CSC373 -- Algorithm Design, Analysis & Complexity

Fall 2022

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Contact information and meeting times

Instructor: Sam Toueg
Office hours: Thursday 11am-1pm (Zoom)
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Teaching assistants: Noah Brustle, Xing Hu, Deepanshu Kush, Xinyuan (Lily) Li, Calum MacRury, Pouya Shati, Haohua Tang, Yibin Zhao, Chen Zhiyang

Lectures:

Section	L0101	L0201
	Monday 11:00-12:00 -- LM 161 Wednesday 11:00-13:00 -- LM 161	Monday 14:00-15:00 -- BA 1170 Wednesday 14:00-16:00 -- KP 108

Tutorials:

Section	L0101	L0201
	Friday 11:00-12:00	Friday 14:00-15:00
	TUT 0101 SF 3202	**TUT 0201** BA 1180
	TUT 0102 BA 1180	**TUT 0202** AB 107

Teaching assistant office hours:

Monday (Zoom)	**Tuesday** (Zoom)	**Friday** (Zoom)
13:00-14:00	10:00-11:00	
	13:00-14:00	

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Course content and schedule

Course goals: To learn standard algorithm design techniques (divide&conquer, greedy algorithms, dynamic programming, network flow, linear programming, approximation algorithms, randomization) through concrete examples. You will also learn elements of complexity and in particular NP-Completeness. By the end of this course, you will be able to design algorithms using standard techniques, prove their correctness, and analyze their complexity, You will also learn techniques to determine whether a problem is NP-Complete. Throughout the course, emphasis is on abstract thinking

and problem-solving, not on programming.

Prerequisites: CSC263H1/CSC265H1. Given the importance of this prerequisite for success in CSC373, it is strictly enforced. It may be waived only for students with a strong academic record and solid evidence that they previously learned all the prerequisite material (e.g., they took an equivalent course outside U of T).

Textbooks: The course lecture slides cover most if not all the material you need. The following textbooks are supplemental sources with complementary strengths:
- [CLRS]: *Introduction to Algorithms*. 3rd edition. Cormen, Leiserson, Rivest, and Stein. MIT press and McGraw-Hill 2009.
- [KT]: *Algorithm Design*. Kleinberg and Tardos. Addison Wesley 2006.
- [DPV]: *Algorithms*. Dasgupta, Papadimitriou, and Vazirani. McGraw-Hill 2006.

Tentative weekly schedule: *(This schedule may change during the term)*

Dates	Lecture topics	Supplementary study material	Assignm Due on Wed at 11:0(
Week 1	***Divide & conquer (D&C) algorithms*** • D&C recurrence (Master Theorem) • Karatsuba's integer multiplication • Strassen's matrix multiplication algo • Closest pair of points • Order statistics	KT 5.1-5.2, DPV 2.2, notes KT 5.5, DPV 2.1, notes KT 5.4 KT 13.5, DPV 2.4	A1 pos
Week 2	***Greedy algorithms*** • Interval scheduling • Interval partitioning • Minimum lateness scheduling • Huffman codes	KT 4.1 KT 4.2 KT 4.8, DPV 5.2	A1 due, A2
Week 3	***-Greedy algorithms; Dynamic programming (DP)*** • Dijkstra's single-source shortest paths algorithm • DAG single-source shortest paths algorithm • Weighted interval scheduling	KT 4.4, DPV 4.3-4.4, notes KT 6.1	
Week 4	***DP algorithms, cont'd*** • Edit Distance (KT 6.6, DPV 6.3) • Chain Matrix Product • Knapsack	KT 6.6, DPV 6.3 KT 6.4, DPV 6.4	A2 due, A3
Week 5	***DP algorithms, cont'd*** • Bellman-Ford single-source shortest paths • Detecting and identifying negative weight cycles • Floyd-Warshall all-pairs shortest paths • Transitive closure algorithm • Difference constraints (if enough time) • Johnson's all-pairs shortest paths (if enough time)	KT 6.8 DPV 6.6	
Week 6	***Maximum flow & applications*** • Max flow problem • Ford-Fulkerson algorithm • Max-flow Min-cut theorem	KT 7.2, 7.3, DPV 7.2, notes	A3 due, A4 ***Midte***
Week 7	***Maximum flow & applications, cont'd***	KT 7.5, DPV 7.3	

