

Overview

Discrete optimization, also known as combinatorial optimization, is an area of optimization that deals with optimization problems where the underlying decisions are of a discrete flavor, such as, yes/no decisions. Such optimization problems are quite pervasive and model a variety of interesting real-world applications.

In this course, we will study various discrete optimization problems focusing both on modeling and on algorithm design. In particular, we will see how various applications can be abstracted and modeled as discrete optimization problems, and we will learn various algorithm design and analysis techniques for discrete optimization problems. Some broad classes of problems that we will consider are:

- Network connectivity problems, which typically entail constructing a minimum-cost subgraph of an underlying network that possesses certain desired connectivity properties. Examples include shortest paths, minimum spanning trees, minimum Steiner trees, generalized Steiner forests.
- Location problems, that deal with the optimal placement of "facilities" at the nodes of a network. A prototypical example is the uncapacitated facility location problem.
- General integer programs. This class of problems subsumes the above two classes, and are versatile enough to encompass almost all discrete optimization problems.

Prerequisites

The prerequisite for this class is CO 250 (Introduction to Optimization) or something equivalent. In particular, students will be assumed to be familiar with linear-programming formulations and duality. Knowledge of basic graph theory terminology and notation (e.g., paths, cycles, trees) at the level of MATH 239 is useful but not essential.

Study Material

There are no course notes or prescribed textbook for this course. The main study material for the course are the pre-recorded lecture videos (posted under Contents -> Lectures -> Week n Videos). To aid you in studying the course material, PDF transcripts of the lecture videos will also be posted on LEARN (see Contents -> Lectures -> Week n PDFs), which will serve the purpose of course notes. The

transcript of the lecture video may be slightly edited to include some annotations and/or corrections. The lecture videos and PDFs will be the primary means for learning the course content.

The following texts on algorithm design serve as good references for many (but not all) of the topics covered in the course. These texts have been placed on reserve at the Davis Center library.

I may post additional references as the course progresses.

Algorithm Design, Jon Kleinberg and Eva Tardos, Addison Wesley, 2005. (Referred to as [KT] in the Lectures section.)

Approximation Algorithms, Vijay Vazirani, Springer-Verlag, 2001.

Thanks to the publishers, this book can be viewed online [here](#).

(Referred to as [V] in the Lectures section.)

The Design of Approximation Algorithm, David Williamson and David Shmoys, Cambridge University Press, 2011.

Thanks to the publishers, this book can be viewed online [here](#).

(Referred to as [WS] in the Lectures section.)

Collaboration Policy and Cheating

While it is acceptable for students to discuss the course material and the assignments, you are expected to do the assignments on your own.

*Copying or paraphrasing others' work, including past course solutions and external resources found online or in books, qualifies as **cheating** and the TAs are instructed to look for suspicious similarities when grading.*

Students may discuss assignment materials with others, but the *submitted work must be worked through and written up on their own, and you must acknowledge all collaborators; failure to do so constitutes **cheating***. If you have gotten an idea from another student, you should write your own version of the solution and acknowledge the assistance you received. An example of how this might be done is: "The idea for this solution was suggested to me by Jane Doe."; Another possibility, if there was an exchange of ideas, is: "I discussed this problem with Jane Doe. The solution presented is based on that discussion."

Acknowledging your collaborators and any assistance you received from others, will not affect your grade in anyway (but failure to do so will be considered cheating).

All students suspected of cheating will automatically be reported to the Academic Integrity Officer for their actions. They will receive no credit for the assignment in question, in addition any penalty that the Academic Integrity Officer prescribes. Students who are unsure whether an action constitutes an offence, or who need help in learning how to avoid offences should seek guidance from the instructor. For information on categories of offences and types of penalties, students should refer to [Policy #71, Student Academic Discipline](#).

Re-mark requests

For re-mark requests regarding assignments, SQ quizzes, and the midterm, contact me within **one week** of the assessment, and I will forward it to the appropriate marker for consideration.

Students with disabilities

The AccessAbility Services office, located in Needles Hall, Room 1132, 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.

CO353: Computational Discrete Optimization (online) – W21

Course Organization: Schedule, Activities, Assessments, and Grading

Acknowledgment: *The course design closely follows the template of CO342 in Fall 2020, taught by Prof. Penny Haxell. Large portions of that course’s outline have been reproduced here, with permission from the instructor.*

Instructor: Chaitanya Swamy, cswamy@uwaterloo.ca (please include CO353 in the subject line of any course-related email you send)

Office hours: T 10-11am, W 2-3pm (starting Jan 19, 2021), via Zoom; the Zoom link is posted on the LEARN page

1 How to take this course: course schedule and activities

One of the challenges associated with taking an online course is sticking to a schedule. There are various activities planned every week to help you do this and keep you engaged with the course material. Plan to do the following activities in each week n . (For our purposes, each work starts on Monday and ends on Sunday.)

