Combinatorial Modelling Syllabus

Department of Mathematics and Statistics

MATH 4360 Winter 2025

Dalhousie University acknowledges that we are in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq People and pays respect to the Indigenous knowledges held by the Mi'kmaq People, and to the wisdom of their Elders past and present. The Mi'kmaq People signed Peace and Friendship Treaties with the Crown, and section 35 of the Constitution Act, 1982 recognizes and affirms Aboriginal and Treaty rights. We are all Treaty people.

Dalhousie University also acknowledges the histories, contributions, and legacies of African Nova Scotians, who have been here for over 400 years.

Course Instructor(s)

Name	Email	Office Hours
Jason I. Brown	Jason.brown@dal.ca	TR 13:05-14:25

Course Description

This course introduces a common framework for combinatorial structures (graphs, digraphs, hypergraphs, posets, preorders, lattices, finite topologies, simplicial complexes), with an emphasis on how to model these structures with other fields of mathematics, such as matrix theory and linear algebra, commutative algebra, topology, analysis, probability and logic.

Course Prerequisites

MATH 2060.03 and MATH 3032.03 or permission of the instructor.

Course Exclusions

MATH 5360.

Student Resources

I will have office hours Tuesdays and Thursdays during the term, 13:05-14:25, in Chase 216.

Course Structure

Course Delivery

Couse delivery is in-person.

Lectures

TR 11:25-12:55 in Chase 227.

Course Materials

Textbook (required): Discrete Structures and Their Applications by J.I. Brown, Brooks/Cole, CRC Press, 2013.

Course website: The course website is on Brightspace.

Assessment

Assignments (30%)

	Tentative due date	Percentage of final grade
Assignment #1	Thursday February 6, 2025	15%
Assignment #2	Thursday February 27, 2025	15%

Tests (40%)

	Date, time and location	Duration	Percentage of final grade	Tentative topics covered
Test #1	Tuesday, February 11, 2025, 11:35-12:55, Chase 227	80 minutes	20%	Chapters 1-3 of DS
Test #2	Thursday, March 20, 2025, 11:35-12:55, Chase 227	80 minutes	20%	Chapters 4-5 of DS

Project (30%)
The project is chosen in consultation with the instructor of the course. There is to be a written component (handed in on the last day of class, April 3, 2025), worth 20% of the final grade, and a 30 minute in-class presentation during the last week of classes (i.e. on April 1 or 3), worth 10% of the final grade.

Conversion of numerical grades to final letter grades follows the Dalhousie Grade Scale

A+ (90-100)	B+ (77-79)	C+ (65-69)	D (50-54)
A (85-89)	B (73-76)	C (60-64)	F (0-49)
A- (80-84)	B- (70-72)	C- (55-59)	

Course Policies on Missed or Late Academic Requirements

If you miss a test or assignment, you are required to fill out and submit the Student Self-Declaration of Absence (SDA) form online in Brightspace within six (6) days of the missed due date. If an assignment cannot be handed in on time, you are required to contact the instructor prior to the due date to arrange a suitable alternate date; there may be a penalty for handing in a late assignment. For a missed test, you must contact the instructor at jason.brown@dal.ca on or before the scheduled date of the test, and submit a copy of your academic schedule, so that a make-up midterm can be scheduled. You may submit at most 2 SDA forms in the class.

Course Policies related to Academic Integrity

All assignments and projects are to be completed independently; no group assignments or projects are allowed. The use of generative AI and large language models (such as ChatGPT and others) is not allowed for any component of the course.

Learning Objectives

This course is an introduction to combinatorial modelling.

Objective: "The student will be able to identify different types of discrete structures"
Condition: Given a discrete structure.
Behaviour: The student will be able to identify the type of discrete structures provided.

Objective: "The student will be able to identify isomorphic discrete structures"
Condition: Given two discrete structures.
Behaviour: The student will be able to apply the definition of isomorphism to decide whether the two structures are isomorphic.

Objective: "The student will be able to model a discrete structure geometrically"
Condition: Given a discrete structure.
Behaviour: Based on the structure, the student will be able to provide at least one geometric representation of the structure.

Objective: "The student will be able to model a discrete structure algebraically"
Condition: Given a discrete structure.
Behaviour: Based on the structure, the student will be able to provide at least one algebraic representation of the structure.

Objective: "The student will be able to model a discrete structure logically"
Condition: Given a discrete structure.
Behaviour: Based on the structure, the student will be able to model the structure in first order logic.

Objective: "The student will be able to model a discrete structure probabilistically"
Condition: Given a discrete structure.
Behaviour: Based on the structure, the student will be able to provide, where appropriate and available, a probabilistic model of the structure.

Objective: "The student will be able to solve problems on graph colourings."
Condition: Given a graph theoretical problem involving colourings.
Behaviour: The student will be able to provide colourings or bounds on the number colours required.

Objective: "The student will be able to solve problems on network reliability."
Condition: Given a graph.
Behaviour: The student will be able to calculate the all-terminal reliability of the graph.

