

C&O graduate student orientation

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Combinatorics and Optimization

University of Waterloo

Welcome to Waterloo!

Your first term

Research

Courses

Degree requirements

Connections

Teaching Assistantships and Funding

Your first term

People

As well as your supervisor, mentor and colleagues, you will want to know

- **Henry Wolkowicz**, cograd.officer@uwaterloo.ca or hwolkowicz@uwaterloo.ca, Associate Chair for Graduate Studies
- **Melissa Quantrill**, cograd@uwaterloo.ca or melissa.quantrill@uwaterloo.ca, Graduate Coordinator
- **David Jao**, djao@uwaterloo.ca, Chair
- **Mahtab Alghasi**, malghasi@uwaterloo.ca, and **Mike Cummings**, m3cummin@uwaterloo.ca, grad student representatives to the department

If things come up talk to us.

Things to do your first term

- Take courses
- Get started on research
- Work as a TA
- Graduate Research Skills seminar
 - Held weekly. Further details to be announced.
- Attend seminars
 - e.g., William Tutte Colloquium Fridays 3:30PM

And right away some onboarding things (Modules on LEARN):

- Complete the Graduate Academic Integrity Module
- Complete the More Feet on the Ground mental health module.
- Complete CMAHRO TA Orientation: Harassment and Discrimination Module
- Attend **Faculty Graduate TA training**: Weekly/Details to be announced (mandatory! but there's pizza!)

Register for courses

If you are enrolled you should now be able to register for courses.

How many should you take this term? 3? or 2?

Discuss with your supervisor.

- <https://uwaterloo.ca/important-dates/graduate> (clickable)
- can enrol/drop classes using Quest: Aug. 05 to Sept. 29.
- Deadline to drop without penalty: Sept. 29.

Meet with your supervisor

Once a week is a good default for how often to meet with your supervisor.

More or less frequent meetings may end up being better for your situation/work style/project/etc.

In any case keep the lines of communication open.

Why C&O? (Breadth)

Versatility: The discipline bridges foundational, theoretical mathematics with powerful, real-world applications in computer science, engineering, economics, and data science.

- **Algebraic Combinatorics**

techniques from abstract algebra (group theory; representation theory) to solve counting; structural problems in combinatorics.

- **Graph Theory**

study of graphs (networks of vertices connected by edges) to understand structural properties, colorings, and connectivity

- **Combinatorial Optimization**

Finding absolute best or most efficient solution to problems from a finite, discrete set of possibilities

- **Continuous Optimization**

Maximizing or minimizing functions where the variables can vary continuously (infinite possibilities), often involving smooth geometric spaces.

- **Cryptography**

Securing information and communication against adversaries by using hard mathematical problems.

- **Quantum Information**

Investigating how the laws of quantum mechanics can be used to process, store, and transmit information in ways classical systems cannot.

Welcome to Combinatorics and Optimization

uwaterloo.ca/combinatorics-and-optimization/

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Outstanding TA award

The C&O department has 36 faculty members and 60 graduate students. We are intensely research oriented and hold a strong international reputation in each of our six major areas:



Research



- A strength of our system is that you can get started on research right away. Talk to your supervisor and jointly choose a research project.
 - reading papers; asking questions;
 - failed attempts are normal; progress is nonlinear
 - persistence matters more than speed
 - **AI** is a powerful tool that is accelerating math research
- Meet with your supervisor regularly and frequently. They are your coach and ally.
-

Courses

What courses should you take?

What courses should you take?

- Discuss with your supervisor.
- Consider your background and interests.
- Consider core requirements and other requirements.
- For PhD students consider your comprehensive exams.

Plan your courses!

Core courses are offered every year. Most other standard courses (600's) are offered every year or every other year. Topics courses (700's) are one-offs; don't assume it will be offered this year because it was offered last year.

Course requirements

- MMath (thesis option):
 - 2 Core C&O courses
 - 1 other C&O grad course
 - 1 other grad course
- MMath (research paper option):
 - 3 Core C&O courses
 - 1 other C&O grad course
 - 3 other grad courses
- PhD:
 - 4 Core C&O courses
 - 1 other C&O grad course
 - 3 other grad courses
- MMath QI (Quantum Information):
 - the 2 QIC (Quantum Info. & Comput.) core courses
 - 1 other C&O core course
 - 1 other C&O grad course
- PhD QI:
 - the 2 QIC core courses
 - 3 other C&O core courses
 - a total of 8 courses of which 5 are C&O and 4 are QIC (can overlap)

Don't let your core requirement drag on – get them done, ideally within the first 2 terms.

- CO 630 Algebraic enumeration
- CO 642 Graph theory
- CO 650 Combinatorial optimization
- CO 663 Convex optimization
- CO 681 Quantum information processing
- CO 685 Public key Cryptography

Petitions and waivers

Core course waivers

- If you have done a core course in a previous degree (including doing well in its 400 level version) then you can petition to have that part of the core requirement waived, but this does not reduce the total number of courses required (4, 7, or 8).

Extra-to-degree courses

- If you've taken extra courses in a previous degree and achieved a good grade, you can petition to transfer them to reduce course requirements.
- If you take extra courses in your current degree with the intention of using them for a future degree, make sure to get them denoted "extra to degree".

Filing petitions

Melissa will solicit petitions/waivers at the start of each term.

