# EPSY 580I – BAYESIAN INFERENCE

# COURSE SYLLABUS

## INSTRUCTOR INFORMATION

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Wham 222H (NOTE: mail address is Wham 223)

## COURSE INFORMATION

**Course Time & Location**: Tuesday, 1 – 2:50 PM; Wham 226

**Texts:** Bolstad, W. M. (2007). *Introduction to Bayesian statistics* (2nd ed.). Hoboken, NJ: Wiley. (ISBN: 9780470141151)

Kruschke, J. K. (2011). *Doing Bayesian data analysis: A tutorial with R and BUGS.* New York: Academic Press /Elsevier Science. (ISBN: 9780123814852)
Website: http://www.indiana.edu/~kruschke/DoingBayesianDataAnalysis/

**Computer Program:** We will be using R, a powerful (free) statistical graphics and computing language, and JAGS, an open-source, cross-platform engine for Bayesian data analysis that can be accessed from within R. We will also look at programming in R and Matlab to implement Bayesian estimation.

**Course Website:** D2L http://online.siu.edu (course-related materials will be posted on this web site)

## COURSE GOAL AND OBJECTIVES

This is a graduate seminar course intended as a first introduction to Bayesian inference. The course will review relevant theoretical background and introduce the Bayesian approach to data analysis (including choice of prior distributions and calculation of posterior distributions) with an emphasis on practical applications to inference problems in social and behavioral sciences. R with JAGS, software package that implements MCMC, will be introduced and used in most Bayesian computations. Topics to be discussed include: Bayes' Theorem; prior distributions; inferences for discrete random variables and binomial proportion; inferences for continuous random variable and normal means; linear regression; analysis of variance; MCMC/Gibbs sampler; and model evaluation/comparison.

Prerequisites for EPSY 580I include course work or background experience in statistics (e.g., EPSY 506, EPSY 507). While not necessary, most students will find it helpful to also have knowledge and experiences related to matrix algebra, calculus, statistical computing and/or analysis of variances (e.g., EPSY 508).

## Computer Software

Statistical programming and computing are crucial to modern Bayesian inference. We will use extensively the R statistical computing environment. Please download the most current version of R from http://www.r-project.org. I highly recommend RStudio, a free R add-on that is available at http://rstudio.org, and can be used with both Mac and Windows operating systems. Useful references for R are "An Introduction to R," which can be downloaded at http://cran.r-project.org/doc/manuals/R-intro.pdf and the book "An R and S-Plus Companion to Applied Regression" by John Fox. A large part of the instruction in the course will also involve how to use the JAGS (Just Another Gibbs Sampler), which is available at http://mcmc-jags.sourceforge.net. The R package "rjags" enables complete integration of

JAGS into R. Matjags provides a Matlab interface for JAGS

**OVERVIEW OF COURSE REQUIREMENTS**

| Course Requirements: | % of Grade |
|---|---|
| Homework | 30% |
| Take-home Mid-term Exam | 30% |
| Project | 30% |
| Class participation | 10% |

Homework: Problems will be assigned regularly to be turned in and graded. The assignments are due as specified in class, and should be submitted on time for full earned credit. The assignments will be graded on a scale of 0 to 10. You may resubmit homework sets that receive 5 or less than 5 points. Any late assignment can receive no more than 8 points. It is the responsibility of the student to work all of the assigned homework problems independently (which means by yourself, on your own). However, you can always come and ask me if you have questions regarding the homework. The experience gained from doing these problems is necessary for the understanding of the material we shall be covering.

A project will be required. The project will be a research proposal for an application of item response theory that is in the format of the American Educational Research Association (AERA) proposal (i.e., maximum of 2,000 words or 3 pages). Specifications of the AERA proposal and sample proposal copies will be distributed later. The due date of the project is May 8.

Grading: Letter grades will be assigned as indicated below.

| Letter Grade | Percent Grade |
|---|---|
| A | 90-100 |
| B | 80-89 |
| C | 70-79 |
| D | 60-69 |
| F | 0-59 |

Course Drop Policy

Students are permitted "a maximum of 6 credit hours or 50% of total semester enrollment of dropped courses during any given semester with a maximum of 12 credit hours of dropped courses over 60 hours of enrollment. Exceptions to this policy must be approved in writing by the Office of the Provost and Vice Chancellor for Academic Affairs. For the purposes of this policy, a dropped course is defined as any course dropped after the official date for receiving a full refund."

