McGill

Faculty of Science

COMP 251 - Algorithms and Data Structures

Course Outline

McGill University, Fall 2024

Instructors:

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1 Land Acknowledgment

McGill University is on land which has long served as a site of meeting and exchange amongst Indigenous peoples, including the Haudenosaunee and Anishinabeg nations. We acknowledge and thank the diverse Indigenous peoples whose presence marks this territory on which peoples of the world now gather.

L'Université McGill est sur un emplacement qui a longtemps servi de lieu de rencontre et d'échange entre les peuples autochtones, y compris les nations Haudenosaunee et Anishinabeg. McGill honore, reconnaît et respecte ces nations à titre d'intendant traditionnel des terres et de l'eau sur lesquelles nous nous réunissions aujourd'hui.

Please see here for more details: `https://www.mcgill.ca/fph/welcome/traditional-territory`.

2 Course Overview

Welcome to COMP 251. This course is designed for those with a foundational understanding of computer science, and we believe that everyone with the appropriate background can both enjoy it and succeed.

COMP 251 may be your first exposure to the theoretical side of computer science, which can be challenging. We encourage you to embrace these challenges, knowing that we are here to support you throughout the course. Our aim is to create a learning environment that is both welcoming and inclusive, where every student feels comfortable and valued.

We invite you to engage in online and in-class discussions with curiosity and an open mind. Your active participation will not only help you learn but will also contribute to a richer learning experience for everyone.

In this one-semester, 3-credit course, you will review essential data structures and explore new ones, such as balanced search trees and disjoint sets. You will also learn to develop formal proof techniques to analyze the correctness and efficiency of algorithms.

While the course uses the Java programming language to illustrate concepts, please note that this is not a Java programming course. Students are expected to have a solid understanding of Java, as you will apply these skills in a final project, should you choose to do one.

The following sections provide detailed information on course policies and assessment methods.

2.1 Learning Outcomes

By the end of the course you will be able to:

1. Design or select an appropriate data structure and algorithm for a particular problem.
2. Classify algorithms based on their purpose, design techniques, applicable contexts, and efficiency.
3. Implement data structures and algorithms seen in class.
4. Distinguish between algorithm correctness and performance.
5. Analyze the runtime performance of algorithms in terms of Big O, Big Omega, and Big Theta notation.
6. Use appropriate proof techniques to prove the correctness of an algorithm.
7. Compare worse case, best case, average case and amortized analysis.

2.2 Prerequisites

As per the e-calendar the official prerequisites are COMP 250, and MATH 240 or MATH 235. Please note that, COMP 251 is not open to students who have taken or are taking COMP 252.

3 Course Content and Material

All the material needed for this class will be available on myCourses; this includes lecture slides, lecture recordings, recommended exercises, as well as links to any other material that might help you reinforce and broaden your understanding of the course material.

There is no required textbook. However, we recommend the following textbooks from which most lectures will be based upon:

- Cormen, Leiserson, Rivest, & Stein, *Introduction to Algorithms.*

- Kleinberg & Tardos, *Algorithm Design*.
- Jeff Erikson, *Algorithms*.

Instructions to borrow a E-book online are available at http://www.mcgill.ca/library/find/ebooks/borrowing-ebooks/.

