

## SML 2XX: Bayesian Analysis

Instructor: Derek Sollberger (dsollberger@princeton.edu)

**Course Description:** This course provides an introduction to Bayesian analysis, a powerful statistical framework for making inferences and modeling uncertainty in a wide range of applications. Students will **learn** the fundamental principles of Bayesian statistics, including probability theory, Bayesian inference, and **the practical application of Bayesian modeling**. The course will cover both the theory and hands-on implementation using statistical software **R**.

**Prerequisites:** **Maybe rewrite this sentence a bit?**

- Basic knowledge of probability distributions (binomial, normal) **One semester of calculus or discuss with the course instructor.**
- Understanding of statistical concepts (sampling, confidence intervals)
- Proficiency in a statistical software package (~~e.g., R or Python~~) is ~~recommended but not~~ required

**Course Learning Outcomes:** By the end of this course, students will be able to:

1. Understand the foundational principles of Bayesian analysis and probability theory
2. Apply Bayesian techniques for parameter estimation and regression models
3. Create and interpret Bayesian models for various types of data
4. Effectively communicate results and conclusions from Bayesian analyses
5. Gain practical experience using Bayesian analysis software

**Assessment** The course grades will be calculated by the following weights:

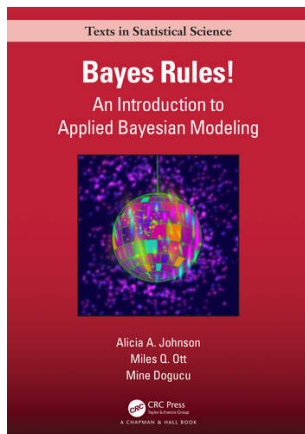
- Before-Lecture Quizzes (10%) **Projects? Problem sets? Do you know how many?**
- Computer Programming (25%)
- Written Summaries (10%) **What is this?**
- Project Benchmarks (10%)
- Progress Presentation (10%) **55% for one project? What will the students do?**
- Final Presentation (10%)
- Final Project (25%)

**Important Dates:**

- January 29: Spring term classes begin      **You do not need this section.**
- February 9: Undergraduate deadline to add/drop courses without a fee
- March 4 to 8: Spring midterm examination week
- March 9 to 17: Spring Recess
- March 18: Undergraduate selection of P/D/F begins
- April 5: Undergraduate deadline to drop Spring courses or select P/D/F
- April 26: Last day of scheduled classes
- May 10 to 16: Spring term final examinations

**Textbook:**

- Title: *Bayes Rules!*
- Authors: Alicia A Johnson, Miles Q Ott, Mine Dogucu
- Online version: <https://www.bayesrulesbook.com/>



**The level of this book seems to be a bit elementary. It will be good to take a look at Andrew Gelman's book:**  
<http://www.stat.columbia.edu/~gelman/book/BDA3.pdf>

**You don't need to use Gelman's book, but it might give a different perspective**

## Calendar and List of Topics:

Can you add in the precept topics?

Which topics do you think the students will be most excited about? Why?

How long are these presentations? What do they present?

How many students do you expect to admit into the course?

Week	Date	Topic	Textbook Chapter	Project Benchmark
1	Jan 30	Conditional Probability	1	
1	Feb 1	Bayes' Rule	2	Software Installation
2	Feb 6	Beta-Binomial Model	3	
2	Feb 8	Balance and Sequentiality	4	Topic Proposal
3	Feb 13	Conjugate Families	5	
3	Feb 15	Approximating the Posterior	6	Data Search
4	Feb 20	MCMC	7	
4	Feb 22	MCMC	7	Explore Data
5	Feb 27	Posterior Inference	8	
5	Feb 29	Posterior Prediction	8	
6	Mar 5	<b>Progress Presentations</b>		
6	Mar 7	<b>Progress Presentations</b>		
	Mar 12	<i>Spring Recess</i>		
	Mar 14	<i>Spring Recess</i>		
7	Mar 19	Normal Regression	9	
7	Mar 21	Evaluating Regression Models	10	Grammar of Tables
8	Mar 26	Extension of Normal Regression	11	
8	Mar 28	Poisson and Negative Binomial	12	rstan
9	Apr 2	Logistic Regression	13	
9	Apr 4	Naive Bayes Classification	14	
10	Apr 9	Hierarchical Models without Predictors	15, 16	
10	Apr 11	Hierarchical Models with Predictors	17	
11	Apr 16	Non-Normal Hierarchical Models	18	
11	Apr 18	Extension of Hierarchical Models	19	
12	Apr 23	<b>Final Presentations</b>		
12	Apr 28	<b>Final Presentations</b>		

Do the students work on a semester-long project? If so, what do they do?

Can you add in the assignment due dates? What topics will they be on?

What will the precepts cover each week?

