

CO 351: Network Flow Theory (Online)

Fall 2020 Course Outline

1 Overview

Networks are pervasive in everyday life; street-networks connect cities, electrical and phone networks connect our homes, social networks connect friends and associates, . . . ; the list of examples is endless. In this course we will study optimization problems in domains that have network structure.

An example for a typical network question that we will study is the following:

How much information can we transfer through the network from a given node to another node?

We will see that this question as well as many others have efficient solutions. Students taking this class will learn (a) how to develop mathematical models for network flow optimization problems, and (b) how to solve these models using fast algorithms. We will see how linear programming and duality are used to solve these problems.

Specific topics covered in this class may include:

- transshipment problem (simplified network simplex);
- minimum cost flows (network simplex);
- shortest paths (Dijkstra, Bellman-Ford);
- maximum flows (max-flow / min-cut theorem, preflow-push);
- global minimum cuts (Hao-Orlin algorithm);
- applications to problems in transportation, distribution, job assignments, and critical-path planning.

2 Instructor

Martin Pei. Email: mpei@uwaterloo.ca

You should use Piazza for almost all communications with the instructor. Use email only if you have an issue that is of a very personal nature, and please include "CO 351" in the subject of the email.

3 Lectures

The lectures are delivered through videos posted on LEARN. You are encouraged to learn from the videos at the set schedule provided.

4 Textbook

There is no official textbook for this course. There is a set of course notes *Network Flows: Course Notes for CO 351* available on LEARN, though we will not closely follow these notes. There are two useful references.

1. *Combinatorial Optimization* by Cook, Cunningham, Pulleyblank, Schrijver. (This is available for download from the UW library website.)
2. *Network Flows: Theory, Algorithms and Applications* by Ahuja, Magnanti, Orlin. (This is not available in the library.)

5 Course webpage

Our course webpage will be hosted on LEARN. All course related information will be posted there. We will regularly post announcements on LEARN, and you are responsible for keeping up with the announcements.

6 Access to technology

As this is an online course, you are expected to have some level of access to technology.

- You should have reliable internet access with enough speed to be able to watch lecture videos, and upload assignment and exam solutions within a short time period. We will strive to keep the size of the lecture videos to be under 100MB each. You may wish to consider having a secondary point of internet access, e.g. through your cellphone network, in case your primary internet access fails at critical points.
- A (phone) camera or scanner is needed if you decide to upload images of your solutions. Alternatively, you may use your tablet to write your solutions and upload from there.

7 Piazza

We will be using Piazza to facilitate discussions during this course. The course staff will visit Piazza on a regular basis and will try to answer questions in a timely manner. Some general guidelines on Piazza posting:

- The aim is to create a positive learning environment for everyone. Please be professional and courteous. (Though an occasional meme post might be ok.)
- For assignment problems, you can ask for clarifications, but do not post any full or partial solutions, nor any strong hints. If you have a specific question that include partial solutions to assignment problems, please use private posts.
- Please put some thoughts into your questions and posts. You should show that you have worked on the problem in some way. A post similar to "I'm stuck, any hints?" is not appropriate and will not receive help.
- You are encouraged to help each other and answer questions. For student answers that are correct and do not require additional clarification, the course staff will endorse them without making a further response.

8 Office hours

Two types of office hours are available.

- The instructor will host drop-in office hours on Zoom. The schedule and details will be posted on LEARN. These office hours will not be recorded.
- If you need one-on-one help, you can make an appointment for a 15-minute time slot with the course staff. To do so, please make a private post on Piazza and list the times that you are available. Then a member of the course staff will respond with a time and the method of contact. This option is not available during weekends and holidays.

9 Assignments

There will be an indeterminate number of assignment problems in this course (the aim is roughly 30-40). Assignment problems are sent to you through Crowdmark, and they are due on Fridays at 11:59pm EDT (or EST after November 1). There will be up to 4 assignment problems each week. Regardless of the length and difficulty, all problems are weighted equally, and are being marked out of 10. You are graded on both accuracy and presentation. A correct solution that is poorly presented may not receive full marks.

9.1 Assignment submissions

We will be using the Crowdmark system for submitting assignment problems online. You will receive a Crowdmark link for each assignment problem, and you need to submit your solutions on Crowdmark. Your submission must be clear and legible, and in the correct orientation. Late submissions will receive a deduction of 0.3 marks for each (full or partial) hour late. You should submit your assignment problems hours ahead of time in case of technical problems.

9.2 Policy on collaboration and internet usage

You may use any help provided by the course staff, and you may discuss the assignments with a small group. However, discussions need to be at a high level, and you cannot discuss specific answers to the assignment problems. The expectation is that the major steps in solving the assignment problems must be done on your own. Also, **you must write up the solutions on your own**. This means that you must write from your own understanding with your own words. You are not allowed share your solutions with anyone.

