DALHOUSIE UNIVERSITY

Faculty of Science Course Syllabus (Section A)
Department of Mathematics and Statistics

Stat 4130/5130

Bayesian Data Analysis

Fall 2023

Dalhousie University is located in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq. We are all Treaty people.

We acknowledge the histories, contributions, and legacies of the African Nova Scotian people and communities who have been here for over 400 years.

Instructor(s): Dr. *Ammar Sarhan* *e-mail: ammar.sarhan@dal.ca*

Lectures: TR 10:05-11:25 Studley LSC-COMMON AREA C220

Office Hours: By appointment

Course delivery: The course is mainly in-person. However, I may be away for some extended periods and will shift to online delivery at those times. For the online delivery, lectures will be either synchronous or recorded and will be available on the course website.

Course Description

This course is intended to make advanced Bayesian methods genuinely accessible to advanced students, graduated students and researchers in applied statistics.

The course covers all the fundamental concepts of Bayesian methods. We will start with exploring the simple familiar models such as those based on normal and binomial distributions, to illustrate basic concepts such as conjugate and non-informative prior distributions, posterior and predictive distributions. We then discuss more advanced tools in Bayesian analysis. We will consider different models, reliability models, including linear regression, random effect model, generalized linear models, and mixed models.

Some aspects of modern Bayesian computational techniques, including Markov Chain Monte Carlo (MCMC) technique such as Metropolis Hastings algorithm and Gibbs Sampler will be discussed.

Throughout the course, we will discuss variety of examples of real statistical analyses.

Course Prerequisites

The formal pre-requistes are:

- STAT 3360 – Probability Theory
- STAT 3460 - Intermediate Statistical Theory or *Permission of the Instructor*.

The Bayesian data analysis course will be of interest to:

- Graduate students (Masters and Ph.D) in statistics, biostatistics or other quantitative fields who acknowledge the need for advanced modeling tools in their research.

- Advanced undergraduate students, faculty, and other researchers from all disciplines, who seeking to learn advanced methods for analyzing complex real data sets from public health, biomedical science, biology, agriculture, industry, and other related fields from Bayesian perspective.

Course Exclusion

NONE

Learning Objectives

This class deals with the analysis of different types of lifetime data, such as complete data, censored and progressively censored. The emphasis of this course is on Bayesian theory, Bayesian inferences and application. The main objective of this course is to provide a solid practical grounding in Bayesian data analysis. The Learning Outcomes are:

- Develop an understanding of the theory underlying Bayesian analysis in statistical models.
- Provide an understanding of the practice of Bayesian data analysis, as well as the ability to apply methods to real data sets and to interpret the results.
- Provide experience in technical writing skills, and with the use of modern statistical software (R or Matlab) for Bayesian data analysis.

Course Materials

- The textbook for the course is "Bayesian Computation with R, 2nd edition, by Jim Albert, Springer, 2009". This textbook will be followed in a broad sense, and it is a useful reference.
- A Dalhousie Brightspace site will be used for the course where all announcements, selected class notes, assignments, and computer code will be posted.
- We will be using the R statistical software extensively in the course. R is available for download at http://www.r- project.org/ . This is state-of-the-art free, open source software for statistical computing. It is available for all platforms.

For online/blended course delivery:

- *The exams and assignments comprise a combination of in-person and online components, with specific details to be provided during class.*
- *Students have the option to submit their exams/assignments either during class or through the Brightspace platform.*

Course Assessment (*NOTE: tentative exam dates - subject to change***)**

Component Weight (% of final grade) Date

Midterm *20% (TBA), in class*

Final *30% (TBA), in class*

Assignments *50% weekly to bi-weekly, submitted in class or on Brightspace.*

- There will be two exams (midterm and final) worth a total of 50%.
- There will be weekly to biweekly assignments worth 50% of the total mark. There will involve theoretical questions, development of computer code (R),
  as well as reports on the analysis and interpretation of real problems and designed to develop your technical writing skills. Your marks will reflect both the technical correctness of your answers, as well as clarity and organization of your written presentation.

- **Note:** Graduate scheme is the same as the undergrad scheme, but with different material on exams and assignments to differentiate undergrad vs grad.

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)	

Course Policies on Missed or Late Academic Requirements

- *Assignments:* late assignments will receive a zero grade.
- *Midterms:* non-attendance at a midterm will result in a zero grade unless a legitimate excuse is provided, ideally well in advance of the scheduled midterm date. In such a case, and at the instructor's discretion, a makeup may be scheduled or else the midterm not counted toward the final grade.
- Note that any disputes over grading will be resolved by a re-grading of the entire assignment or exam.
- All information relevant to class logistics (class cancellation, due date changes, etc) will be communicated via messages posted on the course website

Course Policies related to Academic Integrity

At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect (The Center for Academic Integrity, Duke University, 1999). As a student, you are required to demonstrate these values in all of 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.

Information: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Course Content

Listed below are the topics to be covered:

- Introduction to Bayesian Thinking
- Single-Parameter Models
- Multiparameter Models
- Introduction to Bayesian Computation
- Markov Chain Monte Carlo Methods
- Hierarchical Modeling