- View the lecture videos for week n . These will be posted under “Content -> Lectures -> Week n Videos”, by Sunday midnight of Week $n - 1$. To help you in studying the course material, PDF transcripts of the lecture videos will also be posted on LEARN, under “Content -> Lectures -> Week n PDFs”. The transcript of the lecture video may be slightly edited to include some annotations and/or corrections. The lecture videos and PDFs will be the primary means for learning the course content.
- Submit the “Week n LEARN Quiz (LQ n)”. For ease of reference, this will be posted *both* under “Content -> Lectures” and “Content -> LEARN Quizzes” by Tuesday of Week n . Take this quiz *after* viewing the lecture content for week n . This quiz must be submitted by 11:59pm Sunday of week n .
- Prepare for and attend your Supervision for Week n , which will take place on Thursday at 9:30am or 12 noon EST. Write the Supervision Quiz (SQ n) at the end of your supervision. See the Supervisions section for more information.

The Supervision in week 1 and SQ1 be an exception (see the Supervisions section), and is meant chiefly for practice.

- Work on the next assignment that is due.

2 Assessments and grading

Assessment will take various forms and will happen throughout the term. This is intentional, and is intended to help you stay on track with the course. The assessment will consist of the following.

Assignments: 6 assignments, roughly one every two weeks, submitted via Crowdmark. The lowest assignment grade will be dropped. You may consult the course material, and discuss with other

students, but *you must independently write up your own solutions and acknowledge all collaborators*. For instance, you may say: “The idea for this solution was suggested by ...”, or “I discussed this problem with ..., and the solution here is based on that discussion.” (This acknowledgment will not lower your grade.)

Copying or paraphrasing others’ work, including past course solutions and external resources found online or in books, constitutes cheating. Not acknowledging collaborators or help you received from other students will also be considered cheating.

LEARN Quizzes (LQs): 12 LQs, one each week in weeks 1–12. The lowest two scores will be dropped.

These will be timed quizzes on LEARN that play the role of brief in-class quizzes (e.g., Clicker quizzes). They will test your understanding of recent material.

LQ n must be submitted by 11:59pm Sunday of week n . You may not consult any course material, or discuss with others while writing the LQ, or attempt to gain any information about the quiz from others.

Supervisions: 11 graded Supervisions, one each week in weeks 2–12. These will be held on Thursdays, at 9:30am or 12 noon EST, depending on your group.

Supervisions will partly involve oral assessments; the Supervisions section gives details on this. (The Supervision in week 1 is for practice only, and will not be graded.) The lowest Supervision grade will be dropped.

Supervision Quizzes (SQs): 11 graded SQs, one each week in weeks 2–12. At the end of your supervision meeting, you will be given a Supervision quiz, which you will write immediately and submit on Crowdmark.

This is a timed assessment consisting of one test question. You may not consult any course material, or discuss with others while writing the SQ. (SQ1, the Supervision Quiz in week 1, is for practice only, and will not be graded.) The lowest SQ grade will be dropped.

Exams: There will be two 1-hour exams: a midterm, and a final exam. These will be video-proctored by the course personnel.

Grade calculation. The grade for the course will be calculated as follows.

Assignments	:	20%
LEARN Quizzes	:	10%
Supervisions	:	15%
Supervision Quizzes	:	15%
Midterm	:	20%
Final	:	20%

Missed assessments. Valid reasons for missing an assessment that will be considered are: (a) serious illness, or (b) technology failure. If you miss an assessment for valid reasons, you should send me an email specifying the valid reason. In the case of serious illness, the usual requirements for documentation apply. Work missed during the term will be made up on the basis of individual plans after the term ends, during the Final Exam period. These plans may include oral exams and/or individual comprehensive projects.

Note: Since the lowest x assessments in the categories assignments, LQs, SQs, and Supervisions are dropped (where $x = 1$ or 2), the first x assessments in these categories that are missed for valid reasons will not be made up.

Re-mark requests. For re-mark requests regarding assignments, SQ quizzes, and the midterm, contact me within *one week* of the assessment, and I will forward it to the appropriate marker for consideration.