Tentative Lecture Schedule

Week	Date	Topic
1	Aug 29	Introduction
2	Sep 3	Recurrences
	Sep 5	Proofs by induction and loop invariants
3	Sep 10	Big O notation
	Sep 12	Counting, graphs, and probability
4	Sep 17	Priority queues (incl. heaps)
	Sep 19	Balanced BSTs: AVL trees
5	Sep 24	Balanced BSTs: red-black trees
	Sep 26	Hashing
6	Oct 1	Disjoint-set data structure
	Oct 3	Greedy algorithms
7	Oct 8	*Midterm 1 review*
	Oct 10	Elementary graph algorithms
8	Oct 15	**Reading week: no classes**
	Oct 17	
9	Oct 22	Topological sort and strongly-connected components
	Oct 24	Shortest path problem
10	Oct 29	Minimum spanning trees
	Oct 31	Bipartite graphs
11	Nov 5	Divide-and-conquer 1: merge sort and integer multiplication
	Nov 7	Divide-and-conquer 2: Master theorem
12	Nov 12	Dynamic programming 1: weighted interval scheduling
	Nov 14	Dynamic programming 2: Bellman-Ford and the knapsack problem
13	Nov 19	*Midterm 2 review*
	Nov 21	Amortized analysis
14	Nov 26	Network flows 1
	Nov 28	Network flows 2
15	Dec 3	Randomized algorithms and probabilistic analysis

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3.1 Copyright policy

You are not allowed to post any course materials on github, coursehero, any other websites. This includes PDFs of lecture slides, lecture notes, exercises, quizzes, assignment questions or anything else that we provide for you.

Stated more formally: "Instructor-generated course materials are protected by law and may not be copied or distributed in any form or in any medium without explicit permission of the instructor(s). Note that infringements of copyright can be subject to follow up by the University under the Code of Student Conduct and Disciplinary Procedures."

4 Communication Policies

The University is committed to maintaining teaching and learning spaces that are respectful and inclusive for all. To this end, offensive, violent, or harmful language arising in course contexts may be cause for disciplinary action under the Article 10 of the Code of Student Conduct and Disciplinary Procedures and Section 2.7 of the Policy on Harassment, Sexual Harassment, and Discrimination Prohibited by Law.

4.1 Office Hours

Teaching Assistants (TAs), TEAM Mentors and instructors will be available for office hours to support your learning throughout the semester.

A link to a Google calendar with everyone's office hours will be shared with you on myCourses.

4.2 Discussion board

We will be using Ed Discussion as the official discussion board. The system is highly catered to getting you help fast and efficiently from classmates, the TAs/Mentors, and the instructors. A link to COMP 251's Ed page will be shared on myCourses.

Rather than emailing questions to the teaching staff, **we encourage you to post all your questions related to the course content and the assessments on Ed**. If your question does not reveal sensitive information (e.g., your answers or progress on an assignment question, or a personal situation), *please* make your post public so that other students can also benefit from the answer.

Discussion Board Guidelines

Please follow common sense rules and etiquette for discussion board postings: be polite and respectful, avoid texting shorthand, choose a suitable subject line for your posting, use multiple postings for multiple subjects, proof read before posting, and keep your posts brief if possible.

You may freely answer other students' questions as well, with one important exception: do not post your own code or answers to assignments publicly on Ed.

4.3 Contacting Instructor and Teaching Assistants

For private matters only, you e-mail the instructors directly using the official course email: comp251.cs@mcgill.ca. Be sure to send your email from your `@mail.mcgill.ca` address and include your student ID. When emailing, please follow the guidelines on etiquette described in the video here.

You should **not** reach out to the TAs using their personal emails, unless otherwise instructed. You can instead:

- Post your question on the Ed Discussion Board.
- OR, meet with them during their office hours.

Note that, especially if your questions requires you to share part of your own work, we highly encourage you to take the time to go and see someone from the teaching staff during their office hours.

4.4 Course Announcements

Important information about the course will be announced in class and on Ed Discussion.

Students are expected to monitor both their McGill e-mail account, myCourses, and Ed Discussion for course-related news and information.

5 Means of Assessment

Your final grade in the course is calculated based on the following grading scheme:

	Weight
Assignments (3)	24%
Midterms (2)	44–50%
Final Assessment	25%
Programming Assignments* (3)	0–6%
Mini-interviews* (3)	
Surveys	1%

*You can do a mini-interview OR a programming assignment tied to each assignment, but not both.

