

# ***Discrete Structures (CS 5002)***

*Graduate Course, Khoury College of Computer Sciences  
Northeastern University, Vancouver Campus  
Spring 2021 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 səliwətał (Tseil-Waututh) Nations.*

Class Hours: Thursday 9:30AM-11:30AM (Pacific time)

Class Location: Northeastern Vancouver Campus (333 Seymour), Room 901C

Instructor: Richard Hoshino ([r.hoshino@northeastern.edu](mailto:r.hoshino@northeastern.edu))

Teaching Assistants: Nickyta Patel ([patel.nic@northeastern.edu](mailto:patel.nic@northeastern.edu))  
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Textbook: Discrete Structures (Version 2.1)  
By Harriet Fell and Javed A. Aslam

*CS 5002 introduces the mathematical structures and methods that form the foundation of computer science. We will study basic logic, proof techniques, functions, number theory, algorithms, graphs, and trees. We will discuss counting techniques and apply the techniques to estimate the size of sets, the growth of functions, and the time complexity of algorithms. We will examine inductive and recursive definitions of structures and functions, as well as data structures such as arrays, lists, maps, stacks, and queues.*

**NOTE:** in addition to our class time every Thursday (9:30AM to 11:30AM), I will also hold an informal and optional “Problem-Solving Workshop” from 9:30AM to 11:00AM every Tuesday, where I will be available to answer any questions you have on the weekly Problem Sets.

## **Course Objectives**

This bridge course is open to all students in the Align MSCS Program, and will contribute to your ability to achieve the MSCS program objectives, which are:

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

## Course Overview

Welcome to Discrete Structures! In this course we will study many mathematical concepts that appear in Computer Science. We begin our journey with **representation** – how we represent numbers. Statements and collections of objects are key in reasoning about and programming with these data forms. We then turn to **counting**. Counting is critical to understanding everything from analyzing data sets to understanding the security of a password. Finally, we turn to **relationships**. Data that is structured as a relationship can help us understand many real-world problems, from finding the shortest distance between two points to recommender systems at a streaming service. Specifically, we will explore and unpack the following Big Ideas in Discrete Structures:

### **Unit 1 (Representation)**

Number Representation, Statement Representation, Collection Representation

### **Unit 2 (Counting)**

Set Cardinality, Combinations and Permutations, Probability, Sequences/Series/Induction

### **Unit 3 (Relationships)**

Relations and Functions, Graphs and Trees, Growth of Functions

## Course Schedule

<b>Week</b>	<b>Work Due (by Wednesday 9:30AM)</b>	<b>% of Grade</b>	<b>Date of Class</b>	<b>Topic in Class</b>
1	-	-	Thursday, January 21	<i>Meet and Greet</i>
2	<b>Problem Set 0</b>	<b>2%</b>	Thursday, January 28	<i>Number Representation</i>
3	<b>Problem Set 1</b>	<b>6%</b>	Thursday, February 4	<i>Statement Representation</i>
4	<b>Problem Set 2</b>	<b>6%</b>	Thursday, February 11	<i>Collection Representation</i>
5	<b>Problem Set 3</b>	<b>6%</b>	Thursday, February 18	<i>Set Cardinality</i>
6	<b>Problem Set 4</b>	<b>6%</b>	Thursday, February 25	<i>Combinations and Permutations</i>
7	<b>Problem Set 5</b>	<b>6%</b>	Thursday, March 4	<i>Probability (Part I)</i>
8	<b>Course Synthesis 1</b>	<b>10%</b>	Thursday, March 11	<i>Probability (Part II)</i>
9	<b>Problem Set 6</b>	<b>6%</b>	Thursday, March 18	<i>Sequences/Series/Induction</i>
10	<b>Problem Set 7</b>	<b>6%</b>	Thursday, March 25	<i>Relations and Functions</i>
11	<b>Problem Set 8</b>	<b>6%</b>	Thursday, April 1	<i>Graphs and Trees (Part I)</i>
12	<b>Problem Set 9</b>	<b>6%</b>	Thursday, April 8	<i>Graphs and Trees (Part II)</i>
13	<b>Final Project Proposal</b>	<b>0%</b>	Thursday, April 15	<i>Growth of Functions</i>
14	<b>Course Synthesis 2</b>	<b>10%</b>	Thursday, April 22	<i>Final Project Work</i>
15	<b>Final Project Report</b>	<b>10%</b>	Thursday, April 29	<i>Final Project Presentations</i>

The above percentages add up to 86%. The remaining 14% come from weekly in-class quizzes (12%) and personal SAIL reflections (2%), both of which are explained on the next page.

