

University of Maryland, College Park
EDMS 787: Bayesian Inference and Analysis
Spring 2022
Class Location: EDU (Benjamin Bldg) 3233
Class Meeting Time: Monday 4:15-7:00pm

Instructor

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Virtual Office Hours: Monday 1:30–3:30pm, or by appointment

Zoom Link: <https://umd.zoom.us/j/7149027904>

Course Description

Recently, there has been a surge of interest in Bayesian inference in social sciences, partly due to the flexibility and adaptability of Bayesian methods in handling complex statistical models, as well as the development of powerful and user-friendly software packages. Bayesian methods to statistics, although historically preceding the frequentist methods you have learned in other methodological courses, had not become omnipresently popular until the introduction of efficient sampling algorithms, e.g., Markov chain Monte Carlo (MCMC). EDMS 787 is a graduate-level course on Bayesian statistical inference. It covers the fundamental rationale of Bayesian statistics, sampling algorithms, and applications in educational measurement, statistics, and evaluation. The differences and connections between Bayesian and frequentist approaches to statistical inference will also be discussed.

Prerequisites

The prerequisite of EDMS 787 is EDMS 651 (General Linear Models II) and 779 (Mathematical Foundations and Simulation Techniques). The course involves basic calculus and substantive coding in R. Background knowledge in probability theory, mathematical statistics, and calculus will be helpful. Proficiency in R is necessary.

Objectives

Students who attend this course may have quite varied background: Some may have taken many mathematical statistics courses but have little experience analyzing data, while others may have more experience with empirical data but less solid statistics training. The course is designed to strike a balance among statistical theory, implementation, and application, without going too far into each component. The goal of this course is to fill in the gaps in your conceptual and procedural knowledge. The specific objectives are

- to help you gain a solid understanding on Bayesian inference---expressing all uncertainty in statistical modeling by means of probability distributions
- to give you practice in programming basic samplers and to provide guidance on the use of generic software packages for MCMC sampling (e.g., JAGS)
- to introduce common practices in fitting and interpreting Bayesian models in real-data problems
- to discuss applications of Bayesian inference for popular models in education research (e.g., regression and factor analysis)
- to improve coding skills
- to facilitate reading methodological articles and presenting statistical analyses

References

There is **no required textbook** for this course. We will be reading book chapters and journal articles each week that will be posted on the course website. In addition, the following books may be useful throughout the course:

- Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., & Rubin, D. B. (2013). *Bayesian Data Analysis (3rd Ed.)*. Boca Raton, FL: CRC Press.
- Gill, J. (2014). *Bayesian Methods: A Social and Behavioral Sciences Approach (3rd Ed.)*. London: Chapman & Hall/CRC.
- Kaplan, D. (2014). *Bayesian Statistics for the Social Sciences*. New York, NY: Guildford Press.
- Levy, R., & Mislevy, R. J. (2016). *Bayesian Psychometric Modeling*. Boca Raton, FL: CRC Press.
- Lynch, S. (2007). *Introduction to Applied Bayesian Statistics and Estimation for Social Scientists*. New York, NY: Springer

Some of the reference books can be viewed online through the UMD library. Extra reading materials will be posted if necessary.

Course Delivery

The class meets every Monday from 4:15 to 7:00pm at EDU (Benjamin Bldg) 3233. Course slides and supplemental materials will be made available by 10am every Monday on the [ELMS Canvas system](#). An automatic email notification will be sent out by ELMS when new materials are posted.

Statistical Software

R and JAGS will be used in this course. There will not be lab sessions on statistical software; however, annotated code/output will be distributed.

The R software is free and easy to install on your own computer. It is currently maintained by the R Core development team. Students can download R at the home page of the R project (<http://www.r-project.org>). It is a flexible statistical computing environment that contains a wide variety of packages that allow students to do numerous mathematical and statistical operations ranging from data simulation to data analysis.