	• Bipartite graph matching • Bipartite graph vertex cover • Edge-disjoint disjoint paths	KT7.6	
Week 8	***Linear Programming (LP)*** • Motivation, examples, the geometry of LPs • LP algorithms • Reductions to LP • Integer LP (ILP), reductions to ILP	DPV 7.1 DPV 7.6	A4 due, A5
Reading Week	***Reading Week***	***Reading Week***	***Reading Week***
Week 9	***NP-Completeness*** • Key concepts, definitions • Reducing SAT to Clique (medium) • Class of P and NP problems • NP-Hard and NP-Complete problems • Independent Set • Vertex Cover (reduction from Clique) • Set Cover (reduction from Vertex Cover) • ILP feasibility (reduction from 3SAT) • Graph Coloring(reduction from 3SAT)	CLRS 34, DPV 8, KT 8	A5 due, A6
Week 10	***NP-Completeness, cont'd; approximation algorithms*** • Subset Sum (reduction from 3SAT) • Partition (reduction from Subset Sum) • Exact Set Cover (reduction from Graph Coloring) • NP vs co-NP • Euclidian TSP approximation algorithm	CLRS 35, DPV 9, KT 11 (Euclidian TSP: CLRS: 35.2)	
Week 11	***Approximation algorithms; Local search algorithms*** • Vertex Cover and Matching (greedy) • Weighted Vertex Cover (ILP - relaxation) • Minimum Makespan (on-line and off-line) • Max-Cut (local search)	DPV 9.2.1 KT 11.6 KT 11.1	A6 du

Week 12	***Local search algorithms; Randomization***
	• Exact Max-k-SAT problem
	  ◦ Local search algorithm
	  ◦ Randomized algorithm
	  ◦ Derandomized algorithm
	• Course wrap-up
		CLRS 5, KT13	

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Calendar of important course-related events:

Speak, then, and tell everything. For, it comforts those in pain
To know before hand all the agony they still must bear.

--Aeschylus, *Prometheus Bound*

Date	*Event*
Wednesday, September 14	Assignment 1 handed out

Wednesday, September 21	Assignment 1 due and Assignment 2 handed out
Wednesday, October 5	Assignment 2 due and Assignment 3 handed out
Wednesday, October 19	Assignment 3 due and Assignment 4 handed out
Thursday evening, October 20	**Midterm test**
Wednesday, November 2	Assignment 4 due and Assignment 5 handed out
Wednesday, November 16	Assignment 5 due and Assignment 6 handed out
Wednesday, November 30	Assignment 6 due

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Midterm exam

Material covered: All the material that we covered in class, in the tutorials, in the reading and homework assignments, up to and including the last week of class before the exam.

Aids Allowed: None.

Time: Thursday, October 20, evening at 20:00 (sharp!) - 21:30.
Please try to come at least 5-10 minutes before 8pm,
so that we can pre-distribute the exam and then start it at 8pm sharp.

Location: EX100 (Examination Facility, 255 McCaul Street).

Students who have an irresolvable course conflict with the timing above can take the midterm test from 21:00 to 22:30 instead, on the same day (i.e., Thursday, October 20) in EX100.

If you want to take the delayed exam session from 21:00 to 22:30, you must register for it by e-mailing a note to csc373-2022-09@cs.toronto.edu with your name, student number, and the name and time of the conflicting course. The registration deadline is Monday, September 26.

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Course policies

Course evaluation: There will be 6 homework assignments, one midterm test and a final assessment test. The relative weights of these components towards the final mark are:

Homework	45%
Midterm test	17%
Final test	38%

Important note: A mark of at least 40% on the final test is necessary to pass the course.

Academic integrity: Academic integrity is essential to the University of Toronto and the University treats cases of cheating and plagiarism very seriously. Academic offenses relevant to this course include using someone else's ideas or words without appropriate attribution; obtaining or providing unauthorized assistance on any assignment, test, or exam; misrepresenting your identity; falsifying or altering documentation; and violating the homework collaboration policy stated below.

