CSC373 (Fall 2024) Algorithm Design, Analysis, and Complexity

Navigation	**Home page** (https://q.utoronto.ca/courses/354310/pages/csc265-fall-2023-enriched-data-structures-and-analysis)	**Lectures** (https://q.utoronto.ca/courses/354310/pa

Overview

Welcome to the course webpage for the Fall 2024 term of CSC373 Algorithm Design, Analysis, and Complexity. Here is the course content description:

> Standard algorithm design techniques: divide-and-conquer, greedy strategies, dynamic programming, linear programming, randomization, network flows, approximation algorithms. Brief introduction to NP-completeness: polynomial time reductions, examples of various NP-complete problems, self-reducibility. Additional topics may include approximation and randomized algorithms. Students will be expected to show good design principles and adequate skills at reasoning about the correctness and complexity of algorithms.

All course announcements will be posted here on Quercus. Check the **Lectures** (https://q.utoronto.ca/courses/354310/pages/lectures) page for the required reading.

Where and When

There are two sections for this course. Make sure you look up the location and time for the section you are registered for.

LEC0101

Type	Lecture	Tutorial
Room	BA 1170	BA 1220 (last name starts with A-M) BA 1210 (last name starts with N-Z)
Time	Mon 11am-12pm Wed 11am-1pm	Fri 12pm - 1pm

LEC0201

Type	Lecture	Tutorial
Room	MC 252	SF 2202 (last name starts with A-M) BA 1210 (last name starts with N-Z)
Time	Mon 3pm-4pm Wed 3pm-5pm	Fri 3pm - 4pm

Contact information

Instructor	Aleksandar Nikolov
Course Email	**csc373-2024-09@cs.toronto.edu (mailto:csc373-2024-09@cs.toronto.edu)**
Personal Email	**anikolov@cs.toronto.edu (mailto:anikolov@cs.toronto.edu)**
Office	SF 3316
Office Hours Location:	SF3316 (for now)
Office Hours:	Thursdays 10am-12pm, or by appointment

Prof. Nikolov will attempt to respond to legitimate email inquiries from students within 48 hours. **Please use the course email for all course related matters.** Your email will go to a ticketing system and will be answered promptly by the course team or by instructional support staff. Please send me an email to make an appointment before stopping by my office.

There will be no office hours during the first week of class. We will soon post the location we will use for office hours, which will **not** be my office.

Textbook(s)

Reading assignments will be given from these sources:

- (*Required*) Introduction to Algorithms by Cormen, Leiserson, Rivest, and Stein [CLRS]
- (*Recommended*) Algorithm Design by Kleinberg and Tardos [KT]
- (*Recommended*) Algorithms by Jeff Erickson [E]

The 3rd edition of CLRS (which I use as well) is available online from the **U of T Libraries (https://librarysearch.library.utoronto.ca/permalink/01UTORONTO_INST/14bjeso/alma991106991137506196)** . An ebook version of KT is available for purchase from the **U of T Bookstore (https://www.uoftbookstore.com/adoption-search)** . E is available **online (https://jeffe.cs.illinois.edu/teaching/algorithms/)** . More information about assigned readings is posted in the **Lectures (https://q.utoronto.ca/courses/354310/pages/lectures)** page.

Piazza

You can access Piazza from within Quercus. 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.

Grading Scheme

Your mark for the class will be based on the following components:

- 6 Quizzes: 3% (0.5% each)
- 4 Homework assignments: 32% (8% each)
- Embedded ethiCS module: 5%
- 2 Midterm tests: 30% (15% each)
- Final Exam: 30%

Quizzes will be roughly bi-weekly, to be complete individually on Quercus. Homework assignments will be done in groups of at most two. See **Homeworks (https://q.utoronto.ca/courses/354310/pages/homeworks)** for more information.

The two *midterm tests* will be each 50 minutes long. They are scheduled as follows:

- Midterm test #1: October 18;
- Midterm test #2: November 22.

