CS5008/9: Data Structures, Algorithms, and their Applications in Computer Systems

Spring 2025

Course Details

Instructor: Carter Ithier
E-mail: c.ithier@northeastern.edu
When:
CS5008 - Block 1
Monday, Wednesday 2:50 pm - 4:30 pm
CS5008 - Block 2
Wednesday 6 pm - 9:20 pm
CS5009 - Block 1
Thursday TBD
CS5009 - Block 2
Thursday TBD
Where: Live on zoom (see Canvas for connection details)
Office Hours: TBD

Teaching Assistants and TA Office Hours

TA office hours will be held throughout the week. See piazza for details. There will be no office hours on University Holidays and no appointment is necessary for TA office hours.

TA	Office hours
TBD	TBD
TBD	TBD
TBD	TBD

Further Course Information

Course Description

This course presents an integrated approach to the study of data structures, algorithms, and their applications within computer systems. We introduce a variety of systems-related topics (models of computation, computer architecture, compilation, system software) and fundamental techniques for solving algorithms (divide-and-conquer, dynamic programming, graph algorithms) as they apply to computer systems. The integration of topics is demonstrated through the implementation of fundamental data structures (lists, queues, trees, maps, graphs) in the C programming language. Additional breadth topics can include programming applications that expose students to primitives of different subsystems such as multi-threading or sockets.

Course Objectives

By the end of this course, students should be able to:

- Explain the basic terminology of computer systems (e.g., process, thread), various models of computation (e.g., sequential, multithreaded) and the role of the operating system as a resource manager.

- Demonstrate a working knowledge of using a terminal to navigate the operating system; gather system information; and compile, execute and, debug C programs.
- Describe each step in the compilation process for the C programming language. Analyze assembly code and explain its relationship to C code, the fetch/execute cycle, and basic system architecture.
- Implement common data structures in the C programming language (e.g., lists, trees, graphs) as well as commonly used algorithms that operate on these structures using dynamically allocated memory.
- Compare and contrast different algorithmic approaches to a problem (e.g., searching, sorting, scheduling).
- Describe specific algorithmic strategies and how each can be used to solve problems.
- Analyze the computation and storage complexity of algorithms by employing the substitution method, the Master theorem, and recursion trees. Explain proofs related to algorithm correctness and write a simple proof using loop invariants.

Course Structure

The course will meet each week for lecture and a lab. The lab will be during the recitation period. This is a chance for you to apply the knowledge you learned in lecture, while having faculty and TA support before you attempt the homework. Labs will be due the end of week and are graded– most of which will be autograded. The homework schedule varies a little but most weeks, one assignment will be due. Most homeworks will have an autograder component, as well as a manual grading component.

Student Expectations

In general, not including time spent in class, you should be prepared to spend 3-4 hours per credit hour for this course. This means that **you should plan on spending a minimum of 12-16 hours per week on this course. 16 hours is a rough average of 2.2 hours per day, every day of the week**. Many students find this course takes about **20 hours/week** to successfully complete. 20 hours a week is a rough average of **3 hours per day, every day of the week**. Some students may spend more time than that on certain weeks. Time-on-task also does not always translate to work accomplished; if you find you are spending more time than this on the course, talk to the TAs or professor about how to make your work and study time more efficient.

Please plan ahead! It can be hard to estimate when you might get stuck, so make sure to have extra slack time in your schedule to accommodate tricky problems or new concepts that are harder than you except. Sometimes a problem comes along that you really need to sleep on. Finish your work as early as you can, so that when problems come up that require extra time, you have that time to spend.

See section the section on academic integrity for plagiarism guidelines and academic dishonesty policies. If you're stuck, are far behind, feel lost, etc.: **come talk to us**, either by dropping in during office hours or in a private appointment that you make via email. Do not just copy something you found somewhere or ask a friend for code; the penalties are severe.

Communication

Please post all questions about course material or assignments to Piazza. Only email us directly if you have to provide sensitive personal information. Emails will take us at least 24 hours minimum to respond to. If you haven't heard from us in 48 hours, please email us again with a follow-up. We don't respond to Teams messages or other communication channels.

