Bayesian Statistics
Math 299, Fall 2018

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Office Hours:	Monday 12:00PM-2:00PM, Wednesday 1:00PM – 3:00PM, Thursday 1:00PM – 2:00PM, and by appointment
Class Hours:	Tuesday and Thursday 9:30AM -10:45AM
Room:	330 Swords Hall
Textbook:	*Doing Bayesian Data Analysis* by Kruschke
Reference Books:	*Bayesian Computation with R* by Albert [on reserve in the library] *A First Course in Bayesian Statistical Methods* by Hoff [on reserve in library] *Think Bayes* by Downey
Course Website:	Moodle
Prerequisites:	Math 220 (Statistics)

Welcome to Math 299: Bayesian Statistics! There are two main braches of statistics, frequentist and Bayesian. While most statistics courses take the frequentist perspective, this course will instead take a Bayesian approach to statistical inference. Due to advances in computing, Bayesian techniques have recently become quite popular, mainly because the calculations are now feasible to perform. Throughout the course, we'll be using R to work through a variety of Bayesian topics, from basic calculations to more advanced modeling. The course topics are meant to give you a taste of what is possible, while the final project will allow you to push the boundaries of what you have learned.

At the end of this course, you will be able to:

1) Use the statistical software package R to perform basic calculations and run more advanced functions written by other users.
2) Apply Bayes rule to a variety of different modeling scenarios
3) Create and run MCMC algorithms to solve higher dimension inference problems
4) See the similarities and differences in the Bayesian and frequentist perspectives
5) Use your statistical knowledge to create a model for a more in-depth, real-world problem

The course calendar that follows will briefly describe each of the topics that we will cover. The class will follow the textbook, *Doing Bayesian Data Analysis* by Kruschke, but there are also several topics that I covering from other books. When these come up, I'll try to indicate where in the reference books you can find these topics. Although not enforced, class attendance and reading of the designated sections of the text prior to class are highly recommended. The grade you earn will be a reflection of how well you have mastered the material in this course and will be based upon the following five criteria:

1) Homework (20%): Weekly homework assignments will be given. I truly believe that the only way to learn statistics (and mathematics, in general) is to *do* statistics. A majority of the problems will be drawn

from the book, although I may incorporate some of my own questions. You are permitted (an encouraged!) to work with your classmates on these assignments. However, each student is expected to turn in their own set of solutions. To receive full credit, solutions to homework assignments should be clearly written on the provided worksheet and have all relevant work organized in the proper sequence. Homework assignments will be due on Tuesdays by 5PM. Late homework assignments will not receive full credit and homework more than one day late will receive no credit.

2) Projects (15%): A small project will be assigned each week and due by the end of the day on Friday. The questions on each project will focus on the material covered in the homework assignment submitted that week and will resemble those seen on homework assignments, but will almost certainly be a little more in-depth and require the use of R to solve.

4) Two In-Class Exams (40%): There will be two in-class tests. The exams will not be exercises in memorization, but will try to be written so that students with a solid understanding of the concepts should have little, if any, trouble. The first exam is tentatively set for **Thursday October 3rd**, the second for **Tuesday November 20th**.

5) Final Project (25%): This course will have a final project rather than a final exam. Details about the final project will be forthcoming, but you can expect a group project that asks you create a model for an in-depth, real-world problem. Project presentations will take place during the regularly scheduled final exam period, which is set by the Registrar's office. Once this information becomes available, I will let you know. Unfortunately, there will be no make-ups or other alterations to the timing of the final presentations allowed.

Should you ever need help with this course, there are two great options available to you:

1) Ask a classmate for help
2) Stop by my office during office hours or make an appointment to see me

Additional Course Policies:

Academic Integrity: A student found cheating on an examination or assisting others in the course of an examination will receive an F for the course and will be subject to further sanctions. Copying another student's assignment is considered cheating and will result in receiving a 0 for that assignment. As previously stated, you are encouraged to work together on homework assignments. However, each student is expected to write out their own solutions. For more information, please see the College's Academic Honesty Policy, which can be found at https://www.holycross.edu/sites/default/files/files/registrar/academic_integrity_policy_0.pdf. Additionally, the Mathematics and Computer Science department has its own Academic Integrity policy that I will pass out for all of you to read and sign.

