OFFICIAL SYLLABUS

STAT 575 – Statistical Computing

(Adopted Summer 2010: Committee Rigdon, Sewell)

Catalog Description: Numerical methods for statistical analysis. Numerical linear algebra for multiple regression. Unconstrained optimization for approximation of maximum likelihood estimates. Numerical integration and function approximation. Prerequisites: STAT 480a,b; MATH 465; 466.

Textbook: *Computational Statistics, Geof H. Givens and Jennifer Hoeting,* Wiley: New York.

Course Outline and Topics:

Numerical Linear Algebra (Notes, not in text; review of 321 and 466 - numerical linear algebra)

Linear Regression Analysis (Notes, not in text)

Chapter 2 Optimization and Solving Nonlinear Equations

- 2.1 Univariate problems
  - 2.1.1 Newton's method
  - 2.1.2 Fisher scoring
  - 2.1.3 Secant method
  - 2.1.4 Fixed-point iteration
- 2.2 Multivariate problems
  - 2.2.1 Newton's method and Fisher scoring; iteratively reweighted least squares
  - 2.2.2 Newton-like methods
  - 2.2.3 Gauss-Newton method
  - 2.2.4 Nonlinear Gauss-Seidel iteration

Chapter 4 EM Optimization Methods

- 4.1 Missing data, marginalization, and notation
- 4.2 The EM algorithm
  - 4.2.1 Convergence
  - 4.2.2 Use in exponential families
  - 4.2.3 Variance estimation*
- 4.3 EM Variants*

Chapter 5 Numerical Integration

- 5.1 Newton-Côtes (Riemann, trapezoidal, Simpson's rules)
- 5.2 Romberg integration
- 5.3 Gaussian quadrature
- 5.4 Frequently encountered problems (range of integration, singularities, multiple integrals)

Chapter 6 Simulation and Monte Carlo Integration

- 6.1 Introduction to the Monte Carlo method
- 6.2 Simulation

6.2.1 Generating from standard parametric families
6.2.2 Inverse CDF
6.2.3 Rejection sampling
6.2.4 Sampling importance resampling algorithm
6.3 Variance reduction techniques*
6.3.1 Importance sampling*
6.3.2 Antithetic sampling*
6.3.3 Control variates*
6.3.4 Rao-Blackwellization*

Chapter 7 Markov Chain Monte Carlo
7.1 Metropolis-Hastings algorithm
7.1.1 Independence chains
7.1.2 Random walk chains
7.1.3 Hit-and-run algorithm*
7.1.4 Langevin Metropolis-Hastings algorithm*
7.1.5 Multiple-try Metropolis-Hastings algorithm*
7.2 Gibbs sampling
7.2.1 Basic Gibbs sampler
7.2.2 Properties of the Gibbs sampler
7.2.3 Update ordering
7.2.4 Blocking*
7.2.5 Hybrid Gibbs sampling*
7.3 Implementation
7.3.1 Ensuring good mixing and convergence
7.3.2 Practical implementation

Chapter 9 Bootstrapping
9.1 The bootstrap principle
9.2 Basic methods
9.2.1 Nonparametric bootstrap
9.2.2 Parametric bootstrap
9.2.3 Bootstrapping regression
9.2.4 Bootstrap bias correction*
9.3 Bootstrap inference
9.3.1 Percentile method
9.3.2 Pivoting
9.3.3 Hypothesis Testing

Any instructor should cover all of the material specified, except the starred chapters (also in gray font) which are optional.