DALHOUSIE UNIVERSITY

**Faculty of Science Course Syllabus** Fall 2020 **(revised June 2020)**
**Department of Mathematics and Statistics**
**MATH 4331/5331**
**Topics in Combinatorics**
**Fall 2020**

**Instructor(s):** Jason I. Brown jason.brown@dal.ca (I can be reached online for office hours TR 10:00-11:30 via Brightspace)

**Lectures**: TR 8:35 – 9:55 (synchronous via Brightspace; notes and recording of class will be posted)

**Laboratories**: None

**Tutorials**: None

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**Course Description**

This course will cover current research in combinatorics. Selected topics may include: graph polynomials, simplicial complexes, partial orders, enumeration problems, and algebraic methods in combinatorics.

**Course Prerequisites**

MATH 3330.03 or CSCI 3110.03 or permission of the instructor.

**Course Exclusion**

None.

**Learning Objectives**

Objective: "The student will be able determine a variety of different reliabilities of a graph."
Condition: Given a graph, possibly with a set of terminals.
Behaviour: The student will be able to find a variety of reliabilities (including all-terminal, two-terminal, K-terminal) of a graph, using enumeration.

Objective: "The student will be able determine the all-terminal reliability of a graph."
Condition: Given a graph.
Behaviour: The student will be able to find the all-terminal reliability polynomial of a graph, using a variety of techniques.

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Objective: “The student will be able to understand the relationships between different reliability problems.”

Condition: Given a graph.

Behaviour: The student will be able to use one type of reliability to solve for another (in some cases).

Objective: “The student will be able to calculate reliability via complete state enumeration.”

Condition: Given a graph.

Behaviour: The student will be able to determine the reliability via listing all relevant subgraphs.

Objective: “The student will be able to simplify reliability calculations via graph transformations.”

Condition: Given a graph.

Behaviour: The student will be able to determine the reliability by reducing the graph via transformations.

Objective: “The student will be able to calculate reliability via the Factoring Theorem.”

Condition: Given a graph.

Behaviour: The student will be able to determine the reliability by recursion.

Objective: “The student will be able to calculate reliability via minpaths.”

Condition: Given a graph.

Behaviour: The student will be able to determine the reliability from minpaths via inclusion-exclusion.

Objective: “The student will be able to prove the intractability of reliability problems.”

Condition: Given a reliability.

Behaviour: The student will be able to show that the reliability problem is intractable, via polynomial graph transformations.

Objective: “The student will be able to calculate reliability for restricted classes of graphs.”

Condition: Given a graph.

Behaviour: The student will be able to determine the reliability of the graph (belonging to specific families) via a variety of techniques.

Objective: “The student will be able to work with the variety of forma of the all-terminal.”

Condition: Given a graph.

Behaviour: The student will be able to calculate and move between the S-, N-, F-, C- and H-forms of the all-terminal reliability polynomials.

Objective: “The student will be able to compute certain coefficients of the reliability polynomial exactly in polynomial time.”

Condition: Given a graph.
Behaviour: The student will be able to determine in polynomial time certain coefficieints near both ends of the all-terminal reliability polynomial.

Objective: "The student will be able to efficiently bound the all-terminal reliability polynomial."
Condition: Given a graph.
Behaviour: The student will be able to bound the all-terminal reliability in polynomial time via different techniques (including Kruskal-Katona and Ball-Provan techniques).

Objective: "The student will be able to work with simplicial complexes and matroids."
Condition: Given a graph.
Behaviour: The student will be able to associate a simplicial complex (related to all-terminal reliability) with the graph, and understand properties of such complexes, including matroids.

Objective: "The student will be able to connect shellability of complexes with all-terminal reliability."
Condition: Given a graph.
Behaviour: The student will be able to understand shellability of the associated complex, the connection to commutative algebra and to work with related order ideals of monomials (including the Ball-Provan bounds).

Objective: "The student will be able to understand analytic and algebraic properties of all-terminal reliability."
Condition: Given a graph.
Behaviour: The student will be able to investigate the algebraic and analytic properties of all-terminal reliability polynomials, including the location of their roots.

Objective: "The student will be able to use a programming language to calculate reliability."
Condition: Given a graph.
Behaviour: The student will be able to use the computer algebra system Maple™ to calculate all-terminal reliability (and other reliabilities).

**Course Materials**

C.J. Colbourn, The Combinatorics of Reliability, Oxford University Press, 1987. (Book is freely available; no access code needed).

Course website: The course website is on Brightspace.

All students should download and install the softwareMaple™ (available freely through the Dalhousie Academic Technology Services software download page).

