



## ENU 6937 MONTE CARLO METHODS (Fall 2005)

**Description:** This is a general course on the Monte Carlo Methods used for simulation of physical processes. The course uses simple particle transport concepts to demonstrate various methodologies and examine associated issues. The topics covered include: random processes; random number generation techniques and testing; fundamental formulation of Monte Carlo (FFMC); various sampling procedures; fundamentals of probability and statistics as needed for MC simulations; non-analog or variance reduction techniques; various tallying procedures; representation of physical models based on combinatorial geometry; solving integral formulations via MC; importance sampling and the use of importance function; use of MC for eigenvalue problems; MC methods in parallel and vector environments; and use of MC for simulation of various real-life applications.

### Outline

Chapter 1 - Introduction

Chapter 2 – Random Processes

Chapter 3 - Fundamental Formulation of Monte Carlo (FFMC)

Chapter 4 - Sampling Procedure

Chapter 5 - Random Number Generation

Chapter 6 – Examples of Analog Monte Carlo Simulation

Chapter 7 - Fundamentals of Statistics

Chapter 8 – Non-Analog Monte Carlo Methods, "Variance Reduction Techniques for Basic Physical Processes"

Chapter 9 - Energy-Dependent Neutron-Nucleus Interactions in Monte Carlo Simulations

Chapter 10 – Tallying/Scoring

Chapter 11- Geometry, Model Representation

Chapter 12 - Integrals and Associated Variance Reduction Techniques

Chapter 13 - Monte Carlo Methods for Criticality or Eigenvalue Problems

Chapter 14 - Vector and Parallel Processing of Monte Carlo Methods

## Chapter 15 - Analysis/Discussion of Recent Applications of the Monte Carlo Methods and Monte Carlo Machine

### **Text**

#### **Required:**

Lecture notes, A. Haghghat (see above outline)

#### **Optional:**

- Monte Carlo Methods (Vol. I: Basics), M.H. Kalos and P. A. Whitlock, John Wiley & Sons, 1986
- Monte Carlo Simulation in Radiological Sciences, R.L. Morin, CRC Press, 1988.
- Neutron Transport Method (Chapter 7), E.E. Lewis and W.F. Miller, American Nuclear Society Publication.

#### **References:**

- L.L. Carter and E.D. Cashwell, Particle Transport Simulation in Monte Carlo Method, TID-26607, NTIS, 1975
- E.D. Cashwell and C. J. Everett, A Practical Manual on Monte Carlo Method for Random Walk Problems, Pergammon Press, 1969
- J. Spanier and E.M. Gelbard, Monte Carlo Particle Transport Methods: Neutron and Photon Calculations, CRC Press, 1991.

#### **Grading:**

20% One mid-term exam

80% Homework and course project (see following page for samples)

## Sample Projects from previous years

- Using MCNP to Calculate Parameters of the Six Factor Formula
- Monte Carlo Simulation of Aerosol Particle Detection and Analysis via Laser-Induced Breakdown Spectroscopy
- Approximating Soot-Laser Interactions via Monte Carlo Methods
- Monte Carlo Simulation of a Computed Tomography Scan
- An MCNP Assessment of Moderator Mass Fraction in Boiling Water Reactor Fuel Gas Cores – Design Study
- Radiant Heat Transfer View Factors Between Adjacent Like Spheres
- Performance of Recycled Weapon Grade Plutonium for Use in Commercial PWRs
- MCNP Evaluation of Carbide Nuclear Fuel
- The Use of Monte Carlo Simulation in Design Optimization
- Calculation of the “Flory-exponent” for Linear Polymers using Monte Carlo Methods
- Atomic migration study in intermetallic compounds using Monte Carlo simulation
- Modeling of a set of horizontal venetian blinds using Monte Carlo methods
- MCNP Simulation: Microscopic x-ray fluorescence experiment for Zr alloy
- Modeling of a medical CT scan
- Computer simulation of radiative heat transfer in enclosures using the Monte Carlo method
- Simulation of the collimator for neutron radiography using MCNP
- Study of the influence of thickness of Tungsten insert to the open shutter background of the CSG unit
- Monte Carlo method for thermal radiation in participating media
- Estimation of gamma dose over a nuclear shipping cask with MCNP in non-analog mode
- Investigation of different sources for the pipe-wall thinning device using MCNP
- Analysis of CSG-IV (Compton Scatter Gauge) Behavior using MCNP
- Calculation of the Radiative Heat Fluxes in two Vertical Plates by Monte Carlo Method
- Use of MCNP to solve Shielding Problem of Spent Fuel Shipping Cask
- Monte Carlo Simulation of Radiative Heat Transfer in an Enclosure
- Using the Monte Carlo Method to simulate Servicing Processes
- Radiative Heat Transfer between Cylinder Surfaces using Monte Carlo Method
- An Analysis of Radiative Heat Transfer in a Rectangular Enclosure using Monte Carlo Method