment problems on the homework. For these, you should submit a clear description of the algorithms you are using, a description of the programming environment used (e.g., programming language, clock speed, etc.), a clear presentation of the data collected and a conclusion drawn from this data. Please do not submit your actual program. (However, we might ask you to give us a demo of the program if your results seem odd.)

## Academic Integrity

In this course we expect students to adhere to the [UC San Diego Integrity of Scholarship Policy](http://senate.ucsd.edu/Operating-Procedures/Senate-Manual/Appendices/2). This means that you will complete your work honestly, with integrity, and support and environment of integrity within the class for which you are tutoring.

## Collaboration Policy

In particular, part of academic integrity is to always acknowledge your sources. If you had help from any person, website, on-line tutoring site, document, or text, you should acknowledge this help on the assignment. If your work too closely borrows from the source cited, you might not get credit for the work, but you won’t have an academic integrity violation. If you don’t acknowledge help, you will be in violation of the academic integrity policy. You are allowed to collaborate with your homework group members on the homework, and each homework group member who participates should be included in your answers. On the other hand, homework group members who do not participate on that assignment should NOT be included, even if they participated on other assignments. Other sources that do not need to be acknowledged are the CSE 101 instructional staff for this quarter, the textbook, and any materials linked from the class websites.

Chatbots or other artificial intelligence sources should be viewed in the same light as an alternative textbook or website. You may use these (with caution!) as a general study tool, but should not ask about the solutions to specific (graded) problems. If a chatbot is helpful (for any reason) for a particular problem, you should cite the chatbot in your answer, and possibly describe the prompt you used or the nature of your interaction. We will use this to judge how much credit is due to you and how much to the chatbot, but there will not be an AI violation if the chatbot is acknowledged.

## Regrade Policy

There will be a short window after each assignment is graded when regrades can be requested on gradescope. Usually, you need to be clear exactly why a regrade is appropriate. That means either telling us that a specific rubric item was misapplied to your assignment, or that a rubric item is itself incorrect. Subjective issues such as a rubric being in your opinion too harsh can be discussed on piazza, but will not usually be a basis for a regrade.. (If we agree with you, we can change the points in the rubric item and correct all grades at once, rather than having to answer individual regrade requests.)

## Late or Missed Assignments/Missed Exam Policy

We will be attempting to post answer keys promptly, and new assignments cannot usually be submitted after the answer key is posted. If you know in advance that you will require more time for an assignment, or need to reschedule an exam, let us know and we will try to accommodate your requests if we can.

## Technology Policy

Part of lectures and office hours is to interact with students and to allow questions. You will do better if you do not do other tasks during class. Please join zoom meetings muted, but turn on your camera and microphone if called on, if you can. In breakout rooms, please try to turn on cameras and microphones, and interact with other students.

# Resources for Students

## Getting Help

Please come to office hours as much as you can, especially if you are finding the class difficult.

Also, please raise any questions or concerns in class or on piazza. You can post your concerns anonymously on piazza. (If this is abused, especially to the detriment of other students, we may have to eliminate this.)

Also, we will have sign-ups for one-on-one help sessions.

The IDEA Engineering Student Center, located just off the lobby of Jacobs Hall, is a hub for student engagement, academic enrichment, personal/professional development, leadership, community involvement, and a respectful learning environment for all. The Center offers a variety of programs, listed in the IDEA Center Facebook page at <http://www.facebook.com/ucsdidea/> (you are welcome to Like this page!) and the Center web site at <http://idea.ucsd.edu/>. The IDEA Center programs support both undergraduate students and graduate students.

## Diversity and Inclusion

We are committed to fostering a learning environment for this course that supports a diversity of thoughts, perspectives and experiences, and respects your identities (including race, ethnicity, heritage, gender, sex, class, sexuality, religion, ability, age, educational background, etc.). Our goal is to create a diverse and inclusive learning environment where all students feel comfortable and can thrive.

Our instructional staff will make a concerted effort to be welcoming and inclusive to the wide diversity of students in this course. If there is a way we can make you feel more included please let one of the course staff know, either in person, via email/discussion board, or even in a note under the door. Our learning about diverse perspectives and identities is an ongoing process, and we welcome your perspectives and input.

We also expect that you, as a student in this course, will honor and respect your classmates, abiding by the UCSD Principles of Community (<https://ucsd.edu/about/principles.html>). Please understand that others’ backgrounds, perspectives and experiences may be different than your own, and help us to build an environment where everyone is respected and feels comfortable.

If you experience any sort of harassment or discrimination, please contact the instructor as soon as possible. If you prefer to speak with someone outside of the course, please contact the Office of Prevention of Harassment and Discrimination:<https://ophd.ucsd.edu/>.

## Students with Disabilities

We aim to create an environment in which all students can succeed in this course. If you have a disability, please contact the Office for Students with Disability (OSD), which is located in University Center 202 behind Center Hall, to discuss appropriate accommodations right away. We will work to provide you with the accommodations you need, but you must first provide a current Authorization for Accommodation (AFA) letter issued by the OSD. You are required to present their AFA letters to Faculty (please make arrangements to contact me privately) and to the OSD Liaison in the department in advance so that accommodations may be arranged.

## Basic Needs/Food Insecurities

If you are experiencing any basic needs insecurities (food, housing, financial resources), there are resources available on campus to help, including The Hub and the Triton Food Pantry. Please visit <http://thehub.ucsd.edu/> for more information.

Topic schedule (may be adjusted)

March 31 -April 2: Introduction. Horner’s method for polynomial evaluation. Review of correctness proofs, loop invariants, asymptotic time analysis, recursive algorithms, recurrence relations. Chapter 1 and supplements.

April 4-9: Graph search, depth first search and applications. Chapter 2.

April 11-16: BFS, Shortest paths, Dijkstra’s algorithm, using data structures (heaps). Chapter 3 (first half)

April 18: Reductions. Chapters 3 (second half)

April 21-25: Greedy algorithms. Chapter 4.

April 28-30: Kruskal’s MST algorithm, DSDS. Chapter 5.

May 2-9: Divide and conquer. Chapter 6.

May 12: Backtracking. Chapter 7.

May 14-23: Dynamic programming. Chapter 7-8

May 28- June 2: Network flow and applications. Chapter 9-10

June 4-6: NP-completeness . Under construction.

Assignment schedule

April 8: Hw 1 due (background)

April 15: Hw 2 due (graph search and applications)

April 22: Hw 3 due (shortest paths, data structures) .

May 2, discussion section: Midterm 1 (background, graph algorithms, data structures)

May 6: Hw 4 due (greedy algorithms)

May 13: Hw 5 due (divide and conquer)

May 23: Discussion section: midterm 2 (greedy algorithms, divide and conquer)

May 27: Hw 6 due (backtracking, dynamic programming)

June 5: Hw 7 due (network flow, reductions)

June 11: Final exam.