CSC473H1 S

Advanced Algorithm Design

Winter 2024 Syllabus

Course Meetings

CSC473H1 S

Section	Day & Time	Delivery Mode & Location
LEC0101	Monday, 12:00 PM - 1:00 PM Wednesday, 12:00 PM - 1:00 PM Friday, 12:00 PM - 1:00 PM	In Person: GB 120 In Person: BA 1220 In Person: GB 120

Refer to ACORN for the most up-to-date information about the location of the course meetings.

The Friday session is reserved for tutorials.

Course Contacts

Course Website: https://q.utoronto.ca/courses/337650/

Instructor: Aleksandar Nikolov
Email: anikolov@cs.toronto.edu
Office Hours and Location: Thursdays, 12-2pm, in SF2301B, or by appointment
Additional Notes: Prof. Nikolov will attempt to respond to legitimate email inquiries from students within 48 hours. Please include "CSC473" in the subject line of the email.

Course Overview

Advanced algorithm design techniques, with emphasis on the role that geometry, approximation, randomization, and parallelism play in modern algorithms. Examples will be drawn from linear programming and basics of continuous optimization; randomized algorithms for string matching, graph problems, and number theory problems; streaming algorithms and parallel algorithms in the Map-Reduce model.

Advanced algorithm design techniques, with emphasis on the role that geometry, approximation, randomization, and parallelism play in modern algorithms. Examples will be drawn from linear programming; graph problems; high-dimensional nearest neighbour search; streaming algorithms and parallel algorithms in the Map-Reduce model.

Course Learning Outcomes

By the end of this course, students should be able to:

- Distinguish between Monte Carlo and Las Vegas algorithms.

- Design and analyze simple randomized algorithms.
- Have a deep understanding of Karger's Contraction algorithm, including its analysis and how to implement it efficiently.
- Design and analyze locality sensitive hash functions for different distance metrics, and use them for approximate near neighbour search and related problems.
- Use sampling to estimate sizes of sets, and apply sampling in streaming and other algorithms. Use Chebyshev's inequality and Chernoff bounds to analyze sampling algorithms.
- Define basic terms in polyhedral geometry, like vertex, face, facet, polytope.
- Model optimization problems as linear programs, and derive the dual of a linear program.
- State the complementary slackness theorem, and understand the analysis of primal-dual algorithms, like the Hungarian algorithm, as well as primal-dual approximation algorithms.

Prerequisites: CSC373H1, MAT223H1/ MAT240H1

The link to sign up for our Piazza forum is https://piazza.com/utoronto.ca/winter2024/csc473Links to an external site.. You can also access Piazza from within Quercus.
Piazza is a third-party software. It will be used in this class strictly as a discussion board. All announcements will be made on Quercus. When posting, abide by the academic integrity policy. In particular, **do not post solutions to homework problems**. Make sure to read the Piazza terms of use before signing up, and if you have any concerns, contact the instructor directly. If you decide to participate in Piazza, only provide content that you are comfortable sharing under the terms of the Privacy Policy and Terms of Use.
When using Piazza, be respectful to your instructors and fellow students. Offensive language and threatening behavior will not be tolerated. Keep in mind that when posting "anonymously", you are anonymous only to other students, but not to the instructors.

Course Materials

Lectures notes and slides are posted for the material for each week.

Marking Scheme

Assessment	Percent	Details	Due Date
Midterm test	20%	50 mins, during tutorial time slot	2024-03-01
Homework assignments	8%	Submitted on MarkUs	2024-01-26
Homework assignments	8%	Submitted on MarkUs	2024-02-16

Assessment	Percent	Details	Due Date
Homework assignments	8%	Submitted on MarkUs	2024-03-15
Homework assignments	8%	Submitted on MarkUs	2024-04-04
Quizzes	6%	Submitted on Quercus	2024-01-20,2024-02-03,2024-02-17,2024-03-02,2024-03-16,2024-03-30
In-Person Final Exam	42%		Final Exam Period

The course has 4 *group assignments* to be completed in groups of maximum two people each, and submitted on MarkUs. Additionally, a short quiz will be released on Quercus every other week on Monday, and due by the end of the day the Friday of the same week. Quizzes should be completed *individually.*

Late Assessment Submissions Policy

No late quiz answers will be accepted. Every student has one grace credit, which allows them to be late on one group assignment for up to 24 hours. After the credit is used, no other late submission from the same student will be accepted for the remainder of the course. If you are working in a group, then the credit is taken from both members of the group, and no other late assignments will be accepted from either group member for the remainder of the course.

