

MATH 239: Introduction to Combinatorics

Fall 2021 Course Outline

Course format.

In Fall 2021 Math 239 will be offered using a form of flipped classroom instruction. There will be course note readings and lecture videos made available online which you will be expected to go over, and then we will use our time together to work through problems in small groups, mastering the techniques together. This problem-time is marked as a tutorial in quest, but you should view it as the core learning time for the course. Consequently, **the tutorials will be run by the instructors and your attendance is expected.** We recognize that technical and life situations come up, so 100% attendance is not required for a 100% grade, but you should plan to attend most problem sessions and to catch up with your group-mates if you do need to miss a session. Your group-mates are counting on you and the problems you work on in the problem sessions contribute to your grade.

The course can be taken either with in-person problem sessions or fully online with synchronous online problem sessions. Simply choose an online or in-person tutorial section as suits your situation.

Additionally, we will have both in-person and online office hours and a discussion forum.

A student from an in-person session who is required to self-isolate can be videoed in by their group so as to continue to participate. If the covid situation requires, the in-person problem sessions will revert to online problem sessions in the same time slot.

Overview.

Math 239 is an introduction to combinatorics and is both fun and useful. This material is closely related to many of the staple puzzle book questions you may have pondered as a kid, and is also foundational to every discipline involving discrete structures including theoretical computer science. The course is primarily theoretical and you will develop your proof-writing skills while working with interesting and useful structures.

The first portion of the course is combinatorial enumeration. If you enjoyed puzzle book questions like “how many ways can you tile a $2 \times n$ board with dominoes?” then you will like this part. If you ever wondered how the number of binary trees grows and how we know that, then you will like this part. Practically, you will learn about generating series, which are one of the most important tools in algebraic enumeration, particularly with a focus on classes of binary strings as examples of regular languages, and you will learn how to solve recurrence equations. You will play with combinatorial objects like compositions of an integer.

The second portion of the course is graph theory. If you enjoyed puzzle book questions of the form “can you draw a given figure without lifting your pencil or retracing any line?”, then you will like this part. If you like to think about the structures of networks then you will like this part. Practically you will learn the formal foundations of graph theory, standard results and how to prove them, and some key graph algorithms.

Classes and instructors.

Tutorials begin on September 13 (the first **full** week of class). Be there!

As well as seeing your instructor in tutorial, you are encouraged to ask questions during office hours. Answering your questions in office hours is part of our job, and we are here because we enjoy talking math with people.

If your question is applicable to others, it is even better to ask it on our Piazza discussion forum.

Instructor	Email (@uwaterloo.ca)	Problem sessions	Office hours	Location
Jane Gao	p3gao	102: 8:30-9:20am Wednesdays, online 105: 9:30-10:20am Mondays, online 106: 11:30am-12:20pm Fridays, online	TBA	online
Steve Melczer	steve.melczer	101: 1:30-2:20pm Mondays, online 103: 8:30-9:20am Fridays, online 104: 6:30-7:20pm Mondays, online	TBA	online
Evelyne Smith-Roberge	evelyne.smith-roberge	107: 9:30-10:20am Mondays, MC 4045 108: 9:30-10:20am Wednesdays, MC 2034 109: 9:30-10:20am Fridays, MC 4045	TBA	TBA
Karen Yeats	kayeats	110: 1:30-2:20pm Mondays, MC 4045 111: 1:30-2:20pm Wednesdays, MC 2017 112: 1:30-2:20pm Fridays, MC 4045	TBA	TBA

Assessments.

The grade breakdown will be

- 15% tutorial hand-in questions
- 10% presentations
- 25% individual assignments
- 25% enumeration exam (midterm)
- 25% graph theory exam (final exam)

To pass the course you must pass both the test portion of the assessments and the non-test portion of the assessments.

Assignments. Assignments are to be done **individually**. This is in contrast to the tutorial hand-in questions which are to be done in your tutorial groups based on the work you did in tutorial.

Assignments will typically be due on **Thursdays at 11am Waterloo time on Crowdmark**, though the last assignment will instead be due on a Tuesday. Assignments will be submitted using crowdmark. The lowest assignment grade will be dropped.

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. There is a document on how to present solutions in Learn with further details.

Tutorial hand-in questions and presentations. The tutorial hand-in questions are to be done in your tutorial groups based on work you did in tutorial. You should get the bulk of the work for the question done during tutorial and then your group will only need to write it up neatly and submit it after the tutorial time. Hand-in questions for Monday tutorials are due on Wednesday at the same time your tutorial started, hand-in questions for Wednesday tutorials are due on Friday at the same time your tutorial started, and hand-in questions for Friday tutorials are due on Monday at the same time your tutorial started. The lowest tutorial hand-in question will be dropped.

