Faculty of Science Course Syllabus
Department of Mathematics and Statistics
Math 3330
Applied Graph Theory

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 Instructors

	Name	Email address	Office Hours
Instructor	Jeannette Janssen	jeannette.janssen@dal.ca	WR 1:30 PM – 3:00 PM in Chase 315
TA	Scott Wesley	scott.wesley@dal.ca	TBA

Course Description

An introduction to graph theory and the analysis of networked data. The course covers logical reasoning about graph concepts including: paths and cycles, shortest route problem, connectivity, minimum spanning trees, network flow, matchings, graph colouring. The course also teaches computational analysis of networks and concepts such as: clustering coefficient, centrality, communities, modularity.

NOTES: This course uses computational tools to analyze graphs. Elementary knowledge of computer programming is recommended.

Course Structure

Lectures

In person (not recorded).

Days	Time	Location
TRF	10:35 AM – 11:35 AM	Chase 315

Course format

The aim of this course is to teach the basic concepts of graph theory and of the new application of graph theory in the analysis of networked data, often referred to as network science. Network science usually deals with real-life networks, and to analyze these, computational tools are needed. To learn to apply the concepts learned in class, we will lab. (We will start from scratch; familiarity with programming will be helpful, but is not required.) A detailed guide on how to install the programming environment will be posted in Brightspace before the start of classes. TA Scott Wesley will be available to help with issues involving this aspect of the course.

Delivery of the course is based on workbooks. These are Jupyter notebooks that cover one topic of the course (approx. one week of lectures). Each workbook has text that constitutes the course notes. All the course material is covered by the workbooks; for a more extensive treatment of graph theory topics, pointers are added to the recommended text Each workbook also includes Python code that can be run to provide examples.

At the end of each workbook are programming exercises, where the student needs to fill in and run their own snippet of code. There is also a list of theory questions about the material covered. For each topic, students should:

- Read the text of the workbook.

- Run the programs in the python boxes of the workbook and do the programming exercises. Upload the workbook as a Jupyter notebook.

- Answer the assigned theory questions and upload the answers to Brightspace (separate from the workbook).

- Attempt the practice questions.

Course Materials

- The primary source of material is Dr. Janssen's notes that are given in the workbooks, which will be available under **Content** on BrightSpace.

- Additional Resources for material or practice problems:

    - A first course in graph theory. Gary Chartrand and Ping Zhang, Dover Publications (any edition).

- Brightspace: All course material will be posted on Brightspace. Most importantly:

    1. The course outline and syllabus can be found under **Content**.
    2. The workbooks (Jupyter sheets) can be downloaded from **Content→Workbooks**
    3. Completed workbooks and assignments must be uploaded (separately) to Brightspace.
    4. Your grades can be found under **Assessments**.

- NetworkX. Programming will be done in the Jupyterlab environment, in the language Python, using the package NetworkX. Instructions on how to install the necessary packages and a link to NetworkX documentation are posted on Brightspace. Help with installation or programming issues is available from TA Scott Wesley.

Evaluation and course policy

The assessment of your performance in the course will be based on workbooks, assign- ments, a midterm and a final exam.

Workbooks

All workbooks will be posted on Brightspace in the form of a Jupyter notebook. Students should download the workbook, read the text, run the examples, and fill in the code in the programming boxes. The completed workbook should be uploaded to Brightspace as a Jupyter notebook with output showing. It should be possible to run the cells in the notebook without getting an error message; test this before you submit!

Each workbook will have a submission deadline. Workbooks submitted late will be ac- cepted up to two weeks after the deadline, but with a 30% penalty. No credit will be given for workbooks submitted more than two weeks after the deadline. Students that are unable to complete and submit the workbook for a valid reason will not incur the penalty. To qualify, students must submit a Student Declaration of Absence (SDA) form before the deadline. The mark for this component of the course will be computed out of the remaining workbooks. Student may miss no more than two workbooks under this rule. The penalties will apply to any additional workbooks late or missed.

Assignments

Each workbook will end with a number of theory questions. These are split into assign- ment questions and practice questions. Only the answers to the assignment questions must be uploaded to Brightspace. You must explain your work; solutions without sufficient explanation will not receive full marks. The answers should be in pdf format. They may be handwritten and scanned, or typed. If handwritten and scanned, make sure your submission is legible and correctly scaled and oriented. Incorrectly formatted or illegible submissions will get a 20% penalty. I encourage you to do the practice questions as well; this will help prepare for the exam.

Students that are unable to complete and submit an assignment before the deadline for a valid reason must contact Dr. Janssen *before* the deadline. Students will then be allowed to answer the practice questions instead of the assignment questions, and get one week extension of the deadline. Student may miss no more than two assignments under this rule. Any additional assignments late or missed will be counted as zero.

Midterm and Final Exam

A midterm exam will be held in class on Friday, October 27 and will have a duration of 50 minutes. The final exam will be scheduled in the final exam period by the registrar, and has a duration of three hours. If a student misses the midterm exam for a valid reason, then the weight of the exam will be assigned to the final exam. If a student misses the final exam, then they should contact the instructor to schedule a make-up exam.

Students must contact Dr. Janssen *before* the start of the exam if they are unable to take the midterm or final exam. If I do not receive a message from a student before the start of the exam, the exam will be counted as zero. The questions on the Midterm and Final Exam will be very similar to the theory questions given at the end of each workbook. In addition, students may be asked to reproduce any of a number of graph theory results and their proof; a list will be provided. Midterm and Final exam will be closed book but students will be allowed one letter-sized crib sheet.