Policy on final course grades. We understand that many factors may influence your performance in the class, some of which may be out of your control, but to ensure fairness, we use the same methods for calculating final letter grades for all students. When we calculate your final course grade, we will use a formula that rounds off to the nearest integer. If your grade is 84.4 then it rounds to 84 and you get an A-, whereas if it is 84.6 then it rounds to 85 and you get an A. If your grade is 84.5, our formula will round it up to 85. The same round off procedure holds for low grades. If your calculated final course grade is 49.4 then it rounds to 49 which is an F. We draw a very a hard line on this, so to avoid failing the course you should stay far away from that line.

Official language policy for graded work: In accordance with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded. See here for more details: `https://www.mcgill.ca/study/2019-2020/university_regulations_and_resources/undergraduate/gi_lang_policy`.

Conformément à la Charte des droits de l'étudiant de l'Université McGill, chaque étudiant a le droit de soumettre en français ou en anglais tout travail écrit devant être noté, sauf dans le cas des cours dont l'un des objets est la maîtrise d'une langue. (Énoncé approuvé par le Sénat le 21 janvier 2009)

5.1 Assignments

There will be **three** written, algorithmic assignments, each weighed at 8% of your grade, for a total of 24%. Questions in the assignments will primarily focus on testing two skills:

1. Algorithm design, i.e., the ability to design and properly communicate an efficient algorithm to solve an ambiguous problem, and
2. Formally proving properties of data structures and algorithms.

These assignments are meant to be difficult and may involve some creative thinking. As such, it is recommended to read the questions early to allow yourself time to brainstorm possible solutions.

Timeline (tentative)

	Released	**Due**	**Topic**
Assignment 1	Sept. 24	Oct. 10	Big O, trees, priority queues
Assignment 2	Oct. 10	Nov. 5	Greedy algorithms, hashing, disjoint sets
Assignment 3	Nov. 12	Nov. 28	Graphs, divide and conquer, dynamic programming

Assignments (as well as all other course work) **MUST** represent your own personal efforts (see the section on Plagiarism Policy and Assignments below).

If you do not do submit any work for an assignment, then you will receive a grade of 0 for it.

Late Policy

Assignments and exam material will be released early to give plenty of time to work and study. It is your responsibility to accommodate the deadlines we give. Unforeseen events may arise that prevent you from submitting an assignment on time. For example, you might be sick for several days in the week before the assignment is due. You will be able to submit your work up to two days after each assignment deadline. Each student has 2 free late days at their disposal to be used whenever something unexpected happens. Any additional late day used will receive a penalty of 20 percentage points on that assignment. Use the late days at your disposal wisely! **Please note that no assignment can be handed in later than 2 days after its due date.** Assignments submitted more than 2 days after the deadline will not be accepted, nor graded, and will therefore receive a grade of 0. No exceptions will be made beside in extreme and rare circumstances. Plan appropriately and do NOT submit your assignments only minutes before the assignment deadline. Requests for waiving the late penalty because the system was busy or your machine too slow will not be accepted.

The instructor reserve the right to modify the lateness policy for a particular assignment; any such modifications will be clearly indicated at the beginning of the relevant assignment specifications, in class and on the course webpage.

Grading Policy

The quality of your assignment presentation is important. If an answer is unreadable, uses notation that is not adequately explained, or is organized very poorly, we may not be able to grade it.

An important skill you are expected to learn in this class is **clearly explaining intricate algorithms**. Thus, clarity of your explanations will be a factor in your grades. For instance, even if an algorithm you provide is generally correct at solving a problem, including extraneous information and using convoluted notation will result in an imperfect grade.

5.2 Midterms

You will be required to complete **two in-person**, *closed book* midterm examinations. Tentatively, the midterms are scheduled for **October 8** and **November 19**.

These exams will include a variety of question types, such as True/False, multiple choice, short answer, and long answer, all designed to assess your understanding of the material covered in class.