Course Schedule

Schedule of lectures

Week	Topic	Readings	Tutorials
Week 1: Jan 8 –14	Monte Carlo Algorithms: Global Min-Cut	From "Algorithm Design" by Kleinberg and Tardos: Min Cut Download Min Cut Section 1.4 of Probability and Computing	ContractionDownload Contraction
Week 2: Jan 15–21	Finish Global Min-Cut Las Vegas Algorithms: Closest Pair of Points	Karger-Stein Algorithm Download Karger-Stein Algorithm; From "Algorithm Design" by Kleinberg and Tardos: Closest Pair of PointDownload Closest Pair of Point	Contraction ExercisesDownload Contraction Exercises
Week 3:	Approximate Near	Approximate Near Neighbour	LSH exercisesDownload

Jan 22–28	Neighbours	SearchDownload Approximate Near Neighbour Search	LSH exercises
Week 4: Jan 29– Feb 4	Finish Approximate Near Neighbours Chernoff Bounds	Approximate Near Neighbour SearchDownload Approximate Near Neighbour Search Chapter 4 of Probability and Computing	TBA
Week 5: Feb 5–11	Finish Chernoff Bounds Streaming Algorithms	Chapter 4 of Download Chapter 4 ofProbability and Computing Streaming AlgorithmsDownload Streaming Algorithms	TBA
Week 6: Feb 12–18 **(Reading week: Feb 19-25)**	Streaming Algorithms	Streaming AlgorithmsDownload Streaming Algorithms	Streaming ExercisesDownload Streaming Exercises
Week 7: Feb 26–Mar 3	Linear Programming	Linear ProgrammingDownload Linear Programming LP Duality CheatsheetDownload LP Duality Cheatsheet	Midterm in tutorial slot
Week 8: Mar 4–10	Linear Programming	Linear ProgrammingDownload Linear Programming	LP examplesDownload LP examples
Week 9: Mar 11–17	Matchings	Goemans's matchings lecture notesLinks to an external site..	LP duality exercisesDownload LP duality exercises
Week 10: Mar 18–24	Matchings and the Hungarian Algorithm	Goemans's matchings lecture notesLinks to an external site..	Matchings exercisesDownload Matchings exercises
Week 11: Mar 25–31	Rounding Algorithms Derandomization	Sections 1.3, 1.7, of the Williamson and Shmoys bookLinks to an external site.. All of Chapter 1 of the book is recommended.	No tutorial (Good Friday)
Week 12: Apr 1–7	Primal-Dual Approximation	Sections 7.1-7.2 of the Williamson and Shmoys	Sections 5.1, 5.2 of the Williamson and Shmoys

	Algorithms	bookLinks to an external site..	bookLinks to an external site.

Policies & Statements

Late/Missed Assignments

Every student has **one** grace credit, which allows them to be late on one *group assignment* for up to 24 hours. After the credit is used, no other late submission from the same student will be accepted for the remainder of the course. If you are working in a group, then the credit is taken from both members of the group, and no other late assignments will be accepted from either group member for the remainder of the course.

If you cannot submit your assignment on time, or attend the midterm test due to illness or any other legitimate reason, please contact me as soon as possible. When appropriate, I will reassign the weight of the missed assignment to other assignments, or reassign the weight of the midterm to the final exam. I may also give an extension beyond the grace credit for homework assignments, if you ask for one in advance, with a legitimate reason, and an explanation of how long of an extension you need, and why. I will not grant an extension beyond one week.

Academic Integrity

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters (https://governingcouncil.utoronto.ca/secretariat/policies/code-behaviour-academic-matters-july-1-2019). If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, please reach out to me. Note that you are expected to seek out additional information on academic integrity from me or from other institutional resources. For example, to learn more about how to cite and use source material appropriately and for other writing support, see the U of T writing support website at http://www.writing.utoronto.ca. Consult the Code of Behaviour on Academic Matters for a complete outline of the University's policy and expectations. For more information, please see A&S Student Academic Integrity (https://www.artsci.utoronto.ca/current/academic-advising-and-support/student-academic-integrity) and the University of Toronto Website on Academic Integrity (https://www.academicintegrity.utoronto.ca).