At Webpage: <https://classes.uwaterloo.ca/> ;
<https://cs.uwaterloo.ca/cscf/teaching/schedule/>

- CO 602 Fundamentals of Optimization, Walaa Moursi
- CO 631 Symmetric functions, Oliver Pechenik
- CO 642 Graph Theory, Luke Postle
- CO 650 Combinatorial Optimization, Ricardo Fukasawa
- CO 666 Continuous Optimization, Henry Wolkowicz
- CO 681 Quantum Information Processing, Richard Cleve
- CO 685 Public-Key Cryptography, Sam Jaques
- CO 687 Applied Cryptography, Douglas Stebila
- CO 730 Asymptotic Enumeration, Stephen Melczer
- CO 769 Topics in Convs Optimization, Levent Tuncel

Accommodations

Students with a disability, illness, or other needs can register with <https://uwaterloo.ca/accessability-services/>, **AccessAbility Services**, to arrange for accommodations for courses.

Degree requirements

MMath degree requirements

- Academic integrity module
- Courses (course pass: 60%; degree minimum average: 75%)
- Graduate Research Skills seminar (Fall 2026 and Winter 2027)
- Presentation on thesis/research paper
- Thesis or research paper

PhD degree requirements

- Academic integrity module
- Courses (course pass: 60%; degree minimum average: 70%)
- Graduate Research Skills seminar (Fall 2026 and Winter 2027)
- Comprehensive exams
- Lecturing requirement
- Thesis proposal
- Thesis (and defense)

Comprehensive exams

PhD students must write **two** comprehensive exams, with **at most one from each of the following categories**:

- Combinatorial enumeration, Graph theory
- Discrete optimization, Continuous optimization
- Quantum computing, Cryptography

To pass the comprehensive exam requirement you must pass both exams; if you fail the first attempt, you are allowed a second attempt.

The core courses line up with the comprehensive exams, but not completely.

The exams will be in June or July. Students starting in Fall X write in June/July of year $X + 1$.

Talk to your supervisor already about what exams you plan to take and what courses to prepare with.

Other PhD requirements

Lecturing requirement

You must give 3 lectures/talks, and have two faculty members each see 2 of them.

One nice way to do it is to take someone's class for a week. Seminar talks can also count.

Alternatively, you can complete a course on mathematics teaching.

Must complete **the term before** you submit your thesis.

Thesis proposal

Once you have a solid thesis topic you can do the thesis proposal. You'll need to write a 10 page document, give a presentation, and take questions. It is best done within your first 6 terms.

Connections

Seminars

There are many seminars going on that you can participate in. Check out the seminar or seminars in your area.

Tutte Colloquium, Fridays at 3:30. This is our department colloquium and everyone should plan to attend as often as they can. Snacks start at 3:15.

PMath–C&O joint student colloquium. About once a month with social time afterwards.

Check out the seminar bulletin board outside MC 5491 and the math faculty seminars (emailed out weekly)

Grad student social events

Grad student cookie time in the faculty lounge on Monday at 4pm (Jacob Skitsko) – starting week 2.

Grad student board games night: (Details to come)

Talk to Mahtab or Mike (grad reps) or your mentor about other activities and to join the student Discord server.

Check out university resources for grad student wellness.

<https://uwaterloo.ca/current-graduate-students/grad-experience/resources-and-services> and

<https://uwaterloo.ca/students/health-and-well-being>

Teaching Assistantships and Funding

The funding package for all C&O MMath and PhD students is \$24,500 take-home (after tuition).

- Teaching assistantships
 - 1 TA (5 hours/week) every term
 - plus 1 extra TA periodically:
 - MMath: every 2 years; 1st time in term 3 or 4; 2nd time in term 7
 - PhD: every 3 years; 1st time in term 4/5/6; 2nd time in term 10
- Scholarships
- Graduate research studentships (GRS)

TA assignments

In first term, most new students assigned to undergraduate core course.

Each term, Melissa will email you to ask you to fill out a spreadsheet with your preferences for the next term.

TA responsibilities

Your teaching assistantship (TA) is not just a job.

It's an important part of your training and academic experience.

We expect you to do a **good** job not just an **ok** job.

Workload for one TA is an average of 5 hours per week for 16 weeks.. Some weeks will be busier than others, the 5 hours is an amortized workload.

Don't forget the Faculty Grad TA training during Fall Orientation Week!

TA tasks

Common tasks include

- Grading assignments and exams
- Monitoring and responding to questions on Piazza or other discussion boards
- Running in person tutorials
- Holding in person or online office hours
- Proctoring (for your course)
- Pool proctoring (for other math faculty courses)
- Supervising undergraduate markers

End of term travel

You need to be available to proctor the final exam for your course in person during the exam period. Careful with travel planning!

Most courses do exam marking online via Crowdmark – but talk to your instructor to confirm it's okay to mark remotely.

How to be a good TA

- Know the material.
- Give hints instead of telling students the solution.
- Encourage students to discover solutions themselves.
- Give comments when you grade.
- Be consistent when you grade.
- Don't mistake pedantry for rigour.
- Be punctual and responsive.
- Engage with the students.
- Respect the students, where they are, and how they can learn and grow.
- Ask if you run into problems.

Stuff can come up for various reasons. The most important thing is to stay in communication with the course coordinator.

Keys to Success in C&O

- Meet your supervisor regularly.
- Start research early.
- Attend seminars.
- Build friendships and collaborations.
- Ask questions.
- Seek help early.

We want you to succeed!

If you have difficulties, talk to us (sooner is better than later).