Midterm grading policy

By default, the midterms are weighed together at a total of 50% of your overall grade (25% each). However, the midterm component of your grade can alternatively be weighed at 48%, 46%, or 44%, if you opt-in to one, two, or three of the additional assignments, respectively. This is explained in more depth in the section on additional assignments.

The two midterms are weighed equally regardless of what overall percentage of your grade they make up. For example, if you opt-in to two of the additional assignments, your midterms will each be weighed at 23% of your overall grade.

Importantly, if you fail (earn below 50% on) *both* midterms, you will not pass the course, regardless of your final calculated grade. This policy is in place for the following pedagogical reasons:

- The midterm exams are designed to assess your mastery of the core concepts and skills taught in the course. These concepts form the foundation for more advanced topics that will be covered in later portions of the course or the program. Passing these midterms is a key indicator that you have acquired the necessary foundational knowledge to progress in the course/program.
- The midterm exams could be the only assessments in this course that are proctored, ensuring the integrity of the testing environment. This is crucial for maintaining academic standards and fairness.
- The in-person midterms provide an opportunity for you to demonstrate your knowledge under controlled conditions. Passing these exams shows that you can apply what you've learned without external assistance, which is important for your success in this course and beyond.

Optional Third Midterm: To support your success in the course, we will offer an optional examination, covering the entire course content. This exam is tentatively scheduled for December 2, and is intended for students who may have struggled with the first two midterms. If you fail both midterms, the optional third midterm provides an opportunity to replace your lowest midterm score, potentially allowing you to pass the course. This option is designed to give you a second chance to demonstrate your understanding of the material.

Note that at least half of each midterm will focus on definitions and straightforward applications of the data structures and algorithms discussed in class, ensuring that passing the exam is achievable for those who have kept up with the material. The remaining portion of the exams will challenge you with mathematical proofs and more sophisticated algorithm design tasks. This balance is intended to fairly assess both foundational knowledge and deeper understanding.

This policy is intended to encourage diligent study habits and ensure that all students who pass the course have genuinely mastered the key material.

5.3 Final Assessment

Each student has the option to choose between two forms of final assessment:

1. A **coding project** with an optional in-person code review, or

2. A **live technical interview** examination.

Both options contribute 25% to your final grade.

Final coding project

The final coding project is a large programming assignment in Java where you are tested on your ability to implement data structures and write efficient algorithms. Your algorithms will be tested on both correctness *and* efficiency.

Submission Deadlines:

- **General Deadline:** All projects must be submitted by December 20th.
- **Early Submission Benefits:** To qualify for a potential grade above 80%, submit your project by December 17th and pass the automated tests with a score exceeding 80%. Following this, you must schedule a 15-minute in-person code review session with a TA, to be held between December 18th and December 20th.
  - **Code Review:** This session will evaluate your understanding of the submitted code. The outcome of this review could either confirm your grade from the automated tests or adjust it based on the depth of understanding demonstrated.
  - **Note:** If you do not participate in a code review, or if your final submission is after December 17th, your maximum possible grade will be capped at 80% and will be based solely on the automated tests.

Technical Interview

This option is designed to simulate the experience of a coding interview, aiming to alleviate the stress associated with traditional written exams while providing practical interview practice.

- **Format:** You will be asked to solve and present solutions to three problems within a 45-minute session. Two of the problems will be selected from a list of 25-30, which will be shared with you in advance.
- **Interactive Component:** There will be an opportunity for follow-up questions on your solutions, allowing us to assess your problem-solving approach and depth of understanding.
- **Scheduling:** Interviews will be scheduled during the final exam period based on the availability of both students and teaching staff. Further details will be provided in class and via myCourses/Ed Discussion.

5.4 Optional Assignments

Alongside the core assignments, you have the option to engage in additional mini-assignments, each allowing you to shift 2% of your midterm grade to these tasks. For each of the three main assignments, you may choose **one** of the following options:

- **Programming Assignment**: Complete a short programming task relevant to the main assignment topic. Your solution code must be submitted via Ed Lessons by the respective assignment deadline. The work will be evaluated for both correctness and efficiency and will be graded based solely on the results of automated tests.

