

Overview

Course Motivation: Algorithms provide methods for solving problems, and are at the foundation of computing. It is important that practitioners in electrical and computer engineering understand how algorithms are designed, and how to analyze them for correctness and efficiency. It is important also to be able to distinguish intractable problems from ones that are tractable so one does not naively seek efficient solutions when none may exist. For cases that are intractable, it is important to know how to design approximate solutions that satisfy bounds on correctness and efficiency. Industry has long recognized the critical importance of algorithms that are correct and efficient.

Instructor Prof. Elliot Creager (creager@uwaterloo.ca; Office: EIT 3116).

- In-person Office Hours: 2:00–3:00pm each Wednesday
 - These may be rescheduled during certain weeks. Please monitor LEARN for updates.
- Virtual Office Hours: 1:30-2:00pm each Wednesday
 - Zoom link TBA.
 - These are intended primarily for students who are sick or self isolating after COVID exposure.

Website <http://learn.uwaterloo.ca/>

Forum Piazza: <https://piazza.com/uwaterloo.ca/winter2024/ece406>

Teaching Assistants

- Arezoo Alipanah (aalipanah@uwaterloo.ca)
- Priyank Avijeet (pavijeet@uwaterloo.ca)
- Megnath Ramesh (m5ramesh@uwaterloo.ca)
- Soomin Shin (soomin.shin@uwaterloo.ca)

TA office hours will be posted on LEARN.

Communicating with the course staff

- Use the course forum (Piazza) for questions and comments about the course material.
 - The instructor and TAs will monitor the forum. Given the size of the class you should expect at least a 24h response time, so get started early on your assignments to make sure your questions are answered.
- For anything personal, email Prof. Creager (not the TAs).
 - Please put “ECE406” at the front of your subject line for all course related email.

Lectures

- LEC001: Mon and Fri, 1:00 - 2:20pm (E7 5353)
- LEC002: Mon and Fri, 4:00 - 5:20pm (E7 5353)

Lectures will not be held during reading week (Feb 19 - 23). Please attend the session you are registered for.

Tutorials

- LEC001: Fri, 5:30 - 6:20pm (E7 5353)
- LEC002: Wed, 8:00 - 8:50pm (E7 5353)

Course Objectives At the end of the course, it is hoped that you have learned:

- How to write pseudocode for algorithms.
- How to analyze the run-time and correctness of an algorithm.
- How to design efficient algorithms using divide and conquer, greedy algorithms, and dynamic programming.
- The kinds of problems that can be solved with linear programming, and why they can be solved efficiently.
- The complexity classes P and NP, and what it means for a problem to be “hard”.
- What it means to reduce one problem to another, and how it used in complexity analysis.
- Methods for approximately solving hard problems.

Course Material

Course Outline Design and analysis of efficient, correct algorithms. Advanced data structures, divide and conquer algorithms, recurrences, greedy algorithms, dynamic programming, graph algorithms, search and backtrack, inherently hard and unsolvable problems, approximation and randomized algorithms, and amortized analysis.

The following is a more detail on the material covered in the class. Note that not all sections of each chapter will be covered.

Topic	Chapter in Text	Duration
Introduction to algorithms	Chapter 0	0.5 hours
Factoring, primality, cryptography	Chapter 1	4.5 hours
Divide and conquer algorithms	Chapter 2	5 hours
Graphs, decompositions and depth-first search	Chapter 3	3 hours
Paths in graphs: Dijkstra's alg, priority queues	Chapter 4	3 hours
Greedy algorithms: MST, MP3 encoding, set cover	Chapter 5	3 hours
Dynamic Programming: Shortest paths, knapsack	Chapter 6	4 hours
Linear Programming: Simplex algorithm, duality theorem	Chapter 7	4 hours
Inherently hard problems: NP-completeness, reductions	Chapter 8	5 hours
Intelligent exhaustive search and approximation algorithms	Chapter 9	4 hours

Deliverables Assignments and exams will be administered according to the following schedule:

Deliverable	Date Released	Date Due
Assignment 1	Wed Jan 10	Tue Jan 23
Assignment 2	Wed Jan 24	Tue Feb 6
Assignment 3	Wed Feb 7	Tue Feb 20 Mon Feb 26
Midterm	—	Fri Mar 1
Assignment 4	Wed Feb 28	Tue Mar 12
Assignment 5	Wed Mar 13	Tue Mar 26
Assignment 6	Wed Mar 27	Mon Apr 8
Final Exam	—	TBA by Registrar's Office

For assignments, **turn your work in by 11:59pm on the due date**. Any changes to this schedule will be announced on LEARN.

