

MAT344H1S: INTRODUCTION TO COMBINATORICS

Winter 2025

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Quercus Course Page: Sec 1 <https://q.utoronto.ca/courses/382025>

Sec 2 <https://q.utoronto.ca/courses/382030>

What is Combinatorics?

Combinatorics is a field of mathematics concerned with counting and finite structures. Combinatorics is a very diverse subject that has many applications to other fields of mathematics and computer science. The goal of this course is to introduce you to a variety of techniques and ideas that will help you solve a wide range of problems, and practice your proof techniques.

Textbook

We will use *Combinatorics and Graph Theory* by John M. Harris, Jeffry L. Hurst and Michael J. Mossinghoff. Springer, Undergraduate Texts in Mathematics. Available online at the University of Toronto Library.

Homework

Problem Sets will be assigned weekly.

In mathematics, one learns through practice, i.e. by doing lots of problems. The main goal of the course is to improve your problem solving skills. The problem sets will help you practice and the exams will test this.

If you don't know quite how to proceed on a homework problem, it can be very tempting to ask a friend or ChatGPT or Claude (or maybe your friend *is* Claude). You could memorize their answers and you might get a decent grade on the quizzes. Unfortunately, this will not help you much when it comes to the exams, which will test the skills you were supposed to be practicing. On the other hand, you are encouraged to work together in groups to solve the problems.

The assigned problems will not be graded.

There will be a weekly quiz during the tutorial which will be one of the assigned problems.

The homeworks will be posted each week on Quercus; the quiz on each homework will take place the following week (unless explicitly stated otherwise on Quercus, e.g. because of holidays).

There are many more (good) problems in the textbook than we can assign. We encourage you to try at least some of them to develop your skills.

There are several other books noted at the end of this syllabus where you can find more problems, if the ones in the main text are not enough.

Assessment

Quizzes 25% The three lowest quizzes will be dropped

Midterms 30% Two in class midterms (see schedule). The midterms will be designed for one hour, but you will have 110 minutes so that you do not feel rushed. Midterm grade will be higher of the two grades.

Final Exam 45% To be scheduled in the exam period

Regrades and missed exams

If you would like to request a regrade on an assessment, you will need to make a written submission explaining what you believe was marked incorrectly. TAs will not discuss grading in tutorials. If an assessment is regraded, it will be carefully scrutinized, and your mark may go down.

Since the lowest quiz grades and the lower of the two midterm grades are dropped, there will be no make up quizzes or midterms offered in the course.

Calculators and AI

Calculators are neither necessary nor helpful for this kind of material. We would much prefer that you write your solutions in the form of 17^6 rather than 24137569 (for example).

It is likely that the newer AI chatboxes will be able to produce solutions to many of the homework problems (though they may not always be correct.) We urge you to use the homework problems for your own practice; knowing the actual answers to the homework problems will not help you much on the exams. *If you were trying to learn to play basketball, do you think it would be useful to watch a machine throw baskets?* On the other hand, it can be fun and informative to ask AI questions about combinatorics and it can be a great study and research aid.

No electronic aids of any sort are allowed during exams.

Illnesses

If you have a serious long term illness that prevents you from attending multiple quizzes, email the instructor. Missing both the midterms for medical reasons requires a verification of illness form, and the weight will be put on the final exam. The form can be found at <http://www.illnessverification.utoronto.ca>, and must be filled out by a doctor. Submitting a forged medical note is an academic offence.

Tutorials

Tutorials start the second week of classes. They give you the opportunity to work in-depth on problems in small groups with TA guidance. The problems will require you to apply course concepts and justify your solutions to others. You must attend the tutorials because there will be a quiz each week which counts 25% towards your final grade. Tutorials will be your best opportunity to practice solving novel questions under time constraints, like you would on a test, and get immediate feedback on your solutions from peers and TAs. Solutions will be posted on Quercus after all tutorials have finished.

Role in your program

Prerequisites: MAT 223. We will expect you to have a solid understanding of algebraic manipulations, solving linear systems and set notation, as well as some familiarity with writing and recognizing proofs.

Programs recommending MAT344: Applied Math Specialist, Focus in Theory of Computation, Math Applications in Economics and Finance, Math & Applications Teaching Specialist, Math Major.

We hope to explain the connection between enumeration and algorithm complexity, and motivate pedagogical questions which can be solved by combinatorial methods, while maintaining the standards of 300-level mathematics courses.

These standards include *clear communication* in written proofs.

Policy on Missed Term Work

As flexibility for missed quizzes have been built into the marking scheme, missed quizzes will not be accepted.

Please note that Verification of Illness forms(also known as a “doctor’s note”) are temporarily not required.Students who are absent from class forany reason(e.g., COVID, cold, flu and other illness or injury, family situation) and who require consideration for missed academic work should report their absence through the online absence declaration. The declaration is available on ACORN under the Profile and Settings menu.