- **Mini Presentation**: Deliver a 5-minute in-person presentation on one of the problems provided at the start of the semester, matching the assignment topic. You must sign up for your presentation slot at least one week before the assignment deadline. Presentations will be graded using a rubric similar to that of the final technical interviews, but without follow-up questions.

You can choose different types of optional assignments for each of the three main assignments. For example, you might choose to do a presentation tied to Assignment 1, a programming assignment for Assignment 2, and opt out of an optional assignment for Assignment 3. This flexibility allows you to tailor the assessment methods to your strengths and preparation needs.

These optional assignments are designed to offer flexibility in how you are assessed and to help prepare you for the final assessment. They also provide an opportunity to reduce the weight of the midterms in your final grade, potentially alleviating associated stress.

Even if you choose not to submit these optional assignments for grading, they will remain available as practice material throughout the semester.

It is entirely up to you whether to complete none, one, two, or all three of these optional assignments.

5.5 Participation in surveys

Finally, you will be asked to complete a series of brief surveys about this course. These surveys are worth up to 1% of your final grade. You will have the opportunity to release your survey responses and your course grades for use in a research study on students' experiences in introductory STEM courses. Aside from the points allocated to your completion of the surveys, the way you choose to answer the survey questions and your choice to participate in the research study or not will not affect your grades in any way. If you choose to allow your surveys to be used in the research, your identity will remain confidential in all reports stemming from the study. You can complete the surveys for this course without participating in the research study. Note that we, the course instructors, are not part of the research team handling the data collection or data analysis.

There will be 6 surveys in total:

- One beginning-of-semester survey due by Sept. 15th.
- Five mid-semester surveys to be completed after class on the following days:
  - Oct. 3
  - Oct. 10
  - Oct. 22
  - Oct. 24
  - Oct. 31
- One final end-of-semester survey which will open on Nov. 26 and is due by Dec 4.

To receive full credit for completing the surveys you must complete the beginning-of-semester survey and at least 3 of the remaining surveys (mid-semester + end-of-semester).

5.6 Regrade Requests

If you believe there has been an error in the grading of any of your assessments (assignments, midterms, or presentations), you are entitled to request a regrade. **Regrade requests must be submitted within 5 working days from the date your grade was published**. Requests submitted after this deadline will not be considered.

To ensure fairness and accuracy, regrade requests may lead to a complete re-evaluation of the work in question. This means that not only the part you contest but also other sections of your exam or assignment might be re-graded. As a result, the final grade after regrading could be higher, lower, or the same as originally assigned.

5.7 Supplemental/Deferred Exam

There will be no supplemental or deferred exam for this course as there is no final exam.

5.8 Additional Work

Students who receive unsatisfactory final grades will **NOT** have the option to submit additional work in order to improve their grades.

5.9 Extraordinary Circumstances beyond the University's Control

In the event of extraordinary circumstances beyond the University's control, the evaluation scheme in a Course is subject to change, provided that there be timely communications to the students regarding the change. See section 3.2.3 of the *University Student Assessment Policy*.

6 Policies on Academic Integrity

Official policy: " *McGill University values academic integrity. Therefore all students must understand the meaning and consequences of cheating, plagiarism, and other academic offenses under the Code of Student Conduct and Disciplinary Procedures (see* `www.mcgill.ca/integrity/` *for more information)* ".

6.1 Plagiarism Policy

You must include your name and McGill ID number at the top of all submitted work. By doing so, you certify that the work is entirely your own and solely the result of your individual effort.

Work submitted for this course must represent your own efforts. Assignments **must** be done **individually**; you **must not** work in groups. Do not rely on friends or tutors to do your work for you. You **must not** copy any other person's work in any manner (electronically or otherwise), even if this work is in the public domain or you have permission from its author to use it and/or modify it in your own work. Furthermore, you **must not** give a copy of your work to any other person.