"Just Another Gibbs Sampler" (JAGS) is a program for Bayesian hierarchical modeling using MCMC simulation. It is efficient, supports major operating systems (e.g., Windows and Mac OS), and has an easy-to-use R interface. More information about JAGS can be found at <http://mcmc-jags.sourceforge.net>.

Course Assignment

Homework (60%) There will be **four homework assignments** throughout the semester, each of which is worth **15% of the final grade** and designed to give the students an opportunity to apply and practice the concepts and techniques learned in class. Students are expected to refer to materials from lecture, textbooks, and supplementary notes. Homework assignments must be completed **individually**.

The word-processed homework should conform as closely as possible to the **APA style** presentations of tables, graphics, and references. Students are expected to report statistical results as if it were going into a journal article or a thesis, and include the original software output as an appendix to show how they arrive at the solution. Please **do not just cut and paste all the software output** into the writing without necessary interpretation and formatting.

Please note that **late homework will not be accepted** unless pre-approval is given for exceptional circumstances. You are required to upload a typed document in pdf format on the specified due date of each assignment. Homework will be graded on a scale of **P (pass) or L (low pass)**. Getting P means receiving a full credit for the particular assignment. In case of an L grade, partial credit will be assigned depending on the level of completion.

Final Project (40%) The final project consists of an **in-class presentation (20%) and a paper submission (20%)**. Here are two options for the project: a) it can be more methodologically focused (studying and extending the current methodology), or b) it can be more applied (using the existing methodology to empirical data analysis). A short description of the project should be submitted by the due date (see the tentative schedule for more information), and **the topic must be approved by the instructor**. Students are welcome to discuss the project with the instructor during office hours or by appointment.

The final paper must be **typed** and follow as closely as possible to the **APA format**. The length of the paper should be **no more than 15 pages**. The grade will be determined based on both statistical analyses and writing. Detailed grading rubric and requirements about the in-class presentation will be provided later.

Grading Scheme

Table 1: Grading scheme

Letter grade	Percentage	Letter grade	Percentage
A+	98.00--100.00%	C+	75.00--77.99%
A	92.00--97.99%	C	72.00--74.99%
A-	88.00--91.99%	C-	68.00--71.99%
B+	85.00--87.99%	D+	65.00--67.99%
B	82.00--84.99%	D	62.00--64.99%
B-	78.00--81.99%	D-	58.00--61.99%
		F	0.00--57.99%

With exceptions of computational error, **grades will not be changed once they are posted**. The **incomplete grade is not an option for poor performance** in the course. Unless the student can provide very compelling reasons with proof documents, incomplete will not be given.

Tentative Schedule

Table 2: Tentative schedule (subject to change)

Week	Date	Topic	Due
1	1/24	Welcome and introduction	
2	1/31	Probability and statistical inference	
3	2/7	Conjugate priors	
4	2/14	Basic Monte Carlo methods	Homework 1
5	2/21	Importance sampling	
6	2/28	Markov chain Monte Carlo I	
7	3/7	Markov chain Monte Carlo II	Homework 2
8	3/14	Model selection I	Project description
9	3/21	Spring break, no class	
10	3/28	Model selection II	
11	4/4	Application I: (Generalized) linear models	Homework 3
12	4/11	Application II: Hierarchical linear models	
13	4/18	Application III: Latent variable/psychometric models	
14	4/25	NCME conference, no class	
15	5/2	Prior elicitation; objective Bayes	Homework 4
16	5/9	Final project presentation	
17	5/16	No class	Final paper

Course Procedures and Policies

Please visit <https://gradschool.umd.edu/course-related-policies> for a summary of course-related policies. See below for several points to emphasize.

Masking Requirement [University policy](#) requires that **masks be worn over the nose and mouth while indoors at all times, regardless of vaccination status**. There are no exceptions. Students not wearing a mask will be given a warning and asked to wear one, or will be asked to leave the classroom immediately. Students who have additional issues with the mask expectation after a first warning will be referred to the Office of Student Conduct for failure to comply with a directive of University officials.