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## Course Assessment

| Component | Weight (% of final grade) | Date |
|---|---|---|
| ***Assignments*** | 30% | October 1, 2020<br>October 22, 2020<br>November 17, 2020<br>December 3, 2020 |
| ***Tests/quizzes*** (all open for 24 hours, due following day) | 40% | October 15, 2020, 8:30 am<br>November 19, 2020, 8:30 am |
| ***Project*** | 25% | December 11, 2020 |

## Other course requirements

| | |
|---|---|
| ***Attendance at Synchronous Sessions/ Participation*** | 5% |

**Conversion of numerical grades to Final Letter Grades follows the Dalhousie Common Grade Scale**

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

**Those enrolled in MATH 5331: Conversion of numerical grades to Final Letter Grades follows the Dalhousie Common Grade Scale**

## Course Policies

Late assignments may be accepted until solutions are posted. If you miss a test or an assignment, you are required to fill out and submit the Student Self-Declaration of Absence (SDA) form online in Brightspace (you may use a SDA at most twice in a the course). In the case of a missed assignment, the missed assignment score will not be included in the average for that component, if a Student Self-Declaration of Absence form is submitted within six (6) days of the missed due date. In the absence of a Self-Declaration of Absence, the missed assignment will receive a grade of zero. 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 test can be scheduled.

All assignments, test and projects are to be completed independently; no group assignments are allowed.

## Course Content

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1) Preliminaries

2) Exact Algorithms

3) The Computational Complexity of Reliability Problems
   a) Definitions and basic results
   b) Chromaticity of families of graphs

4) Exact Algorithms for Restricted Classes

5) The Reliability Polynomial

## ACADEMIC INTEGRITY

Academic integrity, with its embodied values, is seen as a foundation of Dalhousie University. It is the responsibility of all students to be familiar with behaviours and practices associated with academic integrity. Instructors are required to forward any suspected cases of plagiarism or other forms of academic cheating to the Academic Integrity Officer for their Faculty.

The Academic Integrity website (http://academicintegrity.dal.ca) provides students and faculty with information on plagiarism and other forms of academic dishonesty, and has resources to help students succeed honestly. The full text of Dalhousie's ***Policy on Intellectual Honesty*** and ***Faculty Discipline Procedures*** is available here:

http://www.dal.ca/dept/university_secretariat/academic-integrity/academic-policies.html

### STUDENT CODE OF CONDUCT

Dalhousie University has a student code of conduct, and it is expected that students will adhere to the code during their participation in lectures and other activities associated with this course. In general:

"The University treats students as adults free to organize their own personal lives, behaviour and associations subject only to the law, and to University regulations that are necessary to protect

- the integrity and proper functioning of the academic and non – academic programs and activities of the University or its faculties, schools or departments;
- the peaceful and safe enjoyment of University facilities by other members of the University and the public;
- the freedom of members of the University to participate reasonably in the programs of the University and in activities on the University's premises;
- the property of the University or its members."

The full text of the code can be found here:
http://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html

### SERVICES AVAILABLE TO STUDENTS

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The following campus services are available to help students develop skills in library research, scientific writing, and effective study habits. The services are available to all Dalhousie students and, unless noted otherwise, are free.

| Service | Support Provided | Location | Contact |
|---|---|---|---|
| **General Academic Advising** | Help with<br>- understanding degree requirements and academic regulations<br>- choosing your major<br>- achieving your educational or career goals<br>- dealing with academic or other difficulties | **Killam Library Ground floor** Rm G28 ***Bissett Centre for Academic Success*** | In person: Killam Library Rm G28<br>By appointment:<br>- e-mail: advising@dal.ca<br>- Phone: (902) 494-3077<br>- Book online through MyDal |
| **Dalhousie Libraries** | Help to find books and articles for assignments<br>Help with citing sources in the text of your paper and preparation of bibliography | **Killam Library Ground floor**<br>Librarian offices | In person: Service Point (Ground floor)<br>By appointment:<br>Identify your subject librarian (URL below) and contact by email or phone to arrange a time:<br>http://dal.beta.libguides.com/sb.php?subject_id=34328 |
| **Studying for Success (SFS)** | Help to develop essential study skills through small group workshops or one-on-one coaching sessions<br>Match to a tutor for help in course-specific content (for a reasonable fee) | **Killam Library 3rd floor**<br>Coordinator Rm 3104<br>Study Coaches Rm 3103 | To make an appointment:<br>- Visit main office (Killam Library main floor, Rm G28)<br>- Call (902) 494-3077<br>- email Coordinator at: sfs@dal.ca or<br>- Simply drop in to see us during posted office hours<br>**All information can be found on our website: www.dal.ca/sfs** |
| **Writing Centre** | Meet with coach/tutor to discuss writing assignments (e.g., lab report, research paper, thesis, poster)<br>- Learn to integrate source material into your own work appropriately<br>- Learn about disciplinary writing from a peer or staff member in your field | **Killam Library Ground floor** Learning Commons & Rm G25 | To make an appointment:<br>- Visit the Centre (Rm G25) and book an appointment<br>- Call (902) 494-1963<br>- email writingcentre@dal.ca<br>- Book online through MyDal<br>We are open six days a week<br>**See our website: writingcentre.dal.ca** |