The more details you give, the better.

Again, have a look at Gelman's book. It be helpful to give you an idea on what applications to cover

**Disclaimer:** Due to the adaptive nature of the course and learning environment, this document is subject to change.

**Class policies:**

1. Lecture sections: Please keep extra noise to a minimum. Cell phones may be used as long as they are on silent or vibrate. This is a lot in Princeton's standard. I am worried that it will discourage some students from taking the course. Will 80 minutes enough?
- Precepts 2. ~~Discussion sections~~ will be held for ~~2 hours~~ each week. Students will develop problem-solving skills through group work on the before lecture, computer programming, and written assignments.
3. Computers: UC Merced students are strongly encouraged to have a laptop computer. Recommended minimum laptop specifications can be found at:  
<https://it.ucmerced.edu/student-laptop-recommendation>.  
 (Note: Chromebooks are not recommended.) ~~Additional financial aid funds may be available to assist students with the cost of purchasing a laptop. Students may request a Cost of Attendance Adjustment for a one-time \$1,200 computer purchase. More information about Cost of Attendance Adjustment can be found at: <https://financialaid.ucmerced.edu/coa-adjustment>. Information about open access computer labs is at [https://it.ucmerced.edu/computer\\_labs](https://it.ucmerced.edu/computer_labs)~~
4. ~~Special Accommodations: University of California, Merced is committed to creating learning environments that are accessible to all. If you anticipate or experience physical or academic barriers based on a disability, please feel welcome to contact me privately so we can discuss options. In addition, please contact Student Accessibility Services (SAS) at (209) 228-6996 or [access@ucmerced.edu](mailto:access@ucmerced.edu) as soon as possible to explore reasonable accommodations. All accommodations must have prior approval from Student Accessibility Services on the basis of appropriate documentation.~~  
~~If you anticipate or experience barriers due to pregnancy, temporary medical condition, or injury, please feel welcome to contact me so we can discuss options. You are encouraged to contact the Dean of Students<sup>1</sup> for support and resources at (209) 228-3633 or <https://studentaffairs.ucmerced.edu/dean-students>.~~
5. Academic Integrity: Academic integrity is the foundation of an academic community and without it none of the educational or research goals of the university can be achieved. All members of the community are responsible for its academic integrity. Existing policies forbid cheating on examinations, plagiarism and other forms of academic dishonesty. ~~The UC Merced Academic Honesty Policy The UC Merced Academic Honesty Policy can be found on the Student Conduct website. Infractions against academic integrity will incur consequences such as an "F" on the assignment/exam and/or a report to the Academic Senate.~~  
~~Lecture and gateway courses have challenges with "homework help" sites like Chegg, Course Hero, and Koofers (to name a few) where course materials including tests and assignments are be posted by students as study guides and ultimately constitute cheating.<sup>2</sup>~~

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<sup>1</sup><https://access.ucmerced.edu/faculty-staff/syllabus-statement>

<sup>2</sup><http://studentconduct.ucmerced.edu/>

**Inclusion and Diversity:** I value all students regardless of their background, country of origin, race, religion, ethnicity, gender, sexual orientation, disability status, etc. and am committed to providing a climate of excellence and inclusiveness within all aspects of the course. If there are aspects of your culture or identity that you would like to share with me as they relate to your success in this class, I am happy to meet to discuss. Likewise, if you have any concerns in this area or facing any special issues or challenges, you are encouraged to discuss the matter with me (set up a meeting by e-mail) with an assurance of full confidentiality (only exception being mandatory reporting of academic integrity code violations or sexual harassment).<sup>3</sup>

### **Pep Talk!**

Learning R can be difficult at first—it is like learning a new language, just like Spanish, French, or Chinese. Hadley Wickham—the chief data scientist at RStudio and the author of some amazing R packages you will be using like `ggplot2`—made this wise observation:

It's easy when you start out programming to get really frustrated and think, "Oh it's me, I'm really stupid," or, "I'm not made out to program." But, that is absolutely not the case. Everyone gets frustrated. I still get frustrated occasionally when writing R code. It's just a natural part of programming. So, it happens to everyone and gets less and less over time. Don't blame yourself. Just take a break, do something fun, and then come back and try again later.

If you are finding yourself taking way too long hitting your head against a wall and not understanding, take a break, talk to classmates, ask questions ... e-mail me, etc.

I *promise* you can do this.<sup>4</sup>

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<sup>3</sup>This inclusion statement was written by chemistry professor Dr. Steve Zimmerman at the University of Illinois at Urbana-Champaign <https://mobile.twitter.com/steveczimmerman/status/1161019135251353606>

<sup>4</sup>This pep talk comes from data science instructor Andrew Heiss at Georgia State University. Source: <https://mobile.twitter.com/andrewheiss/status/1165310391750189063>