What is the relation between the two sections?

The lectures in the two sections of the course will be identical. As long as there is space, it is ok to attend some lectures from the other section. But you have to write your midterms in the section you are registered in; they will not be identical (since they are given on different days) but we will make sure they are of the same level of difficulty.

You have to attend the tutorial you are registered for and take the quiz there. Quizzes of students from other tutorial sections will not be graded or recorded.

Calendar

Graphs Ch. 1.1-1.2 Week 1 (Jan 6-10)

Trees Ch. 1.3 Week 2 (Jan 13-17)

Paths and Planarity 1.4-1.5 Week 3 (Jan 20-24)

Coloring and Matching 1.6-1.7 Week 4 (Jan 27- Jan 31)

Ramsey theory 1.8 Week 5 (Feb 3-7)

Midterm 1 Feb 11 (Sec 1) Feb 12 (Sec 2), in class, covers up to and including 1.7

Binomial coeff's, Pigeonhole principle, inclusion-exclusion 2.1-2.5 Week 6-7 (Feb 13-28)

Generating functions Ch. 2.6.1-2.6.3 Week 8 (Mar 3 - Mar 7)

Recurrences Ch. 2.6.4-2.6.6 Week 9 (Mar 10-14)

Midterm 2 Mar 18 (Sec 1) Mar 19 (Sec 2), up to and including Ch. 2.6.3

Permutation groups, Burnside's lemma Ch. 2.7.1, 2.7.2 Week 10-11 (Mar 20-28)

Partitions, Stirling, Bell and Euler numbers 2.8.1-2.8.5 Week 12 (Mar 31- Apr 4)

Other books

You may want to learn about other combinatorial topics that we don't have time to discuss, like Latin squares or block designs, or more about specific topics. Some other books you may find useful, especially for practice problems are:

- Applied Combinatorics by M.T. Keller and W.T. Trotter. Available for free at <http://www.rellek.net/appcomb/>
- Combinatorics Through Guided Discovery by K. P. Bogart is an inquiry-based learning book that covers many of the topics of the course, and is a great source for insightful problems. Available for free at <http://bogart.openmathbooks.org>
- Combinatorics by J. Morris is a more traditional theorem-proof style textbook that includes topics like Latin squares and designs. Available for free at <http://www.cs.uleth.ca/~morris/Combinatorics/Combinatorics.html>

- Combinatorics and Graph Theory by D. Guichard is another more traditional style textbook with an emphasis on Graph theory. Available for free at
https://www.whitman.edu/mathematics/cgt_online/book/
- generatingfunctionology by H. S. Wilf is a book focused on generating functions and their applications. Available for free at
<https://www.math.upenn.edu/~wilf/DownldGF.htm>

Institutional Policies and Support

Academic Integrity

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters

<https://governingcouncil.utoronto.ca/secretariat/policies/code-behaviour-academic-matters-july-1-2019>

If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, please reach out to your Course Instructor. Note that you are expected to seek out additional information on academic integrity from me or from other institutional resources for example, the University of Toronto website on Academic Integrity

<http://academicintegrity.utoronto.ca/>

Copyright

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Accessibility

The University provides academic accommodations for students with disabilities in accordance with the terms of the Ontario Human Rights Code. This occurs through a collaborative process that acknowledges a collective obligation to develop an accessible learning environment that both meets the needs of students and preserves the essential academic requirements of the University's courses and programs. Students with diverse learning styles and needs are welcome in this course. If you have a disability that may require accommodations, please feel free to approach your Course Instructor and/or the Accessibility Services office as soon as possible. The sooner you let us know your needs the quicker we can assist you in achieving your learning goals in this course.

Link to Accessibility Services website

<https://studentlife.utoronto.ca/departments/accessibility-services/>

Equity, Diversity and Inclusion

The University of Toronto is committed to equity, human rights and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another's differences. U of T does not condone discrimination or harassment against any persons or communities.

Important Academic Dates & Deadlines

The academic dates include enrolment dates, drop deadlines, exam periods, petition deadlines and more.

<https://www.artsci.utoronto.ca/current/dates-deadlines/academic-dates>

Other Academic and Personal Supports

- Writing Centre
<https://writing.utoronto.ca/writing-centres/arts-and-science/>
- U of T Libraries
<https://onesearch.library.utoronto.ca/>
- Feeling Distressed?
<https://studentlife.utoronto.ca/task/support-when-you-feel-distressed/>
- Academic Success Centre
<https://studentlife.utoronto.ca/department/academic-success/>
- College/Faculty Registrars
<https://future.utoronto.ca/current-students/registrars/>