Post a private question. if your question is related to grades or code for current or past graded assignments. If you have questions about a grade you've received, you must post your questions to Piazza in a private post

to All Instructors within 7 days of receiving your assignment grade. The TA who graded your homework will respond to your questions. We will add additional information or a response as needed.

Class Participation and Class Recordings

This is an online but synchronous course with live lectures. Lectures will usually be recorded and the recording will be available on Canvas. Please note that recordings should not be used as a substitute for coming to class. I strongly recommend that you come to every live session with your cameras on and your microphone muted.

If for some reason you are unable to make class, or you have follow up questions from the lecture, feel free to come to office hours or post on Piazza!

I very much welcome active background discussion in my classrooms. To ask a question, feel free to virtually raise your hand or post your question in chat. And if you know the answer, go ahead and respond!

Recommended Reading

The are two required textbooks that are available for free online:
Grokking Algorithms, 1st edition by Aditya Bhargava is a friendly guide for learning algorithms as they apply to practical problems faced by programmers on a regular basis. It is available here.
To access it:

1. Go to NU's library page for computer science here
2. In the lower left hand corner click on "Connect to O'Reilly" which will take you here
3. Select "Not listed"
4. Put in your northeastern.edu email

The other textbook is Dive Into Systems by Suzanne J. Matthews, Tia Newhall, and Kevin C. Webb. It is a free online textbook on computer systems and C.

An optional textbook that will serve as an excellent reference and will most likely be required for Algorithms CS5800 is Introduction to Algorithms by Cormen, Leiserson, Rivest, and Stein.
Note that other materials may be recommended for each module, but they will be provided to you.

Homework and Late Policy

There will be 10 assignments and 10 labs due for this class. The detailed dates are listed in the schedule section. Homework will be submitted on GradeScope via Git Classroom. Homework cannot be accepted by email. Homeworks submitted 1-48 hours late receive a 10% penalty. No homeworks will be accepted more than 48 hours late. Please understand that with a class this size, maintaining a strict schedule for homework submissions and grading is paramount. If you have an emergency that arises and interferes with your work, please let me know as soon as possible so I can determine if an extension should be offered.

Academic Integrity (Please Read!)

Coding can be a creative process that has input from many places. **It is expected in this class that you do not use ChatGPT or Github Copilot to finish assignments**. You will be expected to understand every line of code you submit and may be asked to if we suspect cheating. Everyone must write up their own, individual solutions, but you are encouraged to talk through the problems at a high level with your peers. You can talk about things like approach, edge cases, etc but should not be directly sharing code. Please be aware that I take the issue of academic integrity very seriously. The consequences of cheating in my class are at my discretion and may include receiving a zero for the assignment or quiz, a full letter grade

reduction in your final grade, or failing the course altogether. Please contact me if you have any questions about acceptable conduct. And if you are stuck on an assignment, the TAs and I are here to help, or you can pose your question on Piazza. The university's academic integrity policy discusses actions regarded as violations and consequences for students: http://www.northeastern.edu/osccr/academic-integrity

Evaluation

The final grade for this course will be weighted as follows:

- Homework: 50%
- Labs: 20%
- Learning Activities: 10%
- Midterm: 10%
- Mock Interview: 10%

The midterm and final will be closed-book exams taken on Canvas. The mock interview for the class serves as a final project. The interview will require live coding a solution to an algorithmic problem. This project will allow students to demonstrate at the end of the class that they can:

- Implement either a common data structure in the C programming language or a commonly used algorithm that operates on these structures using dynamically allocated memory
- Compare and contrast different algorithmic approaches to solving a problem
- Describe a specific algorithmic strategy and how it can be used to solve a problem
- Analyze the computation and storage complexity of the algorithm

Final grades will be assigned based on the following scale. Please note that grades are not rounded.