Textbook: The main (and required) text for the course is

1. S. Dasgupta, C. Papadimitriou, and U. Vazirani, *Algorithms*, McGraw-Hill, 2008.

The following textbooks may also be useful for additional information on subjects:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, *Introduction to Algorithms*, MIT Press, 2009
2. J. Kleinberg and E. Tardos, *Algorithm Design*, Addison Wesley, 2005.

Evaluation

Grading: The course will consist of assignments, a midterm, and a final exam. There will be a total of six homework assignments, given roughly once every two weeks. The grading scheme is

- Assignments: 20%
- Midterm: 30%
- Final Exam: 50%

If you do better on the final exam than the midterm, I will instead compute your final grade as Assignments: 20%, Midterm: 15%, Final Exam: 65%.

We will be using Crowdmark for grading. The midterm and final exam will be held in-person and will be closed book.

Midterm Exam: 7:00pm on Mar 1. Held in various E7 classrooms. More info on seating TBA.

Assignments Information and Guidelines: Assignments are given every other week, and their primary goal is to give you practice in designing and analyzing algorithms. Be sure to spend a good amount of time working on these. Assignments are graded fairly leniently. Try not to worry about grades too much and just focus on getting practice. The following are some details:

- **There will be no extensions or late assignments accepted.** As compensation for this rather harsh rule, I will drop your assignment with lowest score when calculating the assignment average. To be fair to all students, requests for extension receive the following “canned” response:

The course policy is that there are no extensions for assignments. As compensation, I will automatically drop your lowest assignment grade of the six.

- Assignments are submitted using Crowdmark <https://app.crowdmark.com/sign-in/waterloo>.
- Programming exercises are written in **Python 3**, and your code is to be submitted in the corresponding Dropbox on LEARN.
- Assignments are to be submitted individually and must be written in your own words. You are free to collaborate with other students on assignments in order to hash out initial solution ideas. You must list these collaborators at the top of the first page of your assignment (there is no penalty for listing collaborators, but it ensures we do not falsely identify plagiarism).
- Cite all sources used in your solutions (other than the course notes or the main textbook). In submitting an assignment, you are “signing off on your work” as described in the academic integrity form at <https://uwaterloo.ca/academic-integrity/>. The penalty for a first plagiarism offence is -100% for the assignment.

Additional Logistics

General University of Waterloo Guidelines

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. Check <http://www.uwaterloo.ca/academicintegrity/> for more information.

Grievance: A student who believes that a decision affecting some aspect of their university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, <http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm>.

When in doubt please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity—check <http://www.uwaterloo.ca/academicintegrity/> to avoid committing an academic offence, and to take responsibility for their actions. A student who is unsure what constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about rules for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, <http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm>. For typical penalties check Guidelines for the Assessment of Penalties, <http://www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm>.

Appeals: A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) <http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm>.

Note for Students with Disabilities: AccessAbility Services, located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

Turnitin.com: Text matching software (Turnitin) may be used to screen assignments in this course. Turnitin is used to verify that all materials and sources in assignments are documented. Students' submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin in this course.

It is the responsibility of the student to notify the instructor if they, in the first week of term or at the time assignment details are provided, wish to submit alternate assignment.

Additional Guidelines from the Faculty of Engineering

Territorial Acknowledgement: The University of Waterloo acknowledges that much of our work takes place on the traditional territory of the Neutral, Anishinaabeg and Haudenosaunee peoples. Our main campus is situated on the Haldimand Tract, the land granted to the Six Nations that includes six miles on each side of the Grand River. Our active work toward reconciliation takes place across our

campuses through research, learning, teaching, and community building, and is centralized within the Office of Indigenous Relations.

Inclusive Teaching-Learning Spaces: The University of Waterloo values the diverse and intersectional identities of its students, faculty, and staff. The University regards equity and diversity as an integral part of academic excellence and is committed to accessibility for all. We consider our classrooms, online learning, and community spaces to be places where we all will be treated with respect, dignity, and consideration. We welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and nonvisible differences. We are all expected to contribute to a respectful, welcoming, and inclusive teaching- learning environment. Any member of the campus community who has experienced discrimination at the University is encouraged to seek guidance from the Office of Equity, Diversity, Inclusion and Anti-racism (EDI-R) via email at equity@uwaterloo.ca. Sexual Violence Prevention and Response Office (SVPRO), supports students at UWaterloo who have experienced, or have been impacted by, sexual violence and gender-based violence. This includes those who experienced harm, those who are supporting others who experienced harm. SVPRO can be contacted at svpro@uwaterloo.ca

Religious and Spiritual Observances: The University of Waterloo has a duty to accommodate religious and spiritual observances under the Ontario Human Rights Code. Please inform the instructor at the beginning of term if special accommodation needs to be made for religious observances that are not otherwise accounted for in the scheduling of classes and assignments. Consult with your instructor(s) within two weeks of the announcement of the due date for which accommodation is being sought.

