

[▶ Syllabus Navigation](#)

Spring 2023 Vancouver

CS 5008/9 -- Data Structures, Algorithms, and their Applications in Computer Systems

*Align Course, Khoury College of Computer Sciences**Northeastern University, Vancouver Campus**Spring 2023 Semester*

We acknowledge that the land on which we gather is the unceded territory of the Coast Salish Peoples, including the territories of the xʷməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), and səliłwətał/Selilwitulh (Tsleil-Waututh) Nations.

Class Hours: Lecture-Workshop: 12-2pm Tuesday, 2:30-4:30pm Tuesday
 Lab: 10-12 Thursday, 2:30-4:30pm Thursday

Class Location: 1426

Instructor: Logan Schmidt
 (e-mail) l.schmidt@northeastern.edu (<mailto:l.schmidt@northeastern.edu>) See
 note below on communication; please use Piazza!

Teaching Assistants:

Office Hours

My office hours, and the TA's office hours, are drop-in: that means that we are always present and available online during our scheduled office hours, held online, and you just "show up" online without an appointment during those office hours to ask us questions. We manage lines/queues of students using an online app, and we talk to you online in a Teams call. Full instructions for joining office hours can be found on Piazza and on the Home page of our Canvas site.

1 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.

1.1 Course

Prerequisites

The course is suitable for students in good standing in the ALIGN MS in CS program that have successfully completed CS 5002 and CS 5001.

1.2 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.

2 Course Structure

Lab assignments are due 24 or 48 hours after the lab ends, and are often autograded. See Canvas for specific assignment due dates. Students will often be assigned groups for their lab work, and working with their assigned group is expected. Students should submit their labs individually, but list their group members in the comments for their submission.

Homeworks are both automatically and manually graded, and the work done for them must be done individually. Homework due dates can vary, as there is often at least one 2-week homework assignment, but generally they will be released the day of the lab and will be due at midnight the day before lab. **The weekly schedule, including homework deadlines and order of topics, are subject to change based on events both within our control and outside of it! But the schedule that follows is a *guideline* for the semester.** The last day for Final Project Codewalks will not change.

Week	Date	Topics	Lab	Assignment
1	09 Jan	01 - Introduction and Getting Started, Processes	Lab 0	Intro to Processes
2	16 Jan	02 – Programming in C	Lab 1	HW 1
3	23 Jan	03 – Stacks, queues, singly and doubly linked lists	Lab 2	HW 2

4	30 Jan	04 – Debugging, registers, and assembly	Lab 3	HW 3
5	06 Feb	05 – Analysis of algorithms, quadratic sorts	Lab 4	HW 4
6	13 Feb	06 – Primer on proofs	Lab 5	HW5
7	20 Feb	07 – Sort analysis, recursion, Divide & Conquer	Midterm Quiz	HW 6
8	27 Feb	08 - Networking	Lab 7	HW7
9	6 Mar	SPRING BREAK		
10	13 Mar	09 - Trees; SIGSCE conference	Lab 8; SIGSCE	HW 8
11	20 Mar	10 – Graphs	Lab 9	HW 9
12	27 Mar	11 - Greedy	Lab 10	HW 10
13	3 Apr	12 - Dynamic Programming	Lab 11	Projects/presentations
14	10 Apr	Concept Presentations		Projects/presentations
15	17 Apr	Final Review & Final Quiz	Final Quiz	Projects
16	24 Apr	Last day of Final Project Codewalks: 26 April		Projects

2.2 Student Expectations

Prior to the lecture/workshop on Monday, students must watch and complete the required video and readings for the course. This course and the lecture/workshop will *assume* students have watched the required materials, which are meant to take 1-2 hours to complete.


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 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 expect. 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 5.5 for plagiarism guidelines and academic dishonesty policies. If you're stuck, are far behind, feel lost, etc.: COME TALK TO ME, 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.


2.3 Communication, including questions about grades

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

Post a private question <https://support.piazza.com/support/solutions/articles/48000616669-post-a-private-note>  (<https://support.piazza.com/support/solutions/articles/48000616669-post-a-private-note>) 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. I will add additional information or a response as needed.