3 Supervisions

Supervisions are weekly online meetings of a small group of students and the instructor or a TA (the “supervisor”) that will take place on Zoom. These will take place on Thursdays, from 9:30-11am EST, or 12-1:30pm EST, depending on your group. You should receive a Zoom link for your Supervision by Wednesday morning; if not, then please contact me. When connecting via Zoom, please display your full name on Zoom. The class has been randomly divided into 8 groups; you can find out your group and its Supervision meeting time by going to Connect -> Groups on the LEARN page for the course. (The groups are intended to remain fixed through the term; however, changing enrollments and certain other considerations—see below—may lead to some modification of the groups.)

Action item: Take a look at your group’s Supervision meeting time. If the meeting time translates to a time in your time zone that falls outside of 8am–9pm, then please contact me (cswamy@uwaterloo.ca) ASAP.

The Supervision will consist of two parts. The first part will involve an oral assessment, where the supervisor will invite solutions from the group, or specific students, to questions on the course material. The questions will be of the following types.

- Open questions, on lecture material from the previous week. Any student may volunteer to answer these questions. Please use the “raise hand” feature in Zoom for volunteering to answer questions. You will *not* be penalized for an incorrect solution to a question you volunteer to answer (but please keep in mind that the supervisor needs to share the opportunities for answering questions).
- Explanation of solutions to questions from the last SQ, the last assignment, or the last LQ. The supervisor may call on a specific student(s) to explain their solutions. You will only be asked to explain your solution if your solution was correct.

This part of the Supervision will be graded out of 4 points: 1 point is for participation, for attending the Supervision; the other 3 points will be awarded based on the merits of the solution provided. A complete, correct solution earns 3 points; a mostly correct solution missing on some details earns 2 points; an idea that leads to some progress earns 1 point. Your grade will be determined by the best solution you give.

The second part of the Supervision serves as office hours and general discussion, where students may ask questions about any portion of the course material, ask for help with the assignment etc.

Supervision Quiz (SQ). At the end of your supervision, you will take a supervision quiz. This is a timed (20-min.) assessment consisting of one test question requiring a written solution. The test question will be based on material covered the previous week. At the end of your supervision, the supervisor will announce the SQ question. You will be emailed the Crowdmark link for submitting the solution towards the end of your supervision; this link will expire roughly 30min. after the end of the supervision. You will have 20min. from when you click the link (up to the expiry time) to submit your solution.

If you are unable to attend the Supervision due to technical difficulties, the supervisor will email you the SQ question, so you can still write the SQ.

Week 1. The Supervision and SQ in week 1 are for practice only, and will not be graded. The Supervision will not have an oral-assessment component, but the office-hours component will take place, and you will receive a “dummy” SQ question. Although not graded, you should plan on attending the first Supervision and taking SQ1 to make sure that the system is working as intended.

Preparing for Supervision. Review your solutions to the last SQ, last assignment, and the last LQ, and have these at hand. Review the lecture material from the previous week. Prepare any questions or comments you might have about the course material or the assignment you are currently working on.

4 Other information

Piazza discussion forum. We will use Piazza as the discussion forum for this course. You should already have been enrolled in the Piazza account for the course; if not (because of late enrollment, for instance), then please contact me. Questions on Piazza will be answered by one of the course personnel (instructor or TAs) for one hour per day, Monday–Friday. Postings from students can be made anonymous to other students, but will be visible to the course personnel.

Mental Health Support: The Faculty of Math encourages students to seek out mental health support if needed.

On-campus Resources:

- Campus Wellness <https://uwaterloo.ca/campus-wellness/>
- Counselling Services: counselling.services@uwaterloo.ca/ 519-888-4567 ext 32655
- MATES: one-to-one peer support program offered by Federation of Students (FEDS) and Counselling Services: mates@uwaterloo.ca
- Health Services: located across the creek from the Student Life Centre, 519-888-4096.

Off-campus Resources:

- Good2Talk (24/7): Free confidential help line for post-secondary students. Phone: 1-866-925-5454
- Here 24/7: Mental Health and Crisis Service Team. Phone: 1-844-437-3247
- OK2BME: set of support services for lesbian, gay, bisexual, transgender or questioning teens in Waterloo. Phone: 519-884-0000 extension 213

Diversity: It is our intent that students from all diverse backgrounds and perspectives be well served by this course, and that students learning needs be addressed both in and out of class. We recognize the immense value of the diversity in identities, perspectives, and contributions that students bring, and the benefit it has on our educational environment. Your suggestions are encouraged and appreciated. Please let us know ways to improve the effectiveness of the course for you personally or for other students or student groups. In particular:

- We will gladly honour your request to address you by an alternate/preferred name or gender pronoun. Please advise us of this preference early in the semester so we may make appropriate changes to our records.
- We will honour your religious holidays and celebrations. Please inform of us these at the start of the course.
- We will follow AccessAbility Services guidelines and protocols on how to best support students with different learning needs.