# Course Information SDS 386D: Monte Carlo Statistical Methods
# Unique number: 57530 Spring 2015

**Instructor.** Peter Müller. My office is R.L.M 11.174. I will hold office hours from 4-5 on Monday and Wednesday. If you cannot make my office hours and would like to come by, please make an appointment with me. My office telephone is 471-7168.

**Prerequisites.** Graduate standing, knowledge of mathematical statistics as well as basic coding skills (ideally R, or Matlab or something equivalent). Some prior knowledge of Bayesian inference is needed. (At the level of Peter Hoff's book – see below). The course will start with a brief review of Bayesian inference (see the textbook below).

For a quick self-test, whether this class is right for you: Do you know

- Bayesian inference? Do you know how to do posterior inference in a normal linear regression? In a hierarchical model?
- Basic probability? Do you know what a Markov chain is?
- Some basic computation, ideally in R (or matlab or anything equivalent). The class will not be about computation, but you will need it for homeworks. Can you program an iterative loop, functions (macros)?

**Text.** The main textbook for the course is

> Dani Gamerman and Hedibert F. Lopes, "*Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference,"* Chapman & Hall/CRC Texts in Statistical Science.

The class will cover more material and some more detail than the book. But the book is an excellent reference and overview. As additional text and reference for Bayesian inference we will use

> P. Hoff, *"A First Course in Bayesian Statistical Methods",* Springer-Verlag.

available as e-book at UT Libraries – for $25 you can ask them to print your personal copy. See http://www.springer.com/librarians/e-content/mycopy?SGWID=0-165802-0-0-0 for instructions. I also recommend reading the excellent (public domain) lecture notes for a recent short course by

> Ioana A. Cosma and Ludger Evers, "*Markov Chain Monte Carlo Lecture Notes",* http://users.aims.ac.za/~ioana/

**Course Grading and Exams.** There will be 3 midterm exams, each counting 25% of the course grade.

- Exam 1 will be on We, Mar 4 (tentative)
- Exam 2 will be in We, Apr 1 (tentative).
- Exam 3 will be in We, Apr 22 (tentative).

(Dates to be confirmed in the first class). All three midterms will be take-home. All three are likely to involve some computation (nothing fancy – R programming should do).

Homework problems will count for the remaining 25% of the course grade. There will be one problem set approximately every two weeks.

**Homework.** Homework problems will be assigned throughout the semester. Problems will involve sometimes heavy computational work. The use of R is recommended, but not required.

**Group work.** Students are encouraged (but not required) to work on homeworks in groups. Please hand in one assignment with all group member names. No need to register groups besides simply putting the names on the assignment. You can change groups at any time.

**Website.** Please visit the canvas site for this course

https://utexas.instructure.com/courses/1136020

Homework assignments will be posted there.

**Students with disabilities.** Please notify me of any modification/adaptation you may require to accommodate a disability-related need. You will be requested to provide documentation to the Dean of Students Office, in order that the most appropriate accommodations can be determined. Specialized services are available on campus through Services for Students with Disabilities.

## Week by week outline

In this class we will discuss simulation-based methods to implement Bayesian statistical inference, with an emphasis of Markov chain Monte Carlo methods. Therefore the important prerequisites for the class are

- You should know some Bayesian inference. Well, you need not be experts. But you should be able to describe how a posterior distribution summarizes an inference problem, and why posterior simulation is important.
- You should know some basic probability. At least you should know how to define a Markov chain. No worries -I don't expect that you remember all details about classifying states etc :-)
- You should be familiar with some basic computation, ideally with R (a statistical programming language). Matlab is fine too. The class is not about programming, but you will need to know enough to implement simple algorithms for homework problems etc.

## Text book:

- MCMC, by Gamerman & Lopes
- A First Course in Bayesian Statistical Methods -Hoff (H)

GL will be our main reference
H is a good review of Bayes, but no need to buy it for the course.

## List of topics to be covered

As we proceed, I will put dates on the topics.

### Weeks 1-2: Jan 21, 26/28:

1. **Review of Bayesian inference H:** chapters 3,5,7
2. **Bayesian Regression H:** ch 9, 11

### Week 3: Feb 2/4

1. **Monte Carlo Integration GL:** Ch 3

### Week 4: Feb 9/11

1. **Metropolis-Hastings GL:** Ch 6

### Week 5: Feb 16/18

1. **Gibbs GL:** Ch 5

### Week 6: Feb 23/25

1. **Convergence**

### Week 7: Mar 2/4

1. **Transdimensional MCMC :** Pseudo priors: Carlin & Chib (1995, JRSSB) RJ MCMC: Green (1995 Biometrika)
2. Mar 4: Midterm 1

### Week 8: Mar 9/12

1. Catch up…

### Week 9: Mar 23/25

1. **MCMC in nonparametric Bayes models,** MAD Bayes (if time permits...)

### Week 10: Mar 30/Apr 1

1. **Approximate Bayesian Computation (ABC):** Marin et al. (2011 Stat & Computing)
2. April 1: Midterm 2

### Week 11: Apr 6/8

1. **Hybrid Monte Carlo**

### Week 12: Apr 13/15

1. **Exact approximate methods**

### Week 13: Apr 20/22

1. **Test of fit:** DIC: Spiegelhalter et al. (2002, JRSSB) Chi-square TOF: Johnson (2004, Annals of Stat) Convergence diagnostics

### Week 14: Apr 27/29

1. **Particle filter:** dynamic Monte Carlo
2. Apr 29: Midterm 3

### Week 15: May 4/6 catch up…

1. May 6: last class