

MATH 559

BAYESIAN THEORY AND METHODS

Instructor : David A. Stephens (Burnside 1225)

Email : david.stephens@mcgill.ca

Texts : *The Bayesian Choice*, CP Robert.

Bayesian Core: A Practical Approach to Computational Bayesian Statistics,
J-M Marin and CP Robert.

Bayesian Theory, J.M. Bernardo and AFM Smith

Monte Carlo Statistical Methods, CP Robert and G Casella.

Prerequisites : MATH 323/356, MATH 324/357, or equivalents, or by permission of instructor.

Good knowledge of calculation methods for probability distributions.

Familiarity with classical statistical methods, especially likelihood-based methods

Knowledge of regression approaches (eg MATH 423) useful.

Experience in R or python useful.

This course provides an introduction to Bayesian inference and key Bayesian methods. Contrast will be made with the frequentist or classical approaches to statistics. Core theoretical ideas will be introduced from first principles stemming from de Finetti's representation for exchangeable random variables. Inference for standard parametric models will be introduced, and extended to hierarchical and more complex models. Simulation-based inference will be introduced, specifically computational strategies based on Monte Carlo methods. The course will contain an introduction to Markov chain Monte Carlo with implementation in R, Stan or python. An introduction to Bayesian nonparametric methods.

Method of Evaluation: Evaluation for the course will be on the following basis

- **60 % Final Examination**

- Examination will be in-person and held during the final exam period.
- Please note that the Instructor has no jurisdiction over the date of the final examination.

- **15 % Midterm Examination**

- Midterm will be held on **Tuesday, 20th October**, in class.
- Midterm examination will be a written exam covering material up to and including Lecture 13 material.

- **10 % Final Project**

- There will be a final project, set in Week 12.
- The project will contain theoretical, methodological and applied elements.

- **15 % Quizzes**

- There will be **six** quizzes, the best **five** will count for the assessment.
- Quizzes will be open-book time-limited short answer myCourses questions.
- Quiz topics will be closely related to topics discussed in lectures.

Note: The final grade will be determined by the aggregate score

$$75\% \text{ Final Exam} + 10\% \text{ Final Project} + 15\% \text{ Quizzes}$$

if this score exceeds the principal method of evaluation.

The instructor bears sole responsibility for grading issues. Please contact Prof. Stephens (by email at david.stephens@mcgill.ca) if you have any questions concerning grading of any assessed work.

TARGET COURSE SCHEDULE

- ‘Q’ refers to Quiz, ‘FP’ is Final Project. Quizzes typically released at the end of the week stated.
- Extra (non-assessed) practice quizzes and other materials may be provided.

Week		Lectures	Topics	Q	
1	31/08	1–2	Probability fundamentals; exchangeability		
2	07/09	3–4	de Finetti’s representation; correct and mis-specification		
3	14/09	5–6	Prior/posterior distributions; decision making	Q1	
4	21/09	7–8	Asymptotic theory of the likelihood; modelling extensions	Q2	
5	28/09	9–10	Hierarchical models; Model selection	Q3	
6	05/10	11–12	Alternative formulations; Simulation and Monte Carlo		
7	12/10	13	Markov chain Monte Carlo (MCMC)		
8	19/10	14–15	Midterm; MCMC implementation		
9	26/10	16–17	MCMC implementation	Q4	
10	02/11	18–19	Applications of MCMC	Q5	
11	09/11	20–21	Applications of MCMC in complex models	Q6	
12	16/11	22–23	Non-parametric Bayesian methods		FP
13	23/11	24–25	Advanced MCMC methods		
14	30/11	26	Advanced Bayesian methods		

Key Academic Dates: <https://www.mcgill.ca/importantdates/key-dates>

- Add/Drop deadline: Tuesday, September 15th
- Fall Reading Break: October 9th to October 14th inclusive
- Last lecture: Tuesday, December 1st
- Classes end: Friday, December 4th

Office Hours:

- Instructor will hold weekly Office Hours. Scheduling details will be announced on myCourses.

Policy on Late Submission:

- Late submission of the Quizzes will not be possible due to the time-limited and machine-scored nature of the assessment.
- Requests for accommodation due to extenuating circumstances should be directed to Prof. Stephens, david.stephens@mcgill.ca.

Policy on the use of AI:

- You may use generative AI tools to assist with coding and with the production of text-based answers. However, anything that you submit for assessment must be **your own work**: for example, it must be the result of **your own use** of the AI tools.
- You are responsible for the work you submit: errors resulting from use of AI tools will be penalized in the usual way.

myCourses:

- Official communications will take place via myCourses.
- All course materials will be available via myCourses.

MCGILL POLICY STATEMENTS

- **Policy on Assessment of Student Learning:** [Policy on Assessment of Student Learning](#)

The purpose of the Policy on Assessment of Student Learning (PASL) is to provide a set of common principles to guide the assessment of students' learning. Per PASL, assessment should be equitable and consistent, and promote effective learning experiences, a healthy learning environment, and academic integrity. Learn more on the For Students page of the PASL website. Also see Faculty of Science-specific rules on the implementation of PASL.

- **Accommodations:**

- Legally mandated academic accommodations are handled by Student Accessibility and Achievement. For more information see <https://www.mcgill.ca/access-achieve/>
- Academic considerations for assessments that are missed or late for valid reasons will be provided at the instructor's discretion. Repeated, similar requests for academic considerations in this course are unlikely to be granted.

- **Language of Submission:** *In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded. This does not apply to courses in which acquiring proficiency in a language is one of the objectives.*

Conformément à la Charte des droits de l'étudiant de l'Université McGill, chaque étudiant a le droit de soumettre en français ou en anglais tout travail écrit devant être noté, sauf dans le cas des cours dont l'un des objets est la maîtrise d'une langue.

[Charter of Students' Rights](#) (Approved by Senate on 21 January 2009)

- **Academic Integrity:** *McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures*

L'université McGill attache une haute importance à l'honnêteté académique. Il incombe par conséquent à tous les étudiants de comprendre ce que l'on entend par tricherie, plagiat et autres infractions académiques, ainsi que les conséquences que peuvent avoir de telles actions, selon le Code de conduite de l'étudiant et des procédures disciplinaires.

[Code of Student Conduct and Disciplinary Procedures](#) (Reviewed by Senate on 12 November 2025)

- **Extraordinary circumstances:** *In the event of extraordinary circumstances beyond the control of McGill University, assessment tasks in a course are subject to change, provided students are sent adequate and timely communications regarding the change. [Policy on Assessment of Student Learning, 6.3](#)*

- **Copyright:** *Instructor-generated course materials (e.g., handouts, notes, summaries, exam questions) are protected by law and may not be copied or distributed in any form or in any medium without explicit permission of the instructor. Note that infringements of copyright can be subject to follow up by the University under the Code of Student Conduct and Disciplinary Procedures.*

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