Khoury Student Expectations

1. Respect should be shown in all communications and interactions with faculty, staff, industry, peers, and all others on campus. This includes respecting the preferred methods and response times of faculty and staff.
2. Students come to class prepared and having engaged with the online course materials.
3. Students are to actively participate in course activities and discussion.
4. Any issues that arise should be communicated to the appropriate faculty or staff member proactively.
5. All course interaction including instruction, teamwork, TA advising, and course activities are to be done in English.
6. Students should come in to classroom with the goal of learning and have a **"growth mindset"**  [\(https://fs.blog/carol-dweck-mindset/\)](https://fs.blog/carol-dweck-mindset/).

3 Course Assessment

Final grades will reflect students' effort and performance. The course grade will be based on the following:

Quizzes and Learning Activities	=	5%
Reflections	=	5%
Lab Assignments	=	10%
Homework Assignments	=	40%
Midterm Quiz	=	5%
Concept Presentation	=	10%
Final Quiz	=	10%

Project = 15%

In-class Quizzes and Before-Class Learning Activities 5% We have preparatory learning activities assigned before our lecture-workshop meeting each week. We may also have in-class quizzes over the videos and learning material for the week at the start of lecture-workshop. These quizzes and activities will be turned in on Canvas. Everyone should turn in their quizzes and learning activities individually. In general we will be using before-class online learning activities: in-class quizzes will begin if students stop engaging with offline videos and materials before class.

Reflections 5%: There will be 2-5 written reflections over the course of the semester, roughly every 2-3 weeks. You'll reflect on what you've learned, your progress in teams and individual learning and collaboration environments, and your target technical and interpersonal and workplace skills to acquire. These reflections will be evaluated based on your coverage of each topic in your reflection; grammar & composition skills are not graded, but may be remarked on with a view towards improving professional communication skills.

Lab Assignments 10% are designed as practice problems that illustrate the concepts covered in that week's module. They are designed to be completed in approximately 2-3 hours. They also serve as preparation for the next homework assignment. We will work through the lab, but may not fully complete it, during lab time. It's your responsibility to finish and turn in the lab. You will be assigned lab partners for each lab. Group work with assigned lab partners **on that lab assignment** is permitted and encouraged, both during lab time and outside the lab. **Everyone in the group should turn in their lab assignment individually.** Labs will be turned in on Gradescope.

Homework Assignments 40%: There will be approximately 7-10 homework assignments over the course of the semester. In most homework assignments, students will be asked to solve a problem that requires the applications of topics covered in the lessons. Unlike lab assignments, these tend to be a bit larger and will require you to combine the concepts and use them outside of artificially-created environments. Due to the size of these assignments, you will be provided with time to solve them depending on the complexity of the problem. In addition to programming, students will be expected to use good coding style, to include proper documentation, and to design test cases for the problem. With each assignment, students will be asked to answer questions about their solution. Some of the homework assignments also have a required codewalk as part of their grade.

All homeworks must be completed completely individually, other than asking for help and clarification from TAs, instructors, and on Piazza via private or public posts. No collaboration with anyone else on homework code is permitted; no use of online or AI sources is permitted. See "academic integrity" for additional clarifications on what is permitted. If you have questions, ask.

Midterm Quiz 5%: There will be a midterm quiz. It will be given in class near the middle of the term, and it may ask about any material covered to that point in the semester. Midterm quiz make-ups will only be permitted due to extraordinary circumstances and the need for a make-up quiz should be communicated as soon as possible. The quiz will be designed to be completed in x time, and $1.5x$ time will be given to complete it, where x will be determined later but will not exceed 1.5 hours.

Concept Presentation 10%: One class meeting during the semester will be devoted to student groups giving presentations on an approved CS concept. Students will present, in groups, about one computer science concept that they independently research. A sample topic list will be provided for student groups to choose from, but additional student-suggested topics are allowed, with approval. Students will choose how to organize their group and divide the work to present a presentation to the class.