Assessment

The Final Grade will be computed as follows:

Component	Weight (% of final grade)	Date
Workbooks	15%	10 in total
Theory Questions	15%	10 in total
Midterm Exam	20%	(50 min., Oct. 27)
Final Exam	50%	(3hrs, Scheduled in exam period)

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

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

Course Policies related to Academic Integrity

- Students are permitted to discuss the assignments with classmates, but the final version of the solution must be done individually.

- No use may be made of "tutoring" help sites (Chegg, CourseHero etc.). Any material consulted must be properly credited; this includes web pages, or personal communication.

- No collaboration is permitted on the midterm nor the final exam.

- Violations will be reported to an Academic Integrity Officer, and, if substantiated, will result in penalties.

Learning Objectives

- Become familiar with the basic concepts concerning graphs, such as vertex, edge, degree, connectivity, path, tree, etc.

- Become familiar with basic concepts and parameters of network science and other applications of graphs, such as degree distribution, clustering, centrality, network flow, etc.

- Be able to do elementary proofs (logical arguments) in graph theory

- Be able to determine the value of simple graph parameters (such as connectivity, diameter,..) for a specific given graph

- Be able to understand and execute the algorithms to compute graph optimization parameters such as minimum spanning tree and shortest path.

- Be able to use a software package such as Python/NetworkX to compute common graph parameters and analyze networks.

- Be able to model a "real-world" problem as a graph problem

Course Topics

1. Introduction to graphs: how graphs are used to model real-life networks such as ecological networks, the World Wide Web, the Internet, biological networks, and social networks.

2. Paths and cycles: are all humans really connected by at most "six degrees of sepa- ration"?

3. Degrees: in social networks, popularity is not normal(ly distributed).

4. Subgraphs and isomorphisms: how to measure which networks have similar struc- ture.

5. Spanning Trees: the backbone of a network.

6. Connectivity and communities: finding communities of related entities based on their connections.

7. Graph models: using probability to emulate the formation of network

8. Graph traversals: find the cheapest way for a helicopter to visit all oil platforms.

9. Matrices from graphs: how linear algebra can help in analyzing graphs.

10. Random walks on graphs: how the random Web surfer contributed to Google's success.

11. Matchings: Matching kidney donors with patients, or medical interns with intern- ship placements.

12. Graph colouring: scheduling exams or assigning radio frequencies in cellular net- works

An approximate schedule of what topics are discussed when can be found on Brightspace.

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/dept/university_secretariat/policies/academic/student-submission-of-assignments-and-use-of-.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.

Student Resources and Support

University Policies and Programs

Important Dates in the Academic Year (including add/drop dates): http://www.dal.ca/academics/important_dates.html

Classroom Recording Protocol: https://www.dal.ca/dept/university_secretariat/policies/academic/classroom-recording.html

Dalhousie Grading Practices Policies: https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practi.html

Grade Appeal Process: https://www.dal.ca/campus_life/academic-support/grades-and-student-records/appealing-a-grad.html

Sexualized Violence Policy: https://www.dal.ca/dept/university_secretariat/policies/health-and-safety/sexualized-vic.html

Scent-Free Program: https://www.dal.ca/dept/safety/programs-services/occupational-safety/scent-free.html

Learning and Support Resources

General Academic Support - Advising (Halifax): https://www.dal.ca/campus_life/academic-support/advising.html

General Academic Support - Advising (Truro): https://www.dal.ca/about-dal/agricultural-campus/ssc/academic-support/advising.html

Student Health & Wellness Centre: https://www.dal.ca/campus_life/health-and-wellness.html

On Track (helps you transition into university, and supports you through your first year at Dalhousie and beyond): https://www.dal.ca/campus_life/academic-support/On-track.html

Indigenous Student Centre: https://www.dal.ca/campus_life/communities/indigenous.html

Indigenous Connection: https://www.dal.ca/about-dal/indigenous-connection.html

Elders-in-Residence (The Elders in Residence program provides students with access to First Nations elders for guidance, counsel, and support. Visit the office in the Indigenous Student Centre or contact the program at elders@dal.ca or 902-494-6803: https://cdn.dal.ca/content/dam/dalhousie/pdf/academics/UG/indigenous-studies/Elder-Protocol-July2018.pdf

Black Student Advising Centre: https://www.dal.ca/campus_life/communities/black-student-advising.html

International Centre: https://www.dal.ca/campus_life/international-centre.html

South House Sexual and Gender Resource Centre: https://southhousehalifax.ca/about/

LGBTQ2SIA+ Collaborative: https://www.dal.ca/dept/vpei/edia/education/community-specific-spaces/LGBTQ2SIA-colla html

Dalhousie Libraries: http://libraries.dal.ca/

Copyright Office: https://libraries.dal.ca/services/copyright-office.html

Dalhousie Student Advocacy Services: https://www.dsu.ca/dsas?rq=student%20advocacy

Dalhousie Ombudsperson: https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html

Human Rights and Equity Services: https://www.dal.ca/dept/hres.html

Writing Centre: https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html

Study Skills/Tutoring: http://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html

Faculty of Science Advising Support: https://www.dal.ca/faculty/science/current-students/undergrad-students/degree-planning.html

Safety

Biosafety: http://www.dal.ca/dept/safety/programs-services/biosafety.html

Chemical Safety: https://www.dal.ca/dept/safety/programs-services/chemical-safety.html

Radiation Safety: http://www.dal.ca/dept/safety/programs-services/radiation-safety.html

Laser Safety: https://www.dal.ca/dept/safety/programs-services/radiation-safety/laser-safety.html