CS 5800: Algorithms

Graduate Course, Khoury College of Computer Sciences
Northeastern University, Vancouver Campus
Fall 2024 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), Sḵwx̱wú7mesh(Squamish), and Səl̓ílwətaɬ/Selilwitulh (Tsleil-Waututh) Nations.

Class Hours:	Tuesday 1:00PM - 3:00PM Tuesday 3:15PM - 5:15PM
Class Location:	Room 1426
Instructor:	Dr. Ryan Rad r.rad@northeastern.edu Office Hour: Monday 3:00PM - 5:00PM
TAs	Zuoyang Xu xu.zu@northeastern.edu Ji Chen chen.ji1@northeastern.edu Yichen Wang wang.yichen7@northeastern.edu

1. Course Description

CS 5800 presents a set of practical techniques used for the design and analysis of computer algorithms. We will focus on algorithmic design paradigms and techniques for analyzing the correctness, time, and space complexity of algorithms. Topics may include asymptotic notation, recurrences, loop invariants, sorting and searching, advanced data structures, lower bounds, hashing, greedy algorithms, dynamic programming, graph algorithms, linear programing, and NP-completeness.

1.2 Course Objectives

- Exhibit proficiency in the design, implementation and testing of software.
- Demonstrate skills and experience working in small teams.
- Apply algorithmic and theoretical computer-science principles to solve computing problems from a variety of application areas.
- Demonstrate the ability to learn and develop competencies in specialized or emerging computer science fields.

2 Course Structure*

Week	Date	Topics	Book	Quiz	Notes
1	Sep 10	• Course Introduction • Review Fundamentals	Chapters 2-3		HW1 released
2	Sep 17	• Divide-and-Conquer	Chapters 4	Quiz 1	
3	Sep 24	• Linear Sorting and Selection	Chapter 8-9	Quiz 2	HW 1 due Sep 20 HW 2 released
4	Oct 01	• Dynamic Programming	Chapters 14	Quiz 3	HW 2 due Oct 4 HW 3 released
5	Oct 08	• Greedy Algorithms	Chapter 15	Quiz 4	
6	Oct 15	• Graphs Algorithms	Chapter 20-21	Quiz 5	HW 3 due Oct 18 Mid-course feedback due Oct 18 HW 4 released
7	Oct 22	• Linear Programing • Online Algorithms	Chapters 27 & 29	Quiz 6 **On Paper**	Class Activity #1
8	Oct 29	• Problem Solving • Midterm Practice			HW 4 due Oct 28
9	Nov 05	• Midterm	Weeks 1-7		Midterm Exam In-Class & Paper-Based
10	Nov 12	• Machine Learning Supervised	Chapter 33	Quiz 7 **On Paper**	Project Proposal due Oct 15
11	Nov 19	• Machine Learning Unsupervised	Chapter 33	Quiz 8 **On Paper**	
12	Nov 26	• NP-Completeness	Chapter 34		Class Activity #2
13	Dec 03	• Project Presentation			Project Milestone 3 due Dec 3
14	Dec 10	• Final Project Delivery			Project Milestone 3 due Dec 10

* This schedule is subject to change as we navigate through the term. The latest schedule can be found on Canvas.

2.1 Pre-class Work

This course, as well as other MSCS courses at the Vancouver campus of Northeastern University, will be taught using a pedagogical technique known as the Hybrid classroom. In this approach, there will be a combination of asynchronous (online) materials that you will be expected to study on your own, and synchronous (in-class) activities and discussions, in which important concepts will be reviewed and students are expected to participate at scheduled times. The asynchronous component will be the primary means by which the course materials are delivered. And then during class, you will apply your understanding of these core concepts through carefully-chosen problems and activities, which will enable you to solidify your knowledge.

Our classrooms require much more focus and preparation time, for both the instructor and the students. After all, it is much easier for the instructor to read a set of pre-prepared slides and for the students to passively observe and listen. But on our campus, we will devote our class time to the computational thinking process: resolving obstacles, developing conceptual understanding, communicating solutions supported by evidence, and creating efficient algorithms that solve our problem. Through this process, you will better develop your confidence, creativity, and critical-thinking skills, preparing you to become *computer scientists* (not just programmers).

In order for this course to be a meaningful learning experience, you will need to come to each class well-prepared, with all assigned readings and videos complete, as well as your individual quiz finished to the best of your ability. This emphasis on pre-class work is the reason why our class meets for only 2 hours each week, compared to other four-credit courses at Northeastern that meet for 3.25 hours each week. If you do not complete the pre-class work, you will have a hard time following the in-class activities, which will make it that much harder for you to successfully complete the Problem Sets, Programming Projects, and Course Syntheses.

