Brooklyn College
Department of Computer and Information Sciences

CISC 3820 [48] Introduction to Modeling and Simulation

3 hours; 3 credits

Introduction to simulation and comparison with other techniques. Discrete simulation models. Introduction to queueing theory and stochastic processes. Simulation methodology including generation of random numbers and variables, design of simulation experiments for optimization, analysis of data generated by simulation experiments. Variance reduction in simulation, importance sampling. Quasi-Monte Carlo integration methods, sequential Monte Carlo methods. Applications of simulation.

Syllabus:

Week 1:
Readings: Ross, Chapter 1 – Description of Discrete Event Simulation
Lecture: Develop heuristically a complete single server simulation. Introduce concepts of random events, simulation clock and outcomes.

Week 2:
Readings: Ross, Chapter 2 - Elements of Probability
Lecture: Definition of expected value, variance, standard deviation and probability mass functions.

Week 3:
Readings: Ross, Chapter 2 - Elements of Probability
Lecture: Introduction to probability distribution functions and continuous distributions. Poisson Processes.

Week 4:
Readings: Ross, Chapter 4 - Generating Discrete Random Variables
Lecture: Discussion of the mathematical sampling of several important discrete distributions and in what circumstances these distributions would be useful.

Week 5:
Readings: Ross, Chapter 5 - Generating Continuous Random Variables
Lecture: Discussion of the mathematical sampling of several important continuous distributions. Development of the rudiments of modeling a Poisson process.

Week 6:
Readings: Ross, Chapter 6 - The Discrete Simulation Approach
Lecture: Detailed analysis of a single server simulation, a multiple server simulation and a repair (feedback) model simulation.

Week 7:
Readings: Ross, Chapter 6 - The Discrete Simulation Approach
Lecture: Detailed analysis of a simplified financial analysis of stock options and other advanced simulations

Week 8
Mid-term review
Mid-term exam

Week 9
Readings: Ross, Chapter 7 - Statistical Analysis of Simulation Data
Lecture: A description of how results are gathered and analyzed for terminating simulations, cyclic simulations and continuous (non-terminating) simulations.

Week 10
Readings: Ross, Chapter 9 - Statistical Validation Techniques
Lecture: An overview of validating a simulation from its conception through the implementation of the simulation and the final results. Introduction of the concepts of goodness-of-fit to input data and analyzing the accuracy and precision of the simulation results.

Week 11
Readings: Ross, Chapter 8 - Variance Reduction Techniques
Lecture: Introduce the concept of variance reduction. Discuss the major algorithms: control variates, correlated sampling and importance sampling.

Week 12
Readings: Ross, Chapter 2 - Random Numbers, Jain, "Testing Random Number Distributions"
Lecture: Discussion of the methods and algorithms for generating uniform random numbers on a computer.

Week 13:
Readings: Marsaglia, George, "Random Numbers Fall Mainly on the Plane", Proceedings of the National Academy of Sciences, 1965; excerpts from Ripley, Brian D., *Stochastic Simulation*, Chapters 2 and 3.
Lecture: Correlation in pseudo-random number generation. Testing of algorithms for pseudorandom-number generation.

Week 14:
Lecture: A discussion of how to give a professional presentation of research results. Student will present the results of their own simulation.

Project:
Each student will be expected to carry out a simple simulation study and give an oral presentation on his or her project. The simulation can be an example drawn from the text or one in an area of interest to the student. The computer program to perform the simulation may be written in a general-purpose language such as C, C++, Java or in one

of the specialized languages discussed in class. The oral presentation will serve as an exam in the course.

Required Textbook:

Simulation, 3rd Edition, by Sheldon M. Ross, Academic Press, 2002.

Bibliography:

P. Bratley, F. Fox and L. Schrage, *A Guide to Simulation,* 2nd edition, Springer, 1987.

M.H. Kalos and P.A. Whitlock, *Monte Carlo Methods, Vol. I: Basics,* John Wiley and Sons, 1986.

Raj Jain, *The Art of Computer Systems Performance Analysis Techniques for Experimental Design, Measurement, Simulation, and Modeling,* John Wiley and Sons, 1991.

D.E. Knuth, *The Art of Computer Programming, Vol. 2: Seminumerical Algorithms*

Averill M. Law and W. David Kelton, *Simulation, Modeling and Analysis*, 3rd edition, McGraw Hill, 2000.

B.D. Ripley, *Stochastic Simulation,* John Wiley and Sons, 1987.
R. Rubinstein, *Simulation and the Monte Carlo Method,* John Wiley and Sons, 1981.