Letter	**Range**
A	94-100
A-	90-92
B+	87-89
B	83-86
B-	80-82
C+	77-79
C	73-76
C-	70-72
D+	67-69
B+	87-89
D	63-66
D-	60-62
F	<60

Schedule

Week	Day	Topic	Due
1	Jan 6 - 10	Intro and Getting Started	Lab00, Lab01 (1/10)
2	Jan 13 - 17	Programming in C	HW01 (1/15), Lab1 (1/17)
3	Jan 20 - 24	Stacks, Queues, Linked Lists	HW1 (1/22), Lab2 (1/24)
4	Jan 27 - 31	Debugging, Registers, Assembly	Lab3 (1/27)
5	Feb 3 - 7	Doubly Linked Lists, Arrays vs Linked List, Compilation	HW2 (2/5), Lab4 (2/7)
6	Feb 10 - 14	Introduction to Analysis of Algorithms, Proofs, Quadratic Sorts	HW3 (2/12), Lab5 (2/14)
7	Feb 17 - 21	Sort Analysis, Recursion, Efficient Sorting	HW4 (2/19), Lab6 (2/21)
8	Feb 24 - 28	**MIDTERM**, hashmaps, greedy	HW5 (2/28)
9	Mar 3 - 7	Spring Break	
10	Mar 10 - 14	Dynamic Programming	HW6 (3/12), Lab7 (3/14)
11	Mar 17 - 21	Trees and Heaps	Written HW (3/19), Lab8 (3/21)
12	Mar 24 - 28	Graphs, MSTs, Dijkstra's	HW7 (3/26), Lab9 (3/28)
13	Mar 31 - April 4	Concurrency	
14	April 7 - 11	Networking	HW8 (4/9)
15	April 14 - 18	**Mock Interview**	HW9 (4/15)

Inclusive Class

Northeastern University values the diversity of our students, staff, and faculty; recognizing the important contribution each makes to our unique community.

Respect is demanded at all times throughout this course. In the classroom, not only is participation required, it is expected that everyone is treated with dignity and respect. We realize everyone comes from a different background with different experiences and abilities. Our knowledge will always be used to better everyone in the class.

We strive to create a learning environment that is welcoming to students of all backgrounds. If you feel unwelcome for any reason, please let us know so we can work to make things better. You can let us know by talking to anyone on the teaching staff. If you feel uncomfortable talking to members of the teaching staff, please consider reaching out to your academic advisor.

Students with Disabilities

Northeastern is committed to providing equal access and support to all qualified students through the provision of reasonable accommodations so that each student may fully participate in the learning experience. If you have a disability that requires accommodations, please contact the Disability Resource Center http://www.northeastern.edu/drc/, DRC@northeastern.edu, 617-353-2675. Accommodations cannot be made retroactively and to receive an accommodation, a letter from the DRC or LDP is required.

Title IX

Northeastern University and its faculty are committed to creating a safe and open learning environment for all students. If you or someone you know has experienced discrimination (including discrimination based on sex, gender, gender identity, gender expression, sexual orientation, pregnancy or pregnancy related condition, race, religion, national origin, disability status, veteran status etc.), or sexual violence (including sexual harassment, sexual assault, dating/domestic violence, or stalking), please know that help and support are available. Northeastern strongly encourages all members of the community to take action, seek support, and report incidents of discrimination, harassment, and sexual violence to the Office for University Equity and Compliance (OUEC) through the Online Discrimination Complaint Form found at https://www.northeastern.edu/ouec/file-a-complaint/.

Statement of Land Recognition

We acknowledge the territory on which Northeastern University stands, which is the land of The Wampanoag and The Massachusett People.

While visiting campus, please honor the continued efforts of the Native and Indigenous community leaders who work to preserve the history and culture of the tribes which make up Eastern Massachusetts and the surrounding region. Today, Boston is still home to many indigenous peoples, including the Mashpee Wampanoag and Wampanoag Tribe of Gay Head (Aquinnah), the Mi'kmaq and many more in our region.

For more information, please visit: North American Indian Center of Boston.

For information on resources and services provided by the Commission on Indian Affairs of the Commonwealth of Massachusetts, please visit: Commission on Indian Affairs, State of MA.