Objective: "The student will be able to appreciate and reproduce applications of topology, algebra, analysis, logic and probability to graph theoretic problems."
Condition: Given an appropriate problem stated only in terms of graph theory.
Behaviour: The student will be able to apply a variety of techniques from point-set topology, linear algebra, analysis, first-order logic and probability theory to provide the required proof.

Objective: "The student will be able to manipulate posets and preorders."
Condition: Given a poset or preorder.
Behaviour: The student will be able to carry out various calculations on the poset or preorder.

Objective: "The student will be able to work with finite topologies as preorders."
Condition: Given a finite topology.
Behaviour: The student will be able to model the finite topology as a preorder.

Objective: "The student will be able to model mathematical problems with hypergraphs."

Condition: Given an appropriate mathematical problem.
Behaviour: The student will be using hypergraphs to solve the problem.

Objective: "The student will learn to work with complexes and matroids."
Condition: Given a mathematical problem.
Behaviour: The student will be able to use complexes and matroids to model various combinatorial problems.

Objective: "The student will learn to apply complexes and order ideals of monomials."
Condition: Given a graph colouring or network reliability problem.
Behaviour: The student will be able to use complexes and order ideals of monomials to provide new insights into the problems.

Course Content and Tentative Schedule

0) Introduction – DS Chapter 1	(January 7, 2025)
1) Discrete Structures: A Common Framework – DS Chapter 2	(January 7-16, 2025)
2) Graphs and Directed Graphs – DS Chapter 3	(January 7 – February 9, 2025)
3) Preorders and Partial Orders – DS Chapter 4	(February 13 – March 6, 2025)
4) Hypergraphs – DS Chapter 5	(March 11-18, 2025)
5) Complexes and Multicomplexes – DS Chapter 6	(March 25 – April 1, 2025)

University Policies and Statements

Recognition of Mi'kmaq Territory

Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel, and support. Visit or e-mail the Indigenous Student Centre at 1321 Edward St or elders@dal.ca. Additional information regarding the Indigenous Student Centre can be found at: https://www.dal.ca/campus_life/communities/indigenous.html

Internationalization

At Dalhousie, 'thinking and acting globally' enhances the quality and impact of education, supporting learning that is "interdisciplinary, cross-cultural, global in reach, and orientated toward solving problems that extend across national borders." Additional internationalization information can be found at: https://www.dal.ca/about-dal/internationalization.html

Academic Integrity

At Dalhousie University, we are guided in all our work by the values of academic integrity: honesty, trust, fairness, responsibility, and respect. As a student, you are required to demonstrate these values in all the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity. Additional academic integrity information can be found at: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility

The Student Accessibility Centre is Dalhousie's centre of expertise for matters related to student accessibility and accommodation. If there are aspects of the design, instruction, and/or experiences within this course (online or in-person) that result in barriers to your inclusion, please contact the Student Accessibility Centre (https://www.dal.ca/campus_life/academic-support/accessibility.html) for all courses offered by Dalhousie with the exception of Truro. For courses offered by the Faculty of Agriculture, please contact the Student Success Centre in Truro (https://www.dal.ca/about-dal/agricultural-campus/student-success-centre.html)

Conduct in the Classroom – Culture of Respect

Substantial and constructive dialogue on challenging issues is an important part of academic inquiry and exchange. It requires willingness to listen and tolerance of opposing points of view. Consideration of individual differences and alternative viewpoints is required of all class members, towards each other, towards instructors, and towards guest speakers. While expressions of differing perspectives are welcome and encouraged, the words and language used should remain within acceptable bounds of civility and respect.

Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness (Strategic Priority 5.2). Additional diversity and inclusion information can be found at: http://www.dal.ca/cultureofrespect.html

Student Code of Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner - perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution. The full Code of Student Conduct can be found at: https://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html

Fair Dealing Policy

The Dalhousie University Fair Dealing Policy provides guidance for the limited use of copyright protected material without the risk of infringement and without having to seek the permission of copyright owners. It is intended to provide a balance between the rights of creators and the rights of users at Dalhousie. Additional information regarding the Fair Dealing Policy can be found at: https://www.dal.ca/dept/university_secretariat/policies/academic/fair-dealing-policy-.html

Originality Checking Software

The course instructor may use Dalhousie's approved originality checking software and Google to check the originality of any work submitted for credit, in accordance with the Student Submission of Assignments and Use of Originality Checking Software Policy. Students are free, without penalty of grade, to choose an alternative method of attesting to the authenticity of their work and must inform the instructor no later than the last day to add/drop classes of their intent to choose an alternate method. Additional information regarding Originality Checking Software can be found at: https://www.dal.ca/about/leadership-governance/academic-integrity/faculty-resources/ouriginal-plagiarism-detection.html

Student Use of Course Materials

Course materials are designed for use as part of this course at Dalhousie University and are the property of the instructor unless otherwise stated. Third party copyrighted materials (such as books, journal articles, music, videos, etc.) have either been licensed for use in this course or fall under an exception or limitation in Canadian Copyright law. Copying this course material for distribution (e.g. uploading to a commercial third-party website) may lead to a violation of Copyright law.