In addition, you may not use electronic resources for help with assignment questions directly. For example, you may read internet materials to learn about Dijkstra's Algorithm, however, you may not directly search for an assignment question on Dijkstra's Algorithm. Also, you are not allowed to use solutions obtained from previous offerings of related courses. Any submitted assignments that are suspected of cheating will be reported to the integrity officer of the Faculty of Mathematics.

10 Exams

There will be three term tests and a final exam for this course. They are at the following dates.

- Term test 1: Tuesday October 6, 12:01am to 11:59pm, EDT
- Term test 2: Tuesday November 10, 12:01am to 11:59pm, EST
- Term test 3: Tuesday December 1, 12:01am to 11:59pm, EST
- Final exam: To be scheduled by the Registrar's Office during the final exam period (December 9-23).

Logistics. For each term test, you have 2.5 hours to start and finish the exam within the given 24-hour window. For the final exam, you have 3 hours to do so. You will receive a Crowdmark link at the start of the 24-hour window. You can decide when you want to start the exam, however, you must complete the exam before the end of the 24-hour window. When you open the link, you will be asked to confirm that you want to start the exam. Then the exam problems will be revealed on Crowdmark. You need to write your solutions by hand (either on paper or on a tablet) and upload your solutions.

The term tests are designed to be completed within 2 hours, while the final exam is designed to be completed within 2.5 hours. So you have at least 30 minutes to upload your solutions. We suggest that you upload your solutions periodically throughout your time, in case of unforeseen technical difficulties. If you upload anything after the allowed time, then you will receive a deduction of 10% of the total exam value every (full or partial) minute.

Trial run. To help you familiarize with the exam process, trial runs will be held on Tuesday September 22 and September 29. You should iron out any technical issues that you encountered during the trial run to minimize the chances of a technical difficulty during the real exams. You can also optimize the process of uploading the solutions and practice it to minimize submission time.

Materials allowed. The exams are open book, but not open internet. You are allowed to use anything that is posted on LEARN, Crowdmark and Piazza of this course this term. You are also allowed to use any notes that you have created yourself. However, you are not allowed to use the internet to search or ask for answers. You are also not allowed to communicate with anyone in any form about the exam until the exam period is over.

Academic integrity. You will need to submit a signed academic integrity statement (to be provided) for each exam, signifying that you are the only one who worked on your submitted solutions, you did not communicate the content of the exam with anyone, and you did not access forbidden materials. Cheating on an exam is extremely serious, and may result in automatic failure of the course, or worse. Any submitted exams that are suspected of cheating will be reported to the integrity officer of the Faculty of Mathematics.

11 Re-marking requests

If you believe that there are marking errors in your assignment or exams and you would like to make a re-marking request, then you need to create a private Piazza post that includes your student ID and which assignment problem or which exam that you want re-marked. You need to do this within one week of the return date.

For exams, re-marking requests can only be made on the entire exam, not individual questions. Do not include additional texts (such as which questions and additional explanations). We can only mark what you have submitted. If no marking error is found in the re-marking, then 3% of the total exam value will be deducted from your exam grade.

12 Course grades

- 40% Assignment problems (the 7 lowest marks will not count in your grade)
- Best 3 out of these 4 assessments:
 - 20% Term test 1
 - 20% Term test 2
 - 20% Term test 3
 - 20% Final exam

13 Missed assignments and exams

The course grading scheme accommodates any circumstances you may encounter during the term, including (but not limited to) illness, events and technical issues. We will not shift weights or extend deadlines for any student for any reason.

- If you miss an assignment or an exam for any reason, do not contact the instructor, the grading scheme has already accommodated for it.
- Even though we are dropping your lowest marks from 7 assignment problems and 1 exam, you should not be complacent and skip assignments or exams for minor reasons. You are still expected to put full effort into every assignment and exam. Then you are covered if you encounter unexpected situations and are forced to skip one.
- No INC grade will be given for any reason.

14 Coronavirus information

Check the university's webpage on [coronavirus information for students](#) for updated information on COVID-19 and guidance for accommodations due to COVID-19.

15 Mental health support

All of us need a support system. We encourage you to seek out mental health supports when they are needed. Please reach out to [Campus Wellness and Counselling Services](#).

We understand that these circumstances can be troubling, and you may need to speak with someone for emotional support. [Good2Talk](#) is a post-secondary student helpline based in Ontario, Canada that is available to all students.

16 University Policies and AccessAbility

16.1 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 the [Office of Academic Integrity](#) for more information.

16.2 Grievance

A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read [Policy 70, Student Petitions and Grievances, Section 4](#). When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance.

16.3 Discipline

A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for his/her actions. (Check the [Office of Academic Integrity](#) for more information.) A student who is unsure whether an action 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](#). For typical penalties, check [Guidelines for the Assessment of Penalties](#).

16.4 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](#).

16.5 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.