Each midterm for your section of the course will be held during the regularly scheduled tutorial time slot. The location of the midterms will be announced soon. Midterm #1 will cover roughly the first six weeks of the course, and midterm #2 will cover weeks 7-10

There will be a comprehensive *final exam*. **You need to score at least 40% on the final exam to pass the course.**

Academic Integrity

Every student must abide by the **University of Toronto academic integrity policy (https://www.academicintegrity.utoronto.ca/)** , and the **Code of Student Conduct**

(http://www.governingcouncil.utoronto.ca/Assets/Governing+Council+Digital+Assets/Policies/PDF/ppjul012002.pdf) . Academic misconduct is taken **very seriously**! See the **Homeworks** (https://q.utoronto.ca/courses/354310/pages/homeworks) page for information about what resources you are allowed to use when working on your assignments.

Lectures

Navigation	**Home page** (https://q.utoronto.ca/courses/354310/pages/csc265-fall-2023-enriched-data-structures-and-analysis)	**Lectures** (https://q.utoronto.ca/courses/354310/pa

General Info

The **lectures** allow us to explain new material, how it relates to the rest of the course (and what you've learned in other courses), and to show examples of applying the material. You are expected to read the assigned material, and attempt the exercises in the reading on your own time. It is recommended that you make your own notes during lectures and tutorials. Slides and recordings from the lectures will be posted on this page. Nevertheless, you are strongly encouraged to attend lectures, so that you can participate in class discussions and collective problem solving.

Tutorials are an opportunity to apply what you have learned in lectures by solving algorithm design problems. One or more problems will be posted on the course webpage before the tutorial, and students are expected to study the problem and attempt to solve it prior to the tutorial. During the tutorial you will be able to discuss your solution with your classmates, and your TA will explain the solution. Solutions will typically be posted some time after the tutorial. Solving the problems in tutorials will allow you to deepen your understanding of the material, and prepare for homework assignments and tests. Problems from the tutorials will often be similar to problems you will encounter on assignments and tests.

Students often learn a lot from working with one another. You are encouraged to meet with other students taking the course. For example, you might work through exercises in the course text together or discuss any material you found confusing in lecture or in the text.

Tentative Schedule of Lectures

Readings from the 3rd edition of Introduction to Algorithms, by Cormen, Leiserson, Rivest, and Stein are marked by CLRS. You can find an **online version** (https://librarysearch.library.utoronto.ca/permalink/01UTORONTO_INST/14bjeso/alma991106378851006196) of the 3rd edition from the U of T Libraries website. Note that chapter and section numbers may differ in different editions.

Readings from Algorithm Design by Kleinberg and Tardos will be marked by KT. You can purchase an ebook version from the **U of T Bookstore** (https://www.uoftbookstore.com/adoption-search) .

Readings from Algorithms by Jeff Erickson will be marked by E. The book is available **online** (https://jeffe.cs.illinois.edu/teaching/algorithms/) .

Week and Topic	Readings	Tutorials
Week 1: Sept 3–6 Divide & Conquer Algorithms	CLRS Ch 4; KT Ch 5; E Ch 1 **Intro Slides (https://q.utoronto.ca/courses/354310/files/33066064?wrap=1)** ⬇ **(https://q.utoronto.ca/courses/354310/files/33066064/download?download_frd=1)** **D&C Slides (https://q.utoronto.ca/courses/354310/files/33058057?wrap=1)** ⬇ **(https://q.utoronto.ca/courses/354310/files/33058057/download?download_frd=1)** **D&C Annotated Slides (https://q.utoronto.ca/courses/354310/files/33167324?wrap=1)** ⬇ **(https://q.utoronto.ca/courses/354310/files/33167324/download?download_frd=1)**	**D&C Exercises (https://q.utoronto.ca/cou** ⬇ **(https://q.utoronto.ca/cou download_frd=1) Solutio (https://q.utoronto.ca/cou** ⬇ **(https://q.utoronto.ca/cou download_frd=1)**
Weeks 2 & 3: Sept 9–13; Sept 16-20 Dynamic Programming	CLRS Ch 15, 24.1, 24.5; KT Ch 6; E Ch 3 **DP Slides (https://q.utoronto.ca/courses/354310/files/33183711?wrap=1)** ⬇ **(https://q.utoronto.ca/courses/354310/files/33183711/download?download_frd=1)**	**DP Exercises (https://q.utoronto.ca/cou** ⬇ **(https://q.utoronto.ca/cou download_frd=1)**
Weeks 4 & 5: Sept 23-27; Sept 30-Oct 4 Greedy Algorithms	CLRS Ch 16, 24.3; KT Ch 4; E Ch 4 (CLRS Ch 24.3 for Dijkstra?)	
Weeks 6 & 7: Oct 7–11; Oct 14-18 Network Flows	CLRS Ch 26; KT Ch 7; E Ch 10-11	