Accommodations for emergency and email communication All students are expected to submit assignments and exams on the specified dates. You must contact the instructor ahead of time if re-scheduling is needed or delays are expected; otherwise, not being able to submit the assignment in time will result in a zero score for that assessment. The primary communication tool will be email in cases of emergency. Emergency deserves prompt replies, but last minute questions with respect to assignments might not be well taken. I strongly recommend that you should plan ahead to meet the deadlines properly.

Accessibility and Disability Services The University of Maryland is committed to creating and maintaining a welcoming and inclusive educational, working, and living environment for people of all abilities. The University of Maryland is also committed to the principle that no qualified individual with a disability shall, on the basis of disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of the University, or be subjected to discrimination. The [Accessibility & Disability Service \(ADS\)](#) provides reasonable accommodations to qualified individuals to provide equal access to services, programs and activities. ADS cannot assist retroactively, so it is generally best to request accommodations several weeks before the semester begins or as soon as a disability becomes known. Any student who needs accommodations should contact me as soon as possible so that I have sufficient time to make arrangements. For assistance in obtaining an accommodation, contact Accessibility and Disability Service at 301-314-7682, or email them at adsfrontdesk@umd.edu. Information about [sharing your accommodations with instructors](#), [note taking assistance](#) and more is available from the [Counseling Center](#).

Academic integrity The University of Maryland, College Park, has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible to uphold these standards for this course. It is imperative that you are aware of the consequences of **cheating, fabrication, facilitation, and plagiarism**. For more information on the code of Academic Integrity or the Student Honor Council, please see <http://www.president.umd.edu/policies/docs/III-100A.pdf>. Plagiarism and other forms of academic fraud are a violation of university regulations and unacceptable under any circumstance. These instances have to be and will be reported to the Honor Council in writing. Notes on plagiarism in this class: Due to the nature of reporting statistical results, some expressions are commonly used and should be phrased in the same/similar ways. However, how to approach a problem and end up with the solution is definitely a result of logic process, and this should not be stolen and used with proper citations.

Religious observances The University of Maryland policy on religious observances states that students not be penalized in any way for participation in religious observances. Students shall be allowed, whenever possible, to make up academic assignments that are missed due to such absences. However, they must contact the instructor **before the absence** with a written notification of the projected absence, and arrangements will be made for make-up work or examinations.

Student Resources and Services Taking personal responsibility for your own learning means acknowledging when your performance does not match your goals and doing something about it. I hope you will come talk to me so that I can help you find the right approach to success in this course, and I encourage you to visit [UMD's Student Academic Support Services](#) website to learn more about the wide range of campus resources available to you. In particular, everyone can use some help sharpening their communication skills (and improving their grade) by visiting [UMD's Writing Center](#) and schedule an appointment with the campus Writing Center. You should also know there are a wide range of resources to support you with whatever you might need ([UMD's Student Resources and Services website](#) may help). If you feel it would be helpful to have someone to talk to, visit [UMD's Counseling Center](#) or one of the many other [mental health resources on campus](#).

Basic Needs Security If you have difficulty affording groceries or accessing sufficient food to eat every day, or lack a safe and stable place to live, please visit [UMD's Division of Student Affairs website](#) for information about resources the campus offers you and let me know if I can help in any way.

Participation The classes will be composed of lectures and small group/class discussions. Each student's meaningful participation is very appreciated and will contribute to the entire learning process, promoting critical thinking skills. Throwing questions and bringing in topic-related problems to class are always welcomed.

Course Evaluation Please submit a course evaluation through CourseEvalUM in order to help faculty and administrators improve teaching and learning at Maryland. All information submitted to CourseEvalUM is confidential. Campus will notify you when CourseEvalUM is open for you to complete your evaluations for fall semester courses. Please go directly to the [Course Eval UM website](#) to complete your evaluations. By completing all of your evaluations each semester, you will have the privilege of accessing through Testudo, the evaluation reports for the thousands of courses for which 70% or more students submitted their evaluations.

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