Respectful Communication and Pronouns: Communications with Instructor(s) and TAs should be through recommended channels for the course (e.g., email, LEARN, Piazza, Teams, etc.) Please use your UW email address. Include an academic signature with your full name, program, student ID. We encourage you to include your pronouns to facilitate respectful communication (e.g., he/him; she/her; they/them). You can update your chosen/preferred name at WatIAM. You can update your pronouns in Quest.

Mental Health and Wellbeing Resources: If you are facing challenges impacting one or more courses, contact your academic advisor, Associate Chair Undergraduate, or the Director of your academic program. Mental health is a serious issue for everyone and can affect your ability to do your best work. We encourage you to seek out mental health and wellbeing support when needed. The Faculty of Engineering Wellness Program has programming and resources for undergraduate students. For counselling (individual or group) reach out to Campus Wellness and Counselling Services. Counselling Services is an inclusive, non-judgmental, and confidential space for anyone to seek support. They offer confidential counselling for a variety of areas including anxiety, stress management, depression, grief, substance use, sexuality, relationship issues, and much more.

Intellectual Property . Be aware that this course contains the intellectual property of their instructor, TA, and/or the University of Waterloo. Intellectual property includes items such as:

- Lecture content, spoken and written (and any audio/video recording thereof).
- Lecture handouts, presentations, and other materials prepared for the course (e.g., PowerPoint slides).
- Questions or solution sets from various types of assessments (e.g., assignments, quizzes, tests, final exams); and

- Work protected by copyright (e.g., any work authored by the instructor or TA or used by the instructor or TA with permission of the copyright owner).

Course materials and the intellectual property contained therein are used to enhance a student's educational experience. However, sharing this intellectual property without the intellectual property owner's permission is a violation of intellectual property rights. For this reason, it is necessary to ask the instructor, TA and/or the University of Waterloo for permission before uploading and sharing the intellectual property of others online (e.g., to an online repository). Permission from an instructor, TA or the University is also necessary before sharing the intellectual property of others from completed courses with students taking the same/similar courses in subsequent terms/years. In many cases, instructors might be happy to allow distribution of certain materials. However, doing so without expressed permission is considered a violation of intellectual property rights and academic integrity. Please alert the instructor if you become aware of intellectual property belonging to others (past or present) circulating, either through the student body or online.

Continuity Plan - Fair Contingencies for Unforeseen Circumstances (e.g., resurgence of Covid):

In the event of emergencies or highly unusual circumstances, the instructor will collaborate with the Department/Faculty to find reasonable and fair solutions that respect rights and workloads of students, staff, and faculty. This may include modifying content delivery, course topics and/or assessments and/or weight and/or deadlines with due and fair notice to students. Substantial changes after the first week of classes require the approval of the Associate Dean, Undergraduate Studies.

Declaring absences: Regardless of the process used to declare an absence, students are responsible for reaching out to their instructors as soon as possible. The course instructor will determine how missed course components are accommodated. Self-declared absences (for COVID-19 and short-term absences up to 2 days) must be submitted through Quest. Absences requiring documentation (e.g., Verification of Illness Form, bereavement, etc.) are to be uploaded by completing the form on the VIF System. The UW Verification of Illness form, completed by a health professional, is the only acceptable documentation for an absence due to illness. Do not send documentation to your advisor, course instructor, teaching assistant, or lab coordinator. Submission through the VIF System, once approved, will notify your instructors of your absence.

Rescheduling Co-op Interviews: Follow the co-op process for rescheduling co-op interviews for conflicts to graded assignments (e.g., midterms, tests, and final exams). Attendance at co-operative work-term employment interviews is not considered to be a valid reason to miss a test.

Prof. Creager's Policies

Use of AI: Do not use Artificial Intelligence tools (Github Copilot, GPT-3, ChatGPT, ...) to write your assignments for you. These tools are powerful, and you will have plenty of opportunities in your career improve your programming efficiency by using them. This course is not such an opportunity,¹ as you should be getting practice solving problems yourself. Use of AI in this course will be treated as an academic integrity issue (Policy 71).

¹Generally speaking, the appropriateness of AI tools at the University of Waterloo will be context-dependent. See <https://uwaterloo.ca/associate-vice-president-academic/artificial-intelligence-uw> for some information and guidelines on AI provided by the University.