Week 8: Oct 21–25 Linear Programming	CLRS Ch 29; LP lecture notes	
Fall break: Oct 28-31		
Nov 6: Embedded Ethics Module	TBA	
Weeks 9 & 10: Nov 4–8; Nov 11-15 Computational Complexity	CLRS Ch 34; KT Ch 8	
Week 11: Nov 18-22 Approximation Algorithms	CLRS Ch 35; KT Ch 11	
Week 12: Nov 25-29, Dec 2 Randomized Algorithms	CLRS Ch 5; KT Ch 13	

Learning Objectives

By the end of this course, you should have the following skills

- Know the three basic algorithm design paradigms - divide and conquer, greedy, dynamic programming. Be able to recognize when an algorithm uses one of the paradigms, when a paradigm is the appropriate one for a given problem, and apply the paradigms to design new algorithms.
- Be able to model problems using network flow and linear programming, and recognize which problems can be modeled in this way.

- Be familiar with basic algorithms for solving network flow problems and linear programs, in particular the Ford-Fulkerson algorithm, and the simplex algorithm.
- Know the definitions of the complexity classes P and NP, understand the significance of the P vs NP problem, understand the concepts of NP hardness and NP completeness. Be able to use reductions to prove NP-hardness.

Homeworks

Navigation	Home page (https://q.utoronto.ca/courses/354310/pages/csc265-fall-2023-enriched-data-structures-and-analysis)	Lectures (https://q.utoronto.ca/courses/354310/pa

Overview

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 roughly every other week on Monday, and due by the end of the day the Friday of the same week. Quizzes should be completed *individually.* Quizzes check basic understanding of the material covered in the lectures and the assigned readings, while group assignments check that you can use the new concepts and techniques creatively to solve algorithmic problems.

Quizzes will generally be posted on Monday after lecture, every other week. They will be due by noon the following Monday. Each group assignment is due **by midnight** on its due date, see below for the schedule.

Assignment	Date out	Date due	Problems/Solutions
Assignment 1	Sept 16	Sept 30	
Assignment 2	Sept 30	Oct 14	
Assignment 3	Oct 21	Nov 4	
Assignment 4	Nov 18	Dec 2	

Additionally, we will have an **Embedded Ethics Module**, with several associated assignments:

- *pre-module survey*, released on Sept 23, due on Sept 30 at 11:59pm, worth 0.5% of your grade;
- *post-module survey*, released on Nov 29, due on Dec 2 at 11:59pm, worth 0.5% of your grade;
- *pre-module assignment*, which will be submitted together with Assignment 3, and will consist of one additional homework question, worth 2% of your grade;
- *post-module assignment*: short essay questions related to the module, released on Nov 6, due on Nov 11 at 11:59pm, worth 2% of your grade.

Working in Groups

A *group assignment* is to be done by at most two people. For these assignments you are strongly encouraged to work with a partner, rather than work alone. You and your partner should discuss the questions with one another, and come up with solutions *together*, but you may **not** discuss them with

other students. For each problem, one student in the group is responsible for writing the solution, and the other student is responsible for proof-reading and revising it. The first page of your submission **must** list the name, student ID, and UTOR email address of each group member, and also indicate, for each problem, who wrote the solution, and who revised it. The purpose of these rules is to ensure that *each student* fully understands the solution of every problem in the group submission.