I have designed this course so that you will be spending approximately 10 to 20 hours per week on all activities relating to this course (i.e., pre-class work, attending class, all assessments).

2.2 In-class Work

If you join class in person, you are strongly encouraged to bring your laptop or phone to class so that you can participate in the activities.

Most lectures will feature interactive activities and/or polls that support the material being presented. You must be present in class to complete the activity or take the poll (participating in an online activity while not attending the synchronous session will be considered academic dishonesty and will be treated harshly). Each instructor may have a different style for assigning participation grades, but historical grading information suggests that each style results in a similar overall grade distribution. Participation grades will be posted on Canvas, and regularly updated.

Students are expected to attend classes regularly, take tests, and submit papers and other work at the times specified by the instructor. Students who are absent repeatedly from class or labs will be evaluated by faculty responsible for the course to ascertain their ability to achieve the course objectives and to continue in the course. Instructors may include, as part of the semester's grades, marks for the quality and quantity of the student's participation in class.

PLEASE DON’T BE LATE. You are an essential part of the class. Your participation is an essential part of the class. If you are late, please be courteous to others when entering.

BE PRESENT WHEN YOU ARE ATTENDING CLASS. Please do not distract yourself from the class by doing other activities such as phone calls, email, facebook, chat/IM/texting, games, web surfing – unless it has a direct bearing on the course. Then, by all means, surf away!

3 Course Assessment

There are several methods of assessment in this course.

- **In-Class Quizzes** **8%**
  - 8 in-class Quizzes (each 1%)
- **Homework Assignments** **36%**
  - 4 Individual Assignments, each 9%
- **Class Activity** **6%**
  - 2-3 Class activity, each 2-3%
- **Final Team Project** **25%**
  - Milestone 1: Project Proposal – 2%
  - Milestone 2: Project Presentation – 3%
  - Milestone 3: Project Final Deliverable - 20%
- **Midterm Exam** **25%**
  - Midterm Exam (Coverage Weeks 1-7) – 25%

Note: Most assignments and deliverables will be due on Fridays at 7pm (PT).

3.1 Assessment Description

- **4 Homework Assignments (36%)** consist of some multi-part questions that are based on key concepts and ideas that are uncovered during class. All assignments are to be done individually. At least, one assignment will have some programming aspects inspired by various Algorithms challenges found on Leetcode (leetcode.com). These programming tasks will enable you to apply the Algorithms concepts you will learn in this course and develop your skills in designing, implementing, and testing programs in the programming language of your choice.
- **8 In-Class Quizzes (8%)** take place at the beginning of each class, based on the weekly course readings that you are to complete in preparation for that class. You must be physically present in class in order to take the quiz; if you are not, you will receive a 0 on the quiz. To accommodate absences, the lowest quiz grade will be dropped. While most of them will be online, we will have few that are on paper.
- **1 Midterm Exam (25%)** consist of short answer questions, as well as several multi-part problems connecting different areas of the course, allowing you to synthesize what you have learned. You'll be able to bring and use a single-sided hand-written cheat sheet.
- **Class Activity (6%)** On a few selected classes, this item take place towards the end of the class. A fun, step-by-step activity where you implement an algorithm for a real-life problem.
- **1 Reflection/Course Feedback (1%)** are your personal reflections on your journey of self-authored integrated learning in this course. You will reflect on your growth across five learning dimensions: Intellectual Agility, Global Mindset, Social Consciousness and Commitment, Professional and Personal Effectiveness, and Well-Being.
- **1 Final Project (25%)** work occurs during the last 2-3 weeks of the course, in lieu of a final examination. Each group will select any topic relating to the design and/or analysis of Algorithms. Your group will submit a project proposal, a written report, and also deliver a presentation on the last day of the course.

3.2 Late/Makeup Policy

All tasks and assignments have a specific due date and time. **Your work is late if it is not turned in by the deadline.** In-class activities and quizzes and final project will not be accepted late. **Homework assignment submissions will be accepted only up to 48 hours after the deadline with 5% penalty every 6 hours (late time will be rounded up to the next level)**. For example, if an on-time submission would have received a grade of 90 points, the same assignment submitted 7 hours late would receive 81 points (90 x 0.90). **Assignments submitted more than 48 hours late will receive a zero.**

Make-up assignments (team or individual) will not be given. Sometimes life gets in the way of schedules. Sickness or other unplanned or extraordinary events happen and will be dealt with individually. It is your responsibility to ensure your situation is known to the instructor as soon as reasonably possible. You are accountable for being heard, which means you need to ensure that the instructor heard you.