Final Quiz 10%: There will be a final quiz. It will be given in class during the last week of class, and it may ask about any material covered during the semester. Final quiz make-ups will only be permitted due to extraordinary circumstances and the need for a make-up quiz should be communicated as soon as possible. The quiz will be designed to be completed in x time, and $1.5x$ time will be given to complete it, where x will be determined closer to the end of the semester but will not exceed 1.5 hours.

Project 15% There is one project towards the end of the semester. The project may not be submitted late, and it will not be dropped. This project will allow students to demonstrate 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

3.1 Late Policy

In general, late work will not be accepted for any credit. However, we understand that sometimes something interferes with your ability to turn in an assignment by the specified time. For this reason, each student will be granted three (3) free, no-questions-asked 24-hour late days during the course of the semester. To use a late day, students must email the instructor **BEFORE** the deadline. No more than one late day may be used on any one assignment. Late days cannot be divided fractionally, but must be used whole. Using a late day means that you may turn in an assignment up to 24 hours late. Submission of assignments is automated, so 1 second late = 1 day late. You can turn in your assignments an unlimited number of times *before* the due time, so be sure to



submit *something* for your assignment before the due time in case you run into submission problems at the last minute. You cannot use late days on the midterm, final quiz, project, or presentation: these assignments are due at a specific time, and we need enough time to grade them fairly.

3.2 Grade Calculations

Grades will be calculated on an absolute basis: there will be no overall curving. The mapping of raw percentage point totals to letter grades is given below. Please note that these grade boundaries may move slightly at the discretion of the instructor, but the grade boundary for A is unlikely to change.

Grades at NU are in the American style; the final letter grade, not the percentage grade, is the only grade that will appear on your transcript once you have completed the class. In other words, there is no ultimate difference between a 93% A and a 99.75% A: both award 4.0 points on the 4.0 grading scale, and both will appear as an A on your transcripts.

93.00–100.00	A	86.00–89.99	B+	73.00–76.99	C+	
90.00–92.99	A-	82.00–85.99	B	69.00–72.99	C	0.00–64.99 F
		77.00–81.99	B-	65.00–68.99	C-	

To progress, student are required to meet the grade point average (GPA) requirements for the MS Computer Science – Align as determined by Khoury College of Computer Sciences ([see Khoury's website for more information](https://www.khoury.northeastern.edu/current-students/masters-and-certificate/masters-academic-policies-and-support/)  [\(https://www.khoury.northeastern.edu/current-students/masters-and-certificate/masters-academic-policies-and-support/\)](https://www.khoury.northeastern.edu/current-students/masters-and-certificate/masters-academic-policies-and-support/)). If you are unfamiliar with the 4.0 grading system, see this explanation <https://registrar.northeastern.edu/article/how-to-calculate-your-gpa/>  [\(https://registrar.northeastern.edu/article/how-to-calculate-your-gpa/\)](https://registrar.northeastern.edu/article/how-to-calculate-your-gpa/).

4 Course Materials

There is an associated Canvas page for this course. I will use it to post weekly content, assignments, lecture materials, labs, feedback, and grades. (Chances are you're reading a page on it right now.)

Additional feedback on code, including comments, will be available on Gradescope where you submit your coding assignment.

4.1 Textbooks

The two required textbooks are available for free online:

- *Grokking Algorithms*, 1st Edition by Aditya Bhargava is friendly guide on for learning algorithms as they apply to practical problems faced by programmers on a regular basis.



Available here: <https://learning.oreilly.com/library/view/grokking-algorithms/9781617292231/> 

(<https://learning.oreilly.com/library/view/grokking-algorithms/9781617292231/>). See instructions that follow for how to access it for free using your Northeastern University account below.

- *Dive Into Systems*  (<https://diveintosystems.org/book/preface.html>), by Suzanne J. Matthews, Tia Newhall, and Kevin C. Webb. A free, online textbook on computer systems and C.

Additional Resources:



You may find these texts helpful if you're looking for additional resources on the C programming language or other course topics.