## Course Assessment

There are five methods of assessment in this course.

- **9 Problem Sets (56%)** consist of five multi-part questions that are based on key concepts and ideas that are uncovered during class. The first three questions are to be done individually, while the last two questions are to be done in pre-assigned teams of three.
- **12 In-Class Quizzes (12%)** take place at the beginning of each class, based on the weekly course readings that you are to complete in preparation for that class. Half of the grade will be based on your individual responses, while the other half will be based on group responses to the same questions in your pre-assigned teams.
- **2 Course Syntheses (20%)** 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. Think of the Course Synthesis as a week-long individual take-home exam where you may consult your class notes but not your classmates or any online resources other than the ones that are explicitly permitted by the course instructor.
- **4 SAIL Reflections (2%)** are your personal reflections on your journey of self-authored integrated learning (SAIL) 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. For more details, check out <https://sail.northeastern.edu/about/>.
- **1 Final Project (10%)** work occurs during the last two weeks of the course, in lieu of a final examination. Each group will select a topic on any area of Discrete Structures that relates to at least one of the three core units (Representation, Counting, Relationships) whose concepts we will uncover in this course. Your group will submit a project proposal, a written report, and also deliver a presentation on the last day of the course.

We will use the following scale to convert numerical scores into letter grades:

<b>A</b>	93.00% – 100.00%
<b>A-</b>	90.00% – 92.99%
<b>B+</b>	86.00% – 89.99%
<b>B</b>	82.00% – 85.99%
<b>B-</b>	77.00% – 81.99%
<b>C+</b>	73.00% – 76.99%
<b>C</b>	69.00% – 72.99%
<b>C-</b>	65.00% – 68.99%
<b>F</b>	Less than 65.00%

Your final grade will be determined by the quality of your nine Problem Sets (280 marks), your twelve In-Class Quizzes (60 marks), your two Course Syntheses (100 marks), four SAIL Reflections (10 marks), and your Final Project proposal, report, and presentation (50 marks).

To calculate your final grade, I will add up your marks for these assessments and simply divide by five. If an assessment is marked out of  $5x$ , then it counts  $x\%$  towards your final grade.

Whenever I return an assessment, I will always post a “model solution” on our Canvas Page. If you wish to respectfully ask why you received a certain mark on a question, you must first carefully review the online model solution that was posted for that question and compare that solution with the comments I have provided for you. If you still disagree with the mark you received, you must email me to request an appointment, and we will set up a time to meet. At this time (and not before), we will discuss your concerns.

Please do not debate grades with me. I find it an incredible drain on my time and energy, and prevents me from serving students well.

### **Course Pedagogy**

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 Flipped/Hybrid classroom. This approach makes the most of our precious class time by eliminating the standard lecturing model, where course material is *introduced* to the students during class, usually via a lengthy PowerPoint presentation. In our Flipped/Hybrid classroom, you will come to class having already completed several readings where you will be introduced to the course material, and complete a pre-class quiz. 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.

Flipped/Hybrid 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 and Course Syntheses.

Please be prepared to spend a minimum of 20 hours per week on this course!

## Course Forum

We have a Canvas page, on which I will post all assessments, class materials, pre-class readings, pre-class videos, and grades. Please bookmark this page as you will check it regularly:

<https://northeastern.instructure.com/courses/65451>

Canvas has a platform for class discussions and course announcements, enabling you to get timely help from classmates, the TA, and the instructor. If you have any questions about any of the assessments, please post your question on Canvas rather than sending me an email.

We will also have a course Google Doc, which we will use during our classes. The URL is:

<http://bit.ly/Vancouver5002>

*NOTE: a PDF of the course textbook will be provided to you so that you do not have to purchase the textbook yourself.*

## Course Policies

### Accommodations

The goal is for every student to succeed in this course. If you require any accommodations (e.g. child care during class hours, extra time to complete assignments, support for a disability), let me know immediately so that we can work out appropriate arrangements. Speak to me at the end of class or contact me by email, and we will set up a time to meet during the first week of the course. I look forward to learning how I can be of service to you.

### Assessments

With the exception of the In-Class Quizzes and Final Project, all assessments are due at **9:30AM** on Wednesday: one day before the start of class. The course assessments are purposely due 24 hours before class, so that you have time on Wednesday night and Thursday morning to complete all of the readings in preparation for the class.

