Introduction to Bayesian Modelling

Syllabus

Departments of Biology/Math & Stats

BIOL4069/STAT3069/BIOL5069 Fall 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
Aaron MacNeil	a.macneil@dal.ca	*Office hours by email appointment LSC 7088*
Arun Oakley-Cogan	Arun.Oakley-Cogan@dal.ca	*Office hours by email appointment LSC 7088*

Course Description

Applied Bayesian statistics using Richard McElreath's popular 'Statistical Rethinking' book, this course provides a broad introduction to applied Bayesian models using R or Python. Examples are drawn from Biology and Social Science examples, in contexts designed to be widely applicable to analysis of observational data across disciplines.

Course Prerequisites

STAT 2060 OR STAT 2080 AND One of: STAT 2450, CSCI 2202, BIOL 3872, or MARI 4600; for 5069: STAT 3340 (or equivalent).

Course Exclusions

Not eligible for credit toward a major in statistics.

Student Resources

Course Structure

Course Delivery

Courses are delivered as in-person lectures, with substantial online supporting material, including additional recorded lectures.

Lectures

M/W/F 1335-1425 Studley SIR JAMES DUNN BUILDING 302

Tutorials

Tutorials will be available throughout the term, typically in the Friday 1335 timeslot.

Course Materials

Course text: 'Statistical Rethinking' 2nd Ed. Richard McElreath

Course Brightspace page: https://dal.brightspace.com/d2l/home/285729

Student will need a laptop computer to complete the work and follow most easily in class/tutorials.

Assessment

Assignments

Weekly homework: Biweekly (5% each) total of 30%	*Every 2nd Friday*
Assignment: (20%)	*End of term*

Exam

Midterm (20%)	*October 20th*
Final exam (30%)	*Final exam period*

Graduate Students

Graduate students will be assessed on the same scale, but with a more challenging rubric for assignments and a longer, more in-depth final exam.

Other course requirements

Attendance in class is strongly recommended to understand material.

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

Late homework or assignments are not accepted, with exceptions made on a case-by-case basis for illness, bereavement etc. Students granted an exception will be allowed to submit the work before the end of term.

Course Policies related to Academic Integrity

Plagiarism, cheating, and other misconduct are serious violations of your contract as a Dalhousie student. You are expected to know and abide by Dalhousie's policies regarding academic misconduct. Violations of these policies will be dealt with according to the Faculty Discipline Process.

For this course, plagiarism is defined as code that is identical or eerily like that of other students - programmers develop code that reflect their individual styles and these conventions are easily recognized. You are absolutely encouraged to collaborate and consult online forums such as Stack Overflow for assignments,

however submitted work must be your own effort, with **sources of borrowed code clearly indicated in script comments**. **Use of generative AI and large language models (e.g., ChatGPT) is discouraged as it will inhibit your ability to apply these methods in the real world and on your final exam; if you chose to use them, you must clearly indicate their use.**

Learning Objectives

Students will learn principles of basic modelling theory and Bayesian probability, how to code a Bayesian statistical model, model checking, causal inference, and how to handle hierarchical data structures. The course is designed to give students the tools needed to go off and fit coherent Bayesian models of their own, being confident that they are using the right model for the inferences they wish to make.

Upon completion, students are expected to be capable of:

1. Developing basic Bayesian statistical models across a wide range of data types;

2. Interrogating models for lack of convergence, model fit, and calibration;

3. Generating and applying causal diagrams for causal modelling.

Course Content

Sep 19: Why Bayes, the Garden of Forking Data
Sep 24: Software Installation Tutorial
Sep 26: Tutorial - Our first model

Sep 29: Geocentric Models & Wiggly Orbits
Oct 01: Spurious Waffles & Haunted DAGs
Oct 03: Tutorial - Linear regressions and DAGs

Oct 6: Ulysses' Compass: Model validation
Oct 8: Model Comparison: How to decide what to use
Oct 10: Tutorial - Model prediction and comparison

Oct 13: Conditional Manatees: Interactions all the way down
Oct 15: Markov Chain Monte Carlo and how to sample
Oct 17: Tutorial - Conditionality, Interactions + MCMC Convergence

Oct 20: MIDTERM
Oct 22: Maximum entropy & GLMs: Principles of information content
Oct 24: God Spiked the Integers: Binomial & Poisson GLMs

Oct 27: Monsters & Mixtures: Poisson GLMs, survival, zero-inflation
Oct 29: Categorical distributions and models
Oct 31: Tutorial - Integer and Mixture Models

Nov 03: Multilevel Models: Foundations of modern inference
Nov 05: Multilevel Models 2: Building the house
Nov 07: Tutorial - Hierarchical Models

Nov 10: Reading week
Nov 12: Reading week
Nov 14: Reading week

Nov 17: The principled Bayesian I + II
Nov 19: Adventures in Covariance: Correlation and how to deal with it
Nov 21: Tutorial - Covariance

Nov 24: Slopes, Instruments: Causal advances
Nov 26: Gaussian Processes: Flexible models and what they mean
Nov 29: Tutorial - Assignment

Dec 01: Missing Values and Measurement Error
Dec 03: Social Relations
Dec 05: Ordered Categories, Left & Right: Models for social science

Dec 10: Bayesian elicitation

Final Exam: TBD

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-originality-checking-software-policy-.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.