- *Head First C* by David Griffiths and Dawn Griffiths is a brain-friendly guide to the C programming language. Available here: <https://learning.oreilly.com/library/view/head-first-c/9781449335649/>  (<https://learning.oreilly.com/library/view/head-first-c/9781449335649/>)
- *C Programming Language*, 2nd Edition by Brian W. Kernighan and Dennis M. Ritchie is a complete guide and great reference for the programming language we will be using in this course. Available here: <https://learning.oreilly.com/library/view/c-programming-language/9780133086249/>  (<https://learning.oreilly.com/library/view/c-programming-language/9780133086249/>)

Accessing O'Reilly Online Resources

As students at NU, you have access to a very awesome resource: O'Reilly Online.

To access it, and all the above textbooks:

1. Go to NU's library page for computer science here: <https://subjectguides.lib.neu.edu/compsci>  (<https://subjectguides.lib.neu.edu/compsci>)
2. In the lower left hand corner, click on "Connect to O'Reilly", which will take you here <https://www.oreilly.com/library/view/temporary-access/>  (<https://www.oreilly.com/library/view/temporary-access/>)
3. Select "Not listed".
4. Put in your northeastern.edu email

See the Course Resources page for additional helpful resources.

4.2 Piazza

Piazza will be used for class discussion and course announcements. It also provides students with a platform for getting you help fast and efficiently from classmates, the TAs, and the instructor. Rather than emailing questions to the teaching staff, I encourage you to post your questions on Piazza. If you have trouble with Piazza, you can get help from team@piazza.com (<mailto:team@piazza.com>). Find our class page at: <https://piazza.com/northeastern/>

4.3 Gradescope

Gradescope is used in this course to manage assignments and give students feedback. Each assignment will have a dedicated slot on Gradescope to accept submissions from students, to provide limited feedback to students before the deadline, and to provide manual feedback after grading. Gradescope deadlines are listed in Eastern Time, so be sure to convert those times to Pacific Time - for example, the midnight PT deadlines for our homework show up as 3am ET deadlines the next day, but they are in fact due at midnight PT.

4.4 Github Classroom

Github Classroom is used in this course to manage programming assignments. While the details of each assignment will be made available on Canvas, students will be required to manage their assignments via commits to Github Classroom. Github is a website that used *git*, a professional version control system used by developers from all over the world to discover, share, and build software. Github Classroom requires a Github.com account.

5 General Policies

5.1 Attendance

It is expected that you attend every class. We begin each class and lab sharply at the start time. If you must miss class, regardless of the reason for your absence, it is your responsibility to catch up on the material you have missed, and obtain the notes from a classmate (not from me). Failing to attend the class and lab meetings may have a detrimental impact on your ability to pass the course. If a graded activity takes place during class or lab, it is your responsibility to turn it in by the deadline whether you are in class or not. Late days may be used for these assignments, but remember that you only have 3 of them, so try to keep them for emergencies and unexpected events (something always comes up!).

5.2 Scheduling Meetings

At any time during the course, if you have any concerns, speak to me at the end of class, or contact me by e-mail, and we will set up a one-on-one meeting at a mutually convenient time.

5.3 Classroom Conduct

To create and preserve a classroom atmosphere that optimizes teaching and learning, all participants share a responsibility in creating a civil and non-disruptive forum for the discussion of ideas. Students are expected to conduct themselves at all times in a manner that does not disrupt teaching or learning.

Your comments to others must be constructive and free from harassing statements. You are encouraged to disagree with other students and the instructor, but such disagreements need to be respectful and be based upon facts and documentation, rather than prejudices and personalities.

The instructor reserves the right to interrupt conversations that deviate from these expectations.

Repeated unprofessional or disrespectful conduct may result in a lower grade or more severe consequences.

5.4 Title IX Policy

Title IX of the USA Education Amendments of 1972 protects individuals from sex or gender-based discrimination, including discrimination based on gender-identity, in educational programs and activities that receive federal financial assistance. Though our campus is located in Canada, all Northeastern University campuses follow the Title IX Policy.