The plagiarism policy is not meant to discourage interaction or discussion among students. We encourage you to discuss the assignment problems with each other. However, these discussions should be limited to collaborative problem solving: do not share code or give away answers. Do not share anything with friends that you would not share with the class broadly.

Importantly, we ask you to indicate on your assignments the names of the people with whom you collaborated or with whom you discussed assignment problems (including the TA's and the instructor). You will not be penalized for indicating collaborators, but failure to do so may result in your assignment being flagged or your grade being affected.

Text matching software

Submissions will be checked using text-matching software to detect similarities that suggest plagiarism. Cases with high levels of similarity will undergo a manual review.

You may also be asked to present and explain your assignment submissions to an instructor at any time.

When the instructors suspects that plagiarism has occurred, the instructors will report the case to the Disciplinary Officer in the student's Faculty (Science, Arts, Engineering, etc). For more details on the process, see Section III Articles A.37 (p. 10) and A.48 (p. 13) of the Code of Student Conduct and Disciplinary Procedures:

`https://www.mcgill.ca/deanofstudents/files/deanofstudents/code_of_conduct_revision_jan2019.pdf`

Posting assignment solutions on a website

We encourage you to use tools like GitHub for version control systems. However, you must **not** share your assignment solutions by posting them on a public space such as your GitHub account. If you do and if another student copies your solution from there, then there will be no way to discriminate who did the work, and you may be accused of plagiarism along with the other student(s).

This rule extends beyond the duration of the course.

6.2 Use of Generative AI

Students are encouraged to make use of technology, including generative artificial intelligence tools, to contribute to their understanding of course materials.

Students are not encouraged, unless otherwise stated, to make use of artificial intelligence tools, including generative AI, to help produce assignments. This includes tools such as ChatGPT or CodePilot. We believe that working through the assignments on your own will help you gain a better understanding of the course material and will better prepare you not only for the other course examinations, but also for the subsequent CS courses, internships, research opportunities, and jobs. However, students are ultimately accountable for the work they submit. Any content produced by an artificial intelligence tool must be cited appropriately. Many organizations that publish standard citation formats are now providing information on citing generative AI (e.g., MLA: `https://style.mla.org/citing-generative-ai`).

7 Post-Coronavirus-Pandemic Public Health issues

The Quebec government (`https://www.quebec.ca/en/health/health-issues/a-z/2019-coronavirus`) provides the following guidelines for educational institutions (as of August 2023). Wearing masks is not required, however, if you are experiencing cough, sore throat, or nasal congestion it is recommended that you wear a mask and, as much as possible, keep your distance from others and advise them you may be contagious. In the case of a fever, remain at home.

8 Accommodations

For this course, we are adopting flexible assessment strategies that create greater access for all students by incorporating principles of Universal Design for Learning. As such, we have taken into consideration the variety of learner needs and barriers that students may face in this course and have designed the assessments with these considerations in mind.

8.1 Student Accessibility and Achievement

Student Accessibility and Achievement helps McGill's diverse student body achieve their academic goals and overcome barriers by providing not only accommodations for students with documented disabilities but also additional learner support for students facing barriers in university.

There may be circumstances in which some disability-related accommodations may still be needed for this course. If you feel this is the case for you, please reach out to the SAA office at `access.achieve@mcgill.ca` or (514) 398-6009 (options #1-3). They will assess the situation and coordinate with the instructors when necessary.

8.2 Pregnancy and Caregiving

Students who are pregnant and/or caring for a dependent also often may find it helpful to receive academic accommodations. McGill's guidelines for accommodations for students who are pregnant and/or caring for a dependent may be found at `https://www.mcgill.ca/study/2018-2019/university_regulations_and_resources/graduate/gi_accommodation_pregnancy_caring_dependants`