

Statistical Rethinking Syllabus

Departments of Biology/Math & Stats

BIOL4069/STAT3069 Fall 2023

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	<i>Office hours by email appointment LSC 7088</i>
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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

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 1135-1225 Studley LSC-COMMON AREA C206

Tutorials

Tutorials will be available throughout the term, typically in the Friday 1135 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 preferably laptop computer to complete the work and follow most easily in class.

Assessment

Assignments

Weekly homework: One per week (6% each) total of 60% Due Friday in tutorial

Assignments: Two take-home assignments (20% each) See lecture schedule

Other course requirements

Attendance in class is strongly recommended to review assigned homework.

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; 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

W1L1 – Sept 06: The Golem of Prague: Models and why they exist

W1L2 – Sept 08: Garden of Forking Data: From counting to probability

W2T1 – Sept 11: Programming Tutorial

W2T1 – Sept 13: Programming Tutorial

W2L1 – Sept 15: Geocentric Models: Why normal dominates the world

W2L1 – Sept 18: Wiggly Orbits: Building blocks for the real world

W2L2 – Sept 20: Spurious Waffles: Domain knowledge in model building

W2T1 – Sept 22: No class

W3L1 – Sept 25: Haunted DAG: Causal model building

W3L2 – Sept 27: Ulysses' Compass: Model validation

W3T1 – Sept 29: Tutorial

W4L1 – Oct 2: University Closed

W4L2 – Oct 4: Model Comparison: How to decide what to use

W4T1 – Oct 6: Conditional Manatees: Interactions all the way down

W5L1 – Oct 9: University Closed

W5L2 – Oct 11: Miracles of Doom: Markov Chain Monte Carlo and how to sample

W5T1 – Oct 13: Maximum entropy & GLMs: Principles of information content

W6L1 – Oct 16: God Spiked the Integers: Binomial & Poisson GLMs

W6L2 – Oct 18: Monsters & Mixtures: Poisson GLMs, survival, zero-inflation

Assignment 1: Implementing Bayesian models I

W6T1 – Oct 20: Tutorial

W7L1 – Oct 23: Ordered Categories, Left & Right: Models for social science

W7L2 – Oct 25: Multilevel Models: Foundations of modern inference

W7T1 – Oct 27: Tutorial

W8L1 – Oct 30: Multilevel Models 2: Building the house

W8L2 – Nov 01: Adventures in Covariance: Correlation and how to deal with it

W8T1 – Nov 3: Tutorial

W9L1 – Nov 6: Slopes, Instruments and Social Relations: Causal advances

W9L2 – Nov 8: Gaussian Processes: Flexible models and what they mean

Assignment 2: Implementing Bayesian models II

W9T1 – Nov 10: Tutorial

Nov 13-17: Fall study Break

W10L1 – Nov 20: Bayesian workflow I

W10L2 – Nov 22: Bayesian workflow II

W10T1 – Nov 24: Tutorial

W11L1 – Nov 27: Missing Values and Measurement Error: Observation-based science

W11L2 – Nov 29: Generalized linear madness: algebraic models

W11T1 – Dec 01: Tutorial

W12L1 – Dec 4: Ordinary differential models

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.