Northeastern's Title IX Policy prohibits Prohibited Offenses, which are defined as sexual harassment, sexual assault, relationship or domestic violence, and stalking. The Title IX Policy applies to the entire community, including male, female, transgender students, faculty and staff.

If you or someone you know has been a survivor of a Prohibited Offense, confidential support and guidance can be found through University Health and Counseling Services staff and the Center for Spiritual Dialogue and Service clergy members. By law, those employees are not required to report allegations of sex or gender-based discrimination to the University.

Alleged violations can be reported non-confidentially to the Title IX Coordinator within The Office for Gender Equity and Compliance at: titleix@northeastern.edu and/or through the local NU Vancouver switchboard at 844-688-6287. Reporting Prohibited Offenses to NUPD does NOT commit the victim/affected party to future legal action.

Faculty members are considered “responsible employees” at Northeastern University, meaning they are required to report all allegations of sex or gender-based discrimination to the Title IX Coordinator.

In case of an emergency, please call 911. Please visit <http://www.northeastern.edu/titleix>  (<http://www.northeastern.edu/titleix>) for a complete list of reporting options and resources, both on-campus and off-campus.


5.5 Collaboration and Academic Honesty

Computer science, both academically and professionally, is a collaborative discipline. In any collaboration, however, all parties are expected to make their own contributions and to generously credit the contributions of others. In our class, therefore, discussion of the general principles of computer science involved in all homework and programming assignments is encouraged, but you as an individual are responsible for understanding all the material in the assignment and doing your own work. Always strive to do your best, to start early, and to seek help early from both your professors and classmates.

The following rules are intended to help you get the most out of your education and to clarify the line between honest and dishonest work. **The professor reserves the right to ask you to verbally explain the reasoning behind any answer or code that you turn in and to modify your project grade based on your answers.** It is vitally important that you turn in work that is your own. If you have had a substantive discussion of any homework or programming solution with a classmate, then be sure to cite them in your report. If you are unsure of what constitutes “substantive”, then ask us or err on the side of caution. You will not be penalized for working together. **You must not copy answers or code from another student either by hand or electronically. You also must not copy answers or code from an online source.** Another way to think about it is that you should be talking in normal, human language (for example English) with one another, not in Python or other coding languages. The following rules apply to anything you hand in for a grade:


- **You may not copy anyone else's code under any circumstances. This includes online and AI sources.**
- **You may not use any automated or AI tools to generate your assignments or any course material that you turn in for a grade, in whole or in part.**
- **You may not permit any other student to see any part of your program.**
- **You may not permit yourself to see any part of another student's program.**
- **You may not post a public question to Piazza that contains any part of your code.**
- **You may consult online resources as part of your course work, but you may not copy code from online sources. If you get an idea of how to solve a problem from an online source, include a short citation in your README. Use of AI resources and posting on forums is not permitted.**

The only exception to the above rules is that you may collaborate on programs with students in your group when you are assigned a group - almost all labs, for example, will be completed in an assigned group.

As with all other courses at Northeastern, you are expected to adhere to the university's academic integrity policy (<http://www.northeastern.edu/osccr/academic-integrity> ) (<http://www.northeastern.edu/osccr/academic-integrity>).


If you are unsure about the plagiarism policy, **please ask me!**

5.6 Students With Disabilities

Students who have disabilities who wish to receive academic services and/or accommodations should visit the **Disability Resource Center** ) (<http://www.northeastern.edu/drc>) or call (844)-688-6287. They should do so as early as possible in the semester, as the DRC can take time to put accommodations in place.

If you have already done so, please provide your letter from the DRC to the instructor at the start of the semester to arrange those accommodations.

5.7 Feedback

Your opinions are very important to me. All students are strongly encouraged to use the Teacher Rating and Course Evaluation (TRACE) system, at <https://www.northeastern.edu/trace/> ) (<https://www.northeastern.edu/trace/>), to complete your course evaluations. A reminder about TRACE should arrive via email about two weeks before the end of the course. In addition, I will be asking for your feedback throughout the semester. However, if you have concerns about the course, do not wait until you are asked. Please schedule a meeting with me, and we will discuss your concerns then.