Foundations of Artificial Intelligence (CS 5100)

Graduate Course, Khoury College of Computer Sciences
Northeastern University, Vancouver Campus
Fall 2022 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 Səl̓ilwətaʔ/Selilwitulh (Tsleil-Waututh) Nations.

Class Hours:	Thursday 2PM-4PM (Pacific Time)
Class Location:	Northeastern Vancouver Campus, Room #1426
Instructor:	Richard Hoshino (r.hoshino@northeastern.edu)
Teaching Assistants:	Toby Fangyuan Huang (huang.fan@northeastern.edu) Loris Xiaoyang Zhao (zhao.xiaoya@northeastern.edu)
Textbook:	Artificial Intelligence: A Modern Approach (3rd Edition) By Stuart Russell and Peter Norvig

CS 5100 introduces the fundamental problems, theories, and algorithms of the artificial intelligence field. Topics include heuristic search and game trees, automated deduction and its applications, problem solving and planning, and introduction to machine learning. Required course work includes the creation of working programs that solve problems, reason logically, and improve their own performance using techniques presented in the course. Coding assignments will be done in Python.

Course Objectives

This course is open to all graduate students in the MSCS program, and fulfills the following course objectives (numbered 1-3), as well as overall MSCS program objectives (numbered 4-7).

1. Understand representations, algorithms, and techniques used across works in artificial intelligence, and be able to apply and evaluate them in applications as well as develop their own.
2. Understand the basic processes that an agent must perform – from perceiving its environment to making decisions on how to act and performing those actions – and be able to develop and evaluate the technology that can be used to perform these processes.
3. Understand and apply machine learning techniques, in particular to draw inferences from data and help automate the development of AI systems and components.
4. Exhibit proficiency in the design, implementation and testing of software.
5. Demonstrate skills and experience working in small teams.
6. Apply algorithmic and theoretical computer-science principles to solve computing problems from a variety of application areas.
7. Demonstrate the ability to learn and develop competencies in specialized or emerging computer science fields.

Course Overview

Artificial Intelligence (AI) is the foundation for nearly every 21st century technological breakthrough. From self-driving cars to automated translation apps, AI is transforming every aspect of our society, with numerous applications to health care, education, finance, transportation, and environmental sustainability. In this course, we uncover the core ideas of "automated reasoning" that enable us to understand the foundational topics of AI. Specifically, we will explore and unpack the following topics:

Module 1 (Search)
Uninformed Search, Informed Search, Local Search, Adversarial Search

Module 2 (Planning and Scheduling)
Constraint Satisfaction, Constraint Optimization

Module 3 (Decision-Making Under Uncertainty)
Markov Decision Processes, Reinforcement Learning

Module 4 (Graphical Models)
Bayesian Networks, Hidden Markov Models

Module 5 (Machine Learning)
Supervised Learning, Unsupervised Learning

Course Schedule

Week	Work Due (by Wednesday 6PM)	% of Grade	Date of Class	Topic in Class
1	**Problem Set 0**	**0%**	Thursday September 8	*Intro to AI, Uninformed Search*
2	**Programming Project 0**	**0%**	Thursday September 15	*Informed Search*
3	**Problem Set 1**	**8%**	Thursday September 22	*Local and Adversarial Search*
4	**Programming Project 1**	**4%**	Thursday September 29	*Adversarial Search (continued)*
5	**Problem Set 2**	**8%**	Thursday October 6	*Constraint Satisfaction*
6	**Programming Project 2**	**4%**	Thursday October 13	*Constraint Optimization*
7	**Problem Set 3**	**8%**	Thursday October 20	*Markov Decision Processes*
8	**Course Synthesis 1**	**10%**	Thursday October 27	*Reinforcement Learning*
9	**Problem Set 4**	**8%**	Thursday November 3	*Bayesian Networks*
10	**Programming Project 3**	**4%**	Thursday November 10	*Hidden Markov Models*
11	**Problem Set 5**	**8%**	Thursday November 17	*Final Project Planning*
12	**Group Seminar**	**6%**	Thursday November 24	*Machine Learning – Part I*
13	**Group Seminar**		Thursday December 1	*Machine Learning – Part II*
14	**Course Synthesis 2 & Final Project Proposal**	**10% 0%**	Thursday December 8	*Final Project Work*
15	**Final Project Report**	**10%**	Thursday December 15	*Final Project Presentations*