While "life happens," poor planning by you does not count. And definitely do not wait to discuss gray areas. For example, an interview opportunity arises (good!): you should not wait until the day before the assignment is due to let us know that you could not complete the assignment because you had to prepare for the interview. That would be considered poor planning. Good planning would be to alert the TA or Instructor that you got the interview and, while you hope to finish the assignment, there is a concern. Then when you don't finish on time, it's clear that you planned your time and that will be taken into consideration. These "good planning" situations will be considered individually.

3.3 Grade Calculations

Grades will be calculated on an absolute basis: there will be no overall curving. The mapping of raw 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.

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

3.4 Grading Appeal

We strive to provide as much details as possible and model solutions will made available when possible. If you have concerns regarding the grading of your work and would like to respectfully ask us to regrade your work, please let us know *right away* by opening a regrade request by post (private message, including TAs and Professor) on Piazza. All regrade requests must be submitted within 7 days from your receipt of the graded work. If your regrade request is closed and you feel that the response was not satisfactory, you may appeal to the instructor via one single email detailing all your reasons within 48 hours of the initial decision.

I encourage you to spend your time and energy where it serves you the most which will be learning from past mistakes and self-improvement. While we reserve your right to ask for a re-grade, we find debating grades an incredible drain on course staff time and energy and prevents us from serving students well and focusing on most important aspects of the course.

4 Course Materials

There is an associated Canvas page for this course. I will use it to post weekly reading assignments, lecture materials, labs, feedback, and grades.

4.1 Textbook: The required reading for this course is provided on the course website. Students are expected to read each week's materials as well as view any of the supplemental videos before attempting that week's assignments. Trying to do the assignments without reading the posted material or watching the videos will make the assignments much harder than they are designed to be. For some of you, it will be necessary for you to review the module's material more than once to truly understand the material.

4.2 **Programming Language:** In this course, you can work with any language that you're most comfortable with, some recommended languages would be C/C++, Java, and Python.

4.3 Handing in Assignments: We will be using mostly GradeScope in this course. Please note that all deadlines on GradeScope are expressed in Eastern Time (ET.)

5 General Policies

5.1 Attendance

According to Khoury's policy for Vancouver campus, students must attend classes in-person after the course add deadline of Sep 17th. While we understand the convenience of attending classes from home, the positive impact of in-person attendance on the learning outcome and students' performance is undeniable. Now that it's again safe to do so, we would like to maximize the benefits of in-person classes, including interactive/hands-on learning, distraction-free environment, networking, and relationship building.

Sometimes you cannot avoid missing a class. If you need to be away from class, it is your responsibility to catch up on the materials discussed in the class. In case of illness or other emergencies, you might be provided with a temporary link to join the class virtually. However, if you have an ongoing condition that prevents you from attending classes in-person, please email your instructor to discuss your situation.

5.2 Academic Integrity

Students must work individually on all homework assignments. We encourage you to have high-level discussions with other students in the class about the assignments, however, we require that when you turn in an assignment, it is only your work. That is, copying any part of another student's assignment is strictly prohibited, and repercussions for doing so will be severe (up to and including failing the class outright). You are free to reuse small snippets of example code found on the Internet (e.g. via StackOverflow) provided that it is attributed. A good guideline is that if you take more than three lines of code from some source, you must include the information on where it came from. A URL or a notation (e.g., "MATLAB help files") is fine.
If it is an entire function, note it at the beginning of the code segment and include any original credit information. Provide a qualitative description of what you used, and what you changed/contributed. If you are concerned that by reusing and attributing that copied code it may appear that you didn't complete the assignment yourself, then please raise a discussion with the instructor.

Here are a few examples of academic dishonesty:

- Working with one or more partners on an assignment.
- Submitting a copy of work done by another student, with or without their knowledge.
- Submitting work that was primarily found on the web or provided by someone else outside of this class.
- Submitting work by anybody who took this course in the past whether the course was here at Northeastern or at another campus or institution.
- Providing or receiving significant help to another student on an assignment.

If you have a question about what is considered a violation of this policy, **ASK!**
Unless stated otherwise (e.g., group project), assignments reflect individual work.
While you may discuss concepts and ideas with other students, there is to be no direct collaboration.

If you steal someone else's work, you fail the class.
If someone uses your work, you fail the class.
If you are unsure about this policy, **ask the instructor**.

