564 - Stochastic Methods
Michelmas Term - 2013-2014
EXAM REVIEW TOPICS

- Mathematical Background:
  - Single and multi-variable calculus
  - Linear Algebra
  - Basic Combinatorics
- Probability:
  - sample space, probability
  - conditional probability, Bayes' Theorem
  - Discrete and continuous random variables
  - Probability function, probability density function
  - Mean, Variance, Covariance
  - Distributions: Uniform, Gaussian, Exponential, Binomial, Poisson, Geometric
- Statistics:
  - The Central Limit Theorem
  - standard error, error propagation
  - statistical significance
  - Hypothesis testing: the χ^2 test
  - Resampling techniques: jackknife and bootstrap
- Random number generation:
  - Pseudo-random number generation
  - The linear congruential generator: period
  - RNG tests: The 'Birthday', 'Parking Lot', and 'Spectral' tests
  - Generating discrete random variables:
    - Discrete inverse transform method
    - Finite number of choices with arbitrary probabilities
    - Poisson, geometric, binomial
  - Generating continuous random variables:
    - Continuous inverse transform

    - uniform, exponential, cauchy distributions
    - Box-Muller and Marsaglia (polar) methods for gaussian.

- Monte Carlo integration:
  - Integrals as expectation values of random variables
  - variance reduction
  - Importance sampling
  - control variates
  - stratified sampling: MISER and VEGAS
- Markov Chain Monte Carlo:
  - Markov property, Homogeneous Markov Chain, Markov matrix
  - stochastic and doubly-stochastic Markov matrices
  - stationary states
  - n-step transition probabilities
  - first visit probability, total visit probability
  - mean first passage time, mean recurrence time
  - classification of states: positive recurrent, null recurrent, transient
  - accessibility, communication, classes, irreducible
  - period, aperiodic, ergodic
  - fundamental limit theorem, thermalization, equilibrium
  - autocovariance, autocorrelation, integrated autocorrelation time
  - Modified central limit theorem, modified variance.
  - reversibility, detailed balance
  - Metropolis-Hastings algorithm: proposal matrix, acceptance matrix
  - Gibbs sampler (Heatbath)
  - The Ising model: Metropolis and Gibbs sampler
  - Generalizations: Potts, O(N), scalar models
  - Hybrid Monte Carlo: trajectory length, step size
  - Reversible integrators, Leapfrog