Information for Students with Disabilities: The College of the Holy Cross is committed to providing all students with equal access to learning. Any student who feels the need for accommodation based on the impact of a disability should contact the Office of Disability Services to discuss support services available. Once the office receives documentation supporting the request for accommodation, the

student would meet privately with Disability Services to discuss reasonable and appropriate accommodations. Then, with your permission, each instructor will receive a letter outlining the reasonable accommodations they are required to make. Once I have received this letter, you and I should meet to coordinate the way these will be implemented in this course. The Office of Disability Services can be reached by calling 508-793-3693 or by visiting Hogan Campus Center, room 215A. For more information, go to http://www.holycross.edu/health-wellness-and-access/office-disability-services

Cell Phones: Texting and/or playing games during class will hinder your ability to learn. As a deterrent, the first offense will be a warning, the second will result in dismissal from class for the day, and the third will result in a much longer suspension from class. In short, turn your cell phones off during class.

Calculators: A calculator is highly recommended but not required. You do not need to go out and buy a graphing calculator - a basic calculator will be sufficient for our course. Using your cell phone as a calculator is not permitted since phones are meant as communication devices (See Academic Integrity and Cell Phone policies above).

Grading: Final grades will be given according to the following percentage cutoffs. These cutoffs, although fairly strict, can be lowered (according to class performance), but not raised, no matter how well the class performs

Final Grade	Percentage
A	93 to 100
A-	90 to <93
B+	87 to <90
B	83 to <87
B-	80 to <83
C+	77 to <80
C	73 to <77
C-	70 to < 73
D+	67 to <70
D	63 to <67
F	0 to <63

Course Calendar (subject to change)

Date	Section	Topic	Notes
Aug 30 – R	K: 2.1-2.3	Syllabus Introduction to Bayesian Analysis	
Sept 4 – T	K: 3.1-3.4 A: 1.1-1.2, 1.5	Learning R	Course Survey
Sept 6 – R	K:3.5-3.9	Learning R	
Sept 11 – T	K: 4.1-4.2	Review of Probability	HMWK #1 Due
Sept 13 – R	K: 4.3-4.5	Discrete and Continuous Probability Distributions	
Sept 14 – F			Project #1 Due
Sept 18 – T	K: 5.1	Bayes Rule: Definition and Examples	HMWK #2 Due
Sept 20 – R	K: 5.2-5.4	Bayes Rule: More Examples Bayes Rule: Prior and Posterior Probabilities	
Sept 21 – F			Project #2 Due
Sept 25 – T	K: 6.1	Types of Prior Distributions	HMWK #3 Due
Sept 27 – R	K: 6.2-6.5 A: 2.1-2.6	Single Parameter Models: Binomial	
Sept 28 – F			Project #3 Due
Oct 1 – T	A: 3.3, H: 3.2	Single Parameter Models: Poisson and Exponential	
Oct 3 – R		**Exam #1**	
Oct 6-14		**Fall Break – No class!**	
Oct 16 – T	H: 4.1-4.2	Monte Carlo Approximation of the Posterior	
Oct 18 – R	H: 4.3 A: 6.1-6.2	Posterior Prediction of a Future Value Random Walks	
Oct 23 – T	K: 7.1-7.3 A: 6.3	The Metropolis Algorithm	HMWK #4 Due
Oct 25 – R		The Metropolis Algorithm in Higher Dimensions	
Oct 26 – F			Project #4 Due
Oct 30 – T	K: 7.4-7.5 A: 6.4-6.5	Gibbs Sampling Properties of MCMC Algorithms	HMWK #5 Due
Nov 1 – R	H: 5.1-5.3	Multi-parameter Models: The Normal distribution	
Nov 2 – F			Project #5 Due
Nov 6 – T	A: 4.3-4.4	Multi-parameter Models: The Multinomial	HMWK #6 Due
Nov 8 – R			
Nov 9 – F	K: 9.1-9.3	Hierarchical Modeling	Project #6 Due
Nov 13 – T	K: 9.1-9.3	Hierarchical Modeling, cont.	HMWK #7 Due
Nov 15 – R	K:10.1-10.6	Model Comparison and Hierarchical Models	
Nov 16 – F			Project #7 Due
Nov 20 – T		**Exam #2**	
Nov 21 – 25		**Thanksgiving Break – No Class!**	
Nov 27 – T	A: Ch 8	Bayesian Hypothesis Testing	
Nov 29 – R	K:11.1-11.5	More General Hypothesis Testing	
Dec 4 – T	K:12.1-12.4	Hypothesis Testing, cont.	HMWK #8 Due
Dec 6 – R	K: Ch 15 A: Ch 9	A Bayesian Approach to Regression Model Selection, Comparison, and Averaging	**Last Day of Class**
Dec 7 – F			Project #8 Due

Project Presentations: TBA [On or before Saturday December 15th]

Note: K = Kruschke Book A = Albert Book H = Hoff Book