The university's academic integrity policy discusses actions regarded as violations and consequences for students: https://osccr.sites.northeastern.edu/academic-integrity-policy/

5.3 Use of AI-Assisted Technology

In this course, your research project is an opportunity to demonstrate deep understanding and expertise in your field of study. To augment your research process, we encourage the judicious use of AI-assisted technology. AI tools, such as ChatGPT among others, can significantly contribute to your productivity by assisting in idea generation, argument development, and insight acquisition. These tools should be used as intellectual leverage to enhance the quality of your work. It is critical to remember that AI tools are supplementary aids and not a replacement for your scholarly input. They serve to enhance the depth and breadth of your research, not to diminish the necessity of your unique contributions. The true essence of your project lies in your original thought, critical analysis, and personal interpretation of data and concepts.

While AI can offer suggestions and provide information, it is incumbent upon you to critically evaluate and synthesize these elements within your work. AI outputs should be meticulously reviewed, contextualized, and integrated into your research with a clear understanding of their relevance and validity.

As you engage with AI technology, ethical use and academic integrity must guide your actions. This includes the proper attribution of AI-assisted content and ensuring that the bulk of your work is reflective of your intellectual labor.

5.4 Reasonable Accommodations

The goal is that every student should be able to participate in this course. If you require any special accommodations, let me know immediately so that we can work out appropriate arrangements.

5.5 Student Feedback

Your opinions are very important to us. All students are strongly encouraged to use the TRACE (Teacher Rating and Course Evaluation) system https://www.northeastern.edu/trace/ near the end of the course to evaluate this course. 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 at least once about halfway through the semester. However, if you have concerns about the course, don't wait until you are asked. You can contact me any time!

5.6 Classroom Environment

In our commitment to fostering an environment that optimizes teaching and learning, we hold every participant accountable for maintaining a civil and non-disruptive forum for the discussion of ideas. This expectation extends beyond the physical classroom to encompass online platforms such as Canvas and Piazza.

5.6.1 In-Class Conduct: Students are expected to conduct themselves in a manner that supports a constructive learning environment. This includes showing respect for differing opinions, engaging in discussions based on facts and documentation rather than prejudices and personalities, and refraining from disruptive or disrespectful behavior. Constructive criticism is welcome, but it should be free from harassing statements.

5.6.2 Online Platform Etiquette: The respectful and responsible use of online platforms is integral to our classroom environment. These platforms are extensions of our physical classroom, and the same principles of engagement apply. They are not venues for exerting peer pressure, openly criticizing course difficulties in a non-constructive manner, or for personal grievances. Please use these platforms to support each other's learning, ask questions, and engage in meaningful discussions.

The instructors reserve the right to intervene in conversations, either in person or online, that do not align with these expectations. Repeated unprofessional or disrespectful conduct may impact your grade and could lead to more severe consequences. Remember, part of the learning process in this course involves respectful engagement with ideas and people, whether face-to-face or through digital mediums.

5.7 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, harassment, 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/.

Please be aware that faculty members are Mandatory University Reporters who are required to disclose information about alleged discrimination, harassment, and sexual violence (including sexual harassment, sexual assault, dating/domestic violence, or stalking) to the OUEC. If the OUEC receives a report, a member of their office will reach out to offer information about available rights, support resources and pathways towards a resolution as a member of the campus community. Community members are not required to respond to this outreach.

If you, or another community member you know wishes to speak to a confidential resource who does not have this reporting responsibility, please contact any of the following confidential resources. These confidential resources are not required to report allegations of discrimination to the University without your signed release.

- Find@Northeastern: Offers 24/7 mental health support via phone at 877.233.9477 (in the U.S.) or +1.781.457.7777 (outside the U.S.).
- Sexual Violence Resource Center: The SVRC provides confidential, trauma-informed support services to Northeastern students who have experienced any form of sexual violence (i.e., sexual assault, sexual harassment, sexual exploitation, domestic/dating violence, and/or stalking). Request services online at bit.ly/svrequestform.
- Confidential Resource Advisor: The CRA provides confidential, restorative informed support services to Northeastern students who have been accused of sexual or identity based harm. Request services online at https://bit.ly/svrequestform.
- Please visit https://www.northeastern.edu/ouec for a complete list of reporting options and support resources both on- and off-campus and contact the OUEC (ouec@northeastern.edu) at any time.

5.8 Students With Disabilities

The goal is that every student should be able to participate in this course. If you require any special accommodations, let me know immediately so that we can work out appropriate arrangements.

Students who have disabilities who wish to receive academic services and/or accommodations should visit the Disability Access Services (DAS) (https://disabilityaccessservices.sites.northeastern.edu/) or call (844) 688-6287.

If you have already done so, please provide your letter from the DAS to the instructor early in the semester to arrange those accommodations.