CO 330: Combinatorial Enumeration

Fall 2021 Course Outline

Course format.

Because of the ongoing pandemic, this course will meet **online only**. Pre-recorded lectures will be posted each Wednesday, which you will watch on your own. I highly recommend you pause the videos as you go, trying out the examples and proofs for yourself before watching how they are done. The end of each lecture will present some additional problems for you to think about (these are separate from your bi-weekly assignment questions, and mainly exist to give you extra practice and things to discuss in our live tutorial). Our live session tutorial session takes place every Tuesday from 1:30pm – 2:20pm with the instructor and TAs: we will split into groups, go through the problems from the end of the lectures, and take your questions. The live session is a core component of the course, and you should plan to attend every week.

Overview.

This course is about **combinatorial enumeration**: the counting of discrete objects using combinatorial techniques. Combinatorics lies in the intersection of pure mathematics, applied mathematics, and computer science, and this course will showcase the intriguing interactions between these areas. Part of the fun and the usefulness of combinatorial enumeration comes from the nice classes of combinatorial objects that we'll study – which find application in areas from the analysis of algorithms to properties of DNA sequences – and our approach to these concrete problems will lead us to study general techniques for combinatorial sequences. We always strive for *effective methods*, meaning methods that are explicit enough that they can be implemented on a computer.

Assessments.

The grade breakdown will be

- 30% nine assignments (lowest dropped)
- 30% one midterm (October 26)
- 40% final exam

To pass the course you must pass both the test portion and the assignment portion of the assessments. **You are strongly encouraged to submit your assignments well before their deadlines. Late assignments will not be accepted, however your lowest grade will be dropped (your assignment mark comes from your top eight assignments).**

Exams. The exams will be timed online tests where you have the flexibility to choose the 2 hour block of time in which you write them, within a 24 hour window. You may not consult with any reference or person during the test, except for the CO 330 course notes which you may print out or read as a PDF on your computer. The window for the midterm exam will be from **9am Waterloo time on Tuesday October 26 to 9am Wednesday October 27**. The window for the final exam will be scheduled by the registrar during the final exam period and will be announced during the term.

Guidelines on completing the assignments. Assignments are to be done **individually**. You may discuss the assignments in small groups, however **you must write up the solutions on your own**. This means that you may not write up your solutions while you are with a group, and you should not consult any notes you have taken during your group discussions while writing up your solutions. You must **explicitly** acknowledge any discussions with other students by listing their names at the start of your solution (write this for every problem discussed with others).

Assignments will be due on **Fridays at 4pm Waterloo time on Crowdmark**. We will be using the **Crowdmark** system for submitting assignments online; late assignments will not be accepted. . You will

receive a Crowdmark link for each assignment, and you need to submit your solutions on Crowdmark. You must submit each question in the corresponding box, or it will not be graded.

Many assignment questions are proof questions and you will be evaluated on the logic and presentation of your ideas. Aim to present your proofs at a level that would be understood by an average student in the class who has not thought about the problem yet. You may not use electronic resources for help with assignment questions directly. For example, you may read internet materials to learn about the Lagrange inversion formula, however, you may not directly search for an assignment question on this (or any) topic. You are not allowed to use solutions obtained from previous offerings of this course. Any submitted assignments that are suspected of cheating will be reported to the integrity officer of the Faculty of Mathematics.

Piazza. Students are encouraged to help each other understand assignment questions and course materials using the forum at piazza.com. We will be using Piazza as a discussion board, and your mathematical questions about course content should be posted there. Guidelines for usage and details about access will be provided early in the term.

Schedule and material.

Course resources will be posted on Learn, including our course notes and links to video lectures. Don't forget, the weekly tutorial is your main contact time with the instructor and TAs: even though the video lectures are available on demand, you are expected to attend. Please watch the relevant lectures **before** coming to tutorial (you always have six days to do this).

Here is a **tentative** schedule with topics that we plan to cover. The breakdown of topics between weeks may change slightly as we go through the course. Baring technical difficulties, you should expect video lectures to be posted before noon on the relevant day. Remember we have **tutorials Tuesdays, lectures posted Wednesdays, and assignments posted/due Fridays**.

Week	Lecture Date	Topics (Rough Breakdown)	Assignments (Due 4pm)	Assgn. Date
1	Sept 8	combinatorial classes and GFs	A1 Released	Sept 10
2	Sept 15	manipulating GFs and specifications	A1 Due and A2 Released	Sept 17
3	Sept 22	Lagrange Implicit Function Theorem	A2 Due and A3 Released	Sept 24
4	Sept 29	lattice paths and bivariate GFs	A3 Due and A4 Released	Oct 1
5	Oct 6	q-analogues	A4 Due and A5 Released	Oct 8
	Oct 11-15	*reading week*		
6	Oct 20	midterm prep + partitions	A5 Due	Oct 22
7	Oct 27	**Midterm (Oct 26)** + more partitions		
8	Nov 3	labelled objects and exponential GFs	A6 Released	Nov 5
9	Nov 10	more on exponential GFs	A6 Due and A7 Released	Nov 12
10	Nov 17	random generation	A7 Due and A8 Released	Nov 19
11	Nov 24	techniques for asymptotics	A8 Due and A9 Released	Nov 26
12	Dec 1	catch up on topics and summary	A9 Due	Dec 3

Computer Software: I will be using the (free and open source) computer algebra software Sage to illustrate some examples during lectures. Although it is not necessary to learn Sage for the course, I will release the code used to generate these examples and playing around with it yourself can greatly help your understanding. See https://melczer.ca/330/ or LEARN for information on installing Sage and a basic tutorial on how to use it.

Administrative policy

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. **You must do individual work on your own, and you must not do other people's individual work or seek out other people to do yours. You must not upload course material to sharing sites such as chegg nor seek out information there.** Check the Office of Academic Integrity for more information.

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.

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.

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.

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.

Mental Health Support: I encourage you to seek out mental health support if needed. On-campus Resources include

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

Off-campus Resources include

- 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 my 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. I 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 me know ways to improve the effectiveness of the course for you personally or for other students or student groups. In particular:

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