You will also be asked to give 1-3 short informal presentations on your problem solving during tutorials. These may be on the tutorial pre-questions, on previous assignment questions you have done well on, or on the tutorial problems your group is currently working on. Presentations are a chance for you to show your thinking, to intelligently describe the places where you're still unsure as well as to explain the parts you have understood.

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 resource other than the course notes.

The window for the enumeration exam will be from **8am Waterloo time on Tuesday October 26 to 8am Wednesday October 27**. The window for the graph theory exam will be scheduled by the registrar during the final exam period and will be announced during the term.

Schedule and material.

The course resources can be found on Learn. There are two sets of course notes that we will be using. Part I will be used for the enumeration portion of the course and Part II will be used for the graph theory portion of the course. Both can be found on Learn. Also on Learn are links to the video lectures.

Don't forget, the tutorials are your main contact time and learning time. Even though the video lectures are available, you are expected to attend your tutorial.

This is a tentative schedule with topics that we plan to cover. A further breakdown of the readings as they are associated to each lecture video can be found on Learn.

Week	Dates	Topics	Readings	Assessments
1	Sept 8-10	Counting, bijections, combinatorial proofs	Part I 1.1.1-1.1.7	
2	Sept 13-17	Generating series formal power series	Part I 2.1-2.2.1	tutorial 1 hand in question
3	Sept 20-24	Sum, product, and string lemmas integer compositions	Part I 2.2.2-2.3	tutorial 2 hand in question assignment 1 (on week 1&2 material)
4	Sept 27-Oct 1	Binary strings string decompositions	Part I 3.1-3.2.3	tutorial 3 hand in question assignment 2 (on week 3 material)
5	Oct 4-8	String recursion, recurrences	Part I 3.3.3, 4.1-4.3	tutorial 4 hand in question assignment 3 (on week 4 material)
	Oct 11-15	<i>reading week</i>		
6	Oct 18-22	Catalan classes	Part I 4.4	tutorial 5 hand in question assignment 4 (on week 5 material)
7	Oct 25-29	Introduction to graph theory	Part II 4.1-4.5	enumeration exam
8	Nov 1-5	Paths and cycles, connectedness	Part II 4.6, 4.8	tutorial 6 hand in question
9	Nov 8-12	Eulerian circuits bridges, trees	Part II 4.9, 4.10, 5.1	tutorial 7 hand in question assignment 5 (on week 7&8 material)
10	Nov 15-19	Bipartite characterization, spanning trees, TSP	Part II 5.2, 5.3, 5.6	tutorial 8 hand in question assignment 6 (on week 9 material)
11	Nov 22-26	Planarity	Part II 7.1-7.6	tutorial 9 hand-in question assignment 7 (on week 10 material)
12	Nov 29-Dec 3	colouring, matchings	Part II 7.7, 7.8, 8.1, 8.2	tutorial 10 hand-in question assignment 8 (on week 11 material)
13	Dec 6,7	König's theorem, Hall's theorem	Part II 8.3, 8.4, 8.6	assignment 9 (on week 12 material)
	TBA			graph theory exam

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.

It is your responsibility to know the rules and follow them. For more information, check www.uwaterloo.ca/academicintegrity.

Mental health support. Especially in these difficult times, it is important to seek out support if you are struggling. On-campus resources include Campus Wellness, Counselling Services, and the one-on-one peer support program MATES. Off-campus resources include Good2Talk 1-866-925-5454, EMPOWER ME 1-833-628-5589 in Canada and the US, or see http://studentcare.ca/rte/en/IHaveAPlan_WUSA_EmpowerMe_EmpowerMe for other countries. Also OK2BME provides support services for lesbian, gay, bisexual, transgender or questioning youth. Phone 519-884-0000 extension 213 (Waterloo Region only).

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 alternative/preferred name or gender pronoun. Please advise us of this preference early in the term 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.

Students with disabilities. The 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 them at the beginning of each academic term.

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, <http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm>. 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 academic offenses and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about rules for group work/collaboration should seek guidance from the course professor, academic advisor, or the undergraduate associate dean. For information on categories of offenses and types of penalties, students should refer to Policy 71, Student Discipline, <http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm>. For typical penalties check Guidelines for the Assessment of Penalties, <http://www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm>.

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, <http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm>.