Homework collaboration and help policy: In each homework assignment you may collaborate with at most two other students currently taking one of the sections of CSC373H taught this term. If you collaborate with other students on an assignment, you and your partner(s) must submit only one of your solution, with all your names, as a single group. The solution will be graded in the usual way and all partners in a group will receive the same mark. *Collaboration involving more than three students, or between different groups, is not allowed. For help with your homework you may consult only the course instructors, teaching assistants, your homework partners (if you have any), your textbooks, the material that we post, and your class notes. You may not consult any other source.*

Homework submission: You must submit your assignments online through Crowdmark as a *typed* PDF files, as described in detail on the first page of

our homework assignments. The PDF file that you submit must be clearly legible. To this end, we encourage you to learn and use the LaTex typesetting system, which is designed to produce high-quality documents that contain mathematical notation. You can use other typesetting systems if you prefer, but *handwritten documents are not accepted*.

Homework marking: For each homework assignment, we may mark only a selected (but not preannounced) subset of the questions. In that event, the homework assignment will be marked out of the total weight of the selected questions.

Late homework policy: Late assignment submissions are *not* accepted.

Missed homework policy: If you miss an assignment deadline because of a medical or serious personal emergency, you must fill out this form and e-mail it to csc373-2022-09@cs.toronto.edu as soon as possible. In case of a medical emergency, you should also fill the online absence declaration available on **ACORN** under the Profile and Settings menu. If we judge your reason for missing an assignment deadline to be valid, we will use the average mark that you achieved in other assignments as your mark for the missed one.

Remarking policy: Before making a remarking request, you must read and understand the provided solutions and think carefully about your own solution. If, after doing so, you wish to submit a remarking request, you must fill this form and email it to csc373-2022-09@cs.toronto.edu no later than one week from the date the marked assignment or test was made available to the class. *Remarking requests made after this deadline will not be accepted*. Please note that:

1. A remarking request of an assignment or a test may cause the rechecking of all the assignment or test, and the overall mark may stay the same, increase, or decrease.
2. Remarking requests of the type ``yes, my solution is not quite correct, but you took off too many marks for this mistake" are not accepted: the marking scheme was decided and applied as uniformly as possible to all students.
3. To discourage frivolous remarking requests we will apply the following rule: A remarking request that does not result in a mark increase causes a ``demerit" to each of the student(s) who submitted the assignment/test in question. We will not consider remarking requests for an assignment/test submitted by a student who has accumulated two such demerits.

Missed midterm test policy: If you miss a midterm test due to a medical or other serious personal emergency, get in touch with your instructor immediately, fill out this form and e-mail it to csc373-2022-09@cs.toronto.edu as soon as possible. In case of a medical emergency, you should also fill the online absence declaration available on **ACORN** under the Profile and Settings menu. There will be no make-up midterm tests, but if we judge your reason for missing the test to be valid, we will use your final assessment test mark to compute your mark for the missed midterm test.

Attendance in tutorials: Attendance in tutorials is as mandatory as attendance in lectures. In neither case is formal attendance actually taken. However, there will be new material that is presented only in tutorials and not discussed in the lectures for which you are responsible and in which you may be tested in assignments or tests.

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Course Forum

We will use Piazza as the platform for class announcements and discussions. This service is free to use, but requires registration.

To register, follow the link below and provide the access code provided in the initial email to students. Use your @mail.utoronto.ca or @utoronto.ca address as your Piazza email contact for this course. If you have privacy concerns about this, please see your course instructor to discuss alternatives. The bottom line is that we must be able to identify any individual on the forum as a student registered in the course; individuals for whom this is not the case can be removed from the class forum without warning.

The CSC373 Piazza page is: https://piazza.com/utoronto.ca/fall2022/csc373

The Piazza access code is provided in the initial email sent to CSC373 students via Quercus; it is also given in the "Course Links" handout posted in the Quercus "modules".

Guidelines for posting on Piazza:

- Take the time to formulate your postings clearly.
- Be courteous in your communications.
- Your postings must abide by the academic integrity policy and the homework collaboration policy. Postings asking for hints or offering hints on solutions to homework assignments violate these policies. So asking a question such as ``I am using this method to solve this problem, am I on the right track?" violates the homework collaboration policy.
- Your postings can be made anonymously to other students (at your discretion), but not to the instructor.

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