If you would like to work with someone but you don't know anybody who could be your partner, simply post a "Search for Teammates" message in Piazza. Also, make an effort to speak with your classmates during lectures and tutorials - you may find that there are many others in the same situation as yours.

Academic Integrity

When working on assignments, you are not allowed to use other resources except the assigned reading materials, and the materials posted on this site. You should **not** discuss homework solutions with anyone other than the professor, the TA, and, if working on a group assignment, your partner.

Failure to comply with these guidelines is a serious academic offense.
If you have any questions about this policy, make sure you ask the professor or the TA. More information about why plagiarism is bad and what happens to cheaters can be found at **http://www.cs.toronto.edu/~fpitt/documents/plagiarism.html (http://www.cs.toronto.edu/~fpitt/documents/plagiarism.html)** .

Lateness Policy

Every student has **three** grace credits, and each credit allows you or your group to be late on one *group assignment* for up to 24 hours. You can use up to two credits on one assignment. After the credits are 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.

Special Consideration

Please contact your instructor as soon as possible in case you are unable to complete an assignment on time due to some unforeseen circumstances. Also, please contact your instructor if you need special accommodations. You are expected to contact the instructor regarding these special considerations **before** the posted due date of the assignment.

If you have an accommodation letter from Accessibility Services that entitles you to extra time for homework assignments, and you plan to use this accommodation, please reach out to me via the course email and attach the letter. Before each assignment for which you need extra time, please also email me and let me know how much extra time you need.

Remarking Requests

Remarking requests will be accepted up to one week after the date a homework assignment is returned, and should be submitted on MarkUs. A remarking request can be used to alert us to possible mistakes in the grading of an assignment, but *not to question the marking scheme of the assignment.* In response to the remarking request your mark may go up or down.

Submission Instructions

Quizzes will be posted and submitted here on Quercus.

Group assignment submissions will be done using MarkUs. All group assignments should be **typed and not handwritten.**

To submit as a group (**only for group assignments**), one of you needs to *invite* the other to be their partner, and then the other student needs to accept the invitation. To invite a partner, navigate to the appropriate Assignment page, find "Group Information", and click on "Invite". You will be prompted for the other student's username. To accept an invitation, find "Group Information" on the assignment page, find the invitation listed there, and click on "Join". You should do this **before the deadline** even if you are planning to use your grace credit or have been granted an extension.

Once you have submitted, click on the file's name to check that you have submitted the correct version-**and that it is in PDF**.

Remember to put the name, student ID, and UTOR email address of the group member who wrote the solution, and also the name, student ID, and the UTOR email address of the group member who proof-read and revised it on the first page of the submission.

File Formats and LaTeX resources

You are encouraged to use LaTeX to typeset your homework solutions (see below for links to LaTeX resources). However, the use of LaTeX is not required - what matters is that your submissions all be in PDF and typed. **Scans of hand-written solutions will not be accepted!**

LaTeX resources LaTeX is a general-purpose typesetting system that makes it easy to generate high-quality documents, particularly when formatting mathematical formulae. In addition, Piazza supports typesetting equations with LaTeX syntax (by enclosing the equation in double dollar signs, for example `$$e^{2\pi i} - 1 = 0$$`). Here are some links to get you started.

- **TeXworks** (http://www.tug.org/texworks/), a cross-platform LaTeX front-end.
- The **LaTeX Wikibook** (http://en.wikibooks.org/wiki/LaTeX).
- Additional **LaTeX Documentation** (http://www.latex-project.org/guides/), from the home page of **the LaTeX Project** (http://www.latex-project.org/).

- **Overleaf** (https://www.overleaf.com/) allows you to create and collaboratively edit a LaTeX without having to install LaTeX on your machine.