The above percentages add up to 88%. The remaining 12% come from weekly In-Class Quizzes (10%) and personal Reflections (2%), both of which are explained on the next page.

Course Assessment

There are seven methods of assessment in this course.

- **5 Problem Sets (40%)** 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.

- **3 Programming Projects (12%)** are inspired by the video game Pac-Man, and consist of Python assignments developed for the AI course at the University of California Berkeley. These assignments will enable you to apply the AI concepts you will learn in this course and develop your skills in designing, implementing, and testing Python programs.

- **10 In-Class Quizzes (10%)** 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.

- **1 Group Seminar (6%)** will consist of you teaching us one of the big techniques in Machine Learning. This Group Seminar will be conducted in small teams.

- **3 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.

- **1 Final Project (10%)** work occurs during the last two weeks of the course, in lieu of a final examination. Each group will select <u>any</u> topic relating to the Foundations of Artificial Intelligence. 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:

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

Your final grade will be determined by the quality of your five Problem Sets (200 marks), three Programming Projects (60 marks), In-Class Quizzes (50 marks), two Course Syntheses (100 marks), Group Seminar (30 marks), three Reflections (10 marks), and Final Project (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 5***x***, 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 e-mail 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, Programming Projects, 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/117318

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:

https://bit.ly/Vancouver5100

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. For information on Northeastern's Disability Resource Centre, visit https://drc.sites.northeastern.edu/, or call 844-688-6287.

Assessments

With the exception of the In-Class Quizzes and Final Project, all assessments are due at **6PM on Wednesday**: one day before the start of class. The course assessments are purposely due 20 hours before class, so that you have Wednesday evening and/or Thursday morning to complete the readings and quiz in preparation for class on Thursday afternoon.

Late Penalties

Any assessment that is late will be subject to a penalty at my discretion, with a minimum penalty of 10%. 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, Programming Projects, and Course Syntheses. The remaining assessments (In-Class Quizzes, Group Seminar, Reflections, Final Project) must be completed 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 2PM 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

Our Thursday classes will occur in person, and every student is expected to come to campus for each class. However, I will make special accommodations for students to join us via Zoom (www.zoom.us), whenever you are unable to come to campus.

All Monday Problem-Solving sessions (10:00-11:30AM) will occur via Zoom. These workshops are optional for each student, i.e., attendance is recommended but not required.

The Zoom links appear on the course Canvas site.

Students joining via Zoom will adhere to the same rules and expectations as if you were attending in person: being present, actively engaging in discussions, asking questions, and participating in group activities. We ask all students to be fully present during the class and ensure a healthy learning environment.

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.

Whenever you are joining us via Zoom, I would very much appreciate it if you could leave your video camera ON for the entire session. This enables me to see you all on my screen, so that I can better gauge the reactions of the students, appropriately pace myself, 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 or call me on Microsoft Teams. Always contact me by writing to me at r.hoshino@northeastern.edu.

In addition to my Office Hours, I will dedicate time every Monday (10:00-11:30AM) providing assistance on the upcoming Problem Set, via the Zoom link provided above. If you need hints on these problems, please wait until our Monday morning sessions; for all other questions/concerns/issues, let's meet individually during my office hours.

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 and/or by calling 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 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, using a website such as Chegg, obtaining the Model Solutions from a previous semester) 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 – e.g. a student who took CS 5100 with me in a previous semester.

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, Programming Projects, 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!