Incomplete Coursework

"An *INC* is assigned when, for reasons beyond their control, students *engaged in passing work* are unable to complete all class assignments. An INC must be changed to a completed grade within one semester following the term in which the course was taken, or graduation, whichever occurs first. Should the student fail to complete the course within the time period designated, that is, by the end of the semester following the term in which the course was taken or graduation, whichever occurs first, the incomplete will be converted to a grade of F and the grade will be computed in the student's grade point average." (*Graduate Catalog*, http://registrar.siu.edu/records/incgrade.htm)

**COURSE CURRICULUM BY EACH WEEK (Tentative)**
**The order or coverage of these topics may change as we move through the semester!**

| Week | Topics & Reading Assignment | Bolstad | Kruschke |
|---|---|---|---|
| 1 | Introduction. Probability. R | Chapter 1 | Chapters 1-3 |
| 2 | Bayes' theorem | Chapter 4 | Chapter 4 |
| 3 | Bayesian theorem with discrete variables | Chapters 5, 6 | |
| 4 | Bayesian inference for binomial proportion | Chapters 7, 8 | Chapter 5, 6 |
| 5 | Normal distribution | Chapter 11 | Chapter 15 |
| 6 | Markov chain Monte Carlo | | Chapters 7, 8 |
| 7 | Hierarchical models | | Chapter 9 |
| 8 | Simple linear regression | Chapter 14 | Chapter 16 |
| 10 | One-way ANOVA | Chapter 13 | Chapter 18 |
| 11 | Model comparison | | Chapter 10 |
| 12 | Bayesian approach to significance test | | Chapters 11, 12 |
| 13 | Multiple regression | | Chapter 17 |
| 14 | Logistic regression | | Chapter 20 |
| 15 | Factorial ANOVA | | Chapter 19 |
| 16 | Contingency table | | Chapter 22 |

**UNIVERSITY REQUIRED STATEMENTS**

Statement for Academic Dishonesty
Academic dishonesty is fundamental to the activities and principles of a university. All members of the academic community must be confident that each person's work has been responsibly and honorably acquired, developed, and presented. Any effort to gain advantage not given to all students is dishonest whether or not the effort is successful. The academic community regards academic dishonesty as an extremely serious matter, with serious consequences that range from probation to expulsion. When in doubt about plagiarism, paraphrasing, quoting, or collaboration, consult the course instructor.

Statement for ADA
If you have a disability and need accommodations (for example, extended testing time, note taking, large print materials), please inform your instructor privately as soon as possible. In most circumstances, students with disabilities seeking academic accommodations should also contact the Disability Support Services (DSS) office, Woody Hall B-150, 618/453-5738. As necessary, the DSS Office will review documentation about your disability and about the need for accommodations you are requesting. The DSS Office will then assist in planning for any necessary accommodation.

**Other Suggested Readings:**

Bolstad, W. M. (2007). *Introduction to Bayesian Statistics*. New York: Wiley. (A nice introduction into the statistical theory of Bayesian inference.)

Gill, J. (2007). *Bayesian Methods: A Social and Behavioral Sciences Approach* (2nd ed.). Boca Raton: Chapman & Hall. (A solid discussion of Bayesian inference and its computational aspects but not for the faint of heart.)

Carlin, B., and Louis, T. (2008). *Bayesian Methods for Data Analysis* (3rd ed.). New York: Chapman & Hall. (Formal text with theoretical and detailed discussions of Bayesian data analysis.)

Gelman, A., Carlin, J., Stern, H., and Rubin, D. (2003). *Bayesian Data Analysis* (2nd ed.). New York: Chapman & Hall. (Another formal text with theoretical and detailed discussions of Bayesian inference.)

Howson, Colin, and Urbach, Peter. (2005). *Scientific Reasoning: The Bayesian Approach*. Chicago: Open Court. (A nice discussion of Bayesian inference from a philosophy of science perspective.)

Jackman, Simon. (2009). *Bayesian Analysis for the Social Sciences*. New York: Wiley. (A comprehensive discussion of applications with JAGS code. Some chapters are quite complex though and probably not well-suited for beginners.)