### Late Penalties

Any assessment that is late will be subject to a 50% penalty. You are allowed *one* exception to this policy, where you are allowed a reasonable extension to any assessment, with no penalty, provided you have a doctor's note or some other compelling reason. Additional exceptions will only be given under extenuating circumstances.

Note that the Late Penalty only applies to Problem Sets and Course Syntheses. The remaining assessments (In-Class Quizzes, SAIL Reflections, Final Project) must be submitted on time; failure to do so will result in an automatic zero.

### **Attendance and Participation**

It is expected that you attend every class and participate. We begin each day at 9:30AM sharp. If you must miss a class for any reason (e.g. illness, family emergency, religious observance), contact me by email. Regardless of the reason, it is your responsibility to catch up on the material you have missed, and obtain the notes from a classmate (not from me).

Students who are absent repeatedly from class will be evaluated by faculty responsible for the course to ascertain their ability to achieve the course objectives and to continue in the course.

### **Technology**

As part of our commitment to supporting students, NUFlex gives students the option of attending class on campus or attending remotely via video-conference. For each of our 15 classes, you may attend in person or attend remotely: the choice is yours.

For those of you attending the class remotely, we will use Zoom ([www.zoom.us](http://www.zoom.us)). The login details are as follows:

<https://northeastern.zoom.us/j/93137289199>  
(Meeting ID: 931 3728 9199, no password)

Students joining via Zoom will adhere to the same rules and expectations as those attending in person: being present, actively engaging in discussions, asking questions, and participating in group activities. Because you will be working in teams where some of your team members will be on campus while others will be joining remotely, we ask all students to be fully present during the class and ensure a healthy learning environment.

This requires that students in the classroom refrain from using their phones and keep them out of sight, and refrain from browsing non-course related topics. Students joining remotely will ensure that any distractions in their near surroundings are eliminated, or at least minimized to the best of their ability. Please create a distraction-free learning environment to optimize your learning.

For those of you joining via Zoom, I would very much appreciate it if you could leave your video camera ON for the entire class. This enables me to see you all on my screen, so that I can better gauge the reactions of the class, appropriately pace my class, and more quickly respond to any questions you have. (If you prefer to leave your video camera OFF, especially for reasons of personal safety and comfort, then I will fully understand.)

### **Scheduling Meetings**

At any time during the course, if you have any concerns, contact me by email, and we will set up a one-on-one meeting at a mutually convenient time. Please do NOT message me on Microsoft Teams. Always contact me by writing to me at [r.hoshino@northeastern.edu](mailto:r.hoshino@northeastern.edu).

I will also dedicate some time every Tuesday (9:30AM-11:00AM) to providing assistance on the upcoming Problem Set, via the above Zoom link. If you need hints on these problems, please wait until our Tuesday sessions which are open to everyone in the class; for all other questions/concerns/issues, let's meet individually.

### **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.

### **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](mailto:titleix@northeastern.edu) and/or through NUPD Emergency 617.373.3333; Non-Emergency 617.373.2121. 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> for a complete list of reporting options and resources, both on-campus and off-campus.

### **Academic Honesty**

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>).

In this course, any act of cheating (e.g. finding an online solution to an assignment problem) will result in an automatic failure from the course.

If you steal someone else's work, you fail the course. If someone uses your work, you fail the course. If you are unsure about the university's academic integrity policy, **ask me**.

Here are some examples of plagiarism:

- 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.

So that there is no ambiguity, there are two non-negotiable rules. A violation of either rule constitutes plagiarism and will result in you receiving an F for this course.

- Even if you meet with a classmate to discuss an Individual Problem on the Problem Set, the articulation of your thought process (i.e., what you submit to me), must be an *individual* activity, done in your own words, away from others. Please remember that the solution-writing process is where so much of your learning will occur in this course: much more than anything we do in class, and even more than the time you spend on solving the problems. Do not be surprised if it takes you 3 to 5 times as long to write up a solution than it takes you to actually solve the problem. (For me, as an academic researcher writing formal proofs for publications, my ratio is significantly higher!)
- The Problem Sets and Course Syntheses are meant to be demanding, and struggling through a problem is how we learn best. Your educational experience is cheapened by going online and finding the solution to a problem – even using the Internet to look for a “small hint” is unacceptable. If you need support, or would like a hint, please post your query on the Canvas discussion forum and I will respond within 24 hours.

### **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/>, 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 at least once, about halfway through 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.

Thank you for taking this course, and entrusting me to shape your education here at Northeastern. I am so excited to serve as your instructor!