# Statistics 625 -- Applied Bayesian Analysis
# Department of Statistics, Winter Quarter 2008
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## Rationale

This course is intended to introduce Masters-level students to various aspects of applied Bayesian analysis. In the last decade and a half, Bayesian statistics has gained popularity in the statistical community due to the development of computational techniques that allow effective and general model-fitting strategies within the Bayesian statistical paradigm. A consequence of this movement is that Bayesian statistics is no longer suited for study solely at the advanced Ph.D.-level, but is also relevant to Masters students in that it provides practical procedures for analyzing complex phenomena. In addition, as Bayesian analyses increase in popularity, this course hopefully will draw students from a variety of fields of study who are seeking to learn state-of-the-art statistical procedures to apply in their own research.

## Course Overview

This course aims to provide a practical introduction to Bayesian data analysis. Students will be exposed to a variety of Bayesian models including the Bayesian linear model for normal and non-normal data. Bayesian hierarchical modeling will be discussed as a strategy for modeling complex processes and as a means of assimilating a variety of sources of data, and students will be required to complete a project in which they fit a hierarchical model to data. Simulation-based methods for modeling-fitting will be introduced, and students will learn to use the WinBUGS software in addition to programming basic MCMC algorithms in R.

## Topics

1. Introduction
    - Conditional probabilities and Bayes' Theorem
    - Brief overview of the differences between classical and Bayesian statistics
    - Full probability models
    - Prior and posterior distributions
    - Probabilities as measures of uncertainty (e.g., credible intervals and posterior probabilities)
2. Bayesian Modeling
    - Examples (e.g., normal, binomial, and Poisson data)
    - Conditional modeling
    - The Bayesian regression model
    - Linear models for non-normal data (GLM)
    - Incorporating prior information into models
3. Hierarchical Modeling
    - Parameterized prior distributions
    - Exchangeability and model specification
    - Examples using normal data

4. Bayesian Computation
    - Summarizing distributions using simulation
    - Markov chain Monte Carlo (MCMC) algorithms, including Gibbs and Metropolis-Hastings algorithms
    - Software (WinBUGS and/or other MCMC software)
5. Special topics (to be covered if time permits)
    - Bayesian model selection and model averaging
    - Bayesian experimental design
    - Large sample inference / normal approximations to posterior distributions

**Prerequisites**

Statistical Theory (Stat 520 and 521, Stat 610 and 623, or Stat 620 and 621) and Applied Regression Analysis (Stat 645), or permission of the instructor

**Evaluation**

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| Homework | 40% |
| Midterm Exam | 30% |
| Project | 30% |

**Computing**

The homework assignments and project require the use of the R statistical computing package and the Bayesian Inference Using Gibbs Sampling (WinBUGS) software, which are both freely available. No prior knowledge of these computing packages is required, although experience with R will be helpful.

**Required Textbook**

Gelman, A., Carlin, J., Stern, H., and Rubin, D. (2004) "Bayesian Data Analysis, 2nd Ed.", Chapman & Hall.

**Supplemental Material**

Online R Manual - http://cran.r-project.org/doc/manuals/R-intro.pdf

Venables, W.N. and Smith, D.M. (2004) *An Introduction to R, Notes on R: A Programming Environment for Data Analysis and Graphics, Version 2.0.1*.

Online WinBUGS Manual - http://www.mrc-bsu.cam.ac.uk/bugs/winbugs/manual14.pdf

Spiegelhalter, D., Thomas, A., Best, N., Lunn, D. (2003) *WinBUGS User Manual, Version 1.4*.