Fall, 2010
ISE 789
Stochastic Programming

Instructor: Dr. Brian Denton, Associate Professor, Department of Industrial & Systems Engineering,
North Carolina State University
Office Location: Daniels (DN) 376
Telephone: (919) 513-1690
e-mail: bdenton@ncsu.edu
Office Hours: By appointment

Class Room: Daniels (DN) 218
Class Hours: T/TH: 1:30-2:45

Prerequisites: ISE/OR505 (Linear Programming) and ISE/OR760 (Stochastic Models). Nonlinear, Integer and Dynamic programming will also be very helpful. Knowledge of C/C++ and CPLEX will be very useful.

Textbook: Introduction to Stochastic Programming, Birge, J. and Loveaux, F., 1997, Springer, NY.

Note: the following are good supplementary texts that you may find useful. Both are available free online:

Kall and Wallace, Stochastic Programming, 1994:
http://www.ior.uzh.ch/institute/kall/ka-wal-94.pdf

Shapiro and Ruszczynski, Lectures on Stochastic Programming, 2007:
http://www2.isye.gatech.edu/people/faculty/Alex_Shapiro/SPbook.pdf

Course Objectives:

- To build a general understanding of Stochastic Programming and become familiar with the theory and methodologies identified with it
- In depth review of the state-of-the-art in methodology including structural properties of the *recourse function*, decomposition methods for large scale linear programs, upper and lower bounds, sampling based methods, value of information, structural properties of special types of stochastic programs
- To set a foundation for future research in stochastic optimization

Summary of Specific Topic Areas:
• Introduction and example applications
• Review of probability spaces, random variables, decision making under uncertainty
• Simple recourse problems
• Structural properties of two-stage recourse problems
• Value of information
• Two-stage decomposition methods
• Probabilistically constrained stochastic programs
• Multi-stage decomposition methods
• Stochastic Integer Programs
• Bounds and deterministic approximations (Jensen, Edmundson-Medansky, moment based bounds)
• Sampling methods
• Robust optimization

Specific Learning Objectives:

- Be able to derive the optimal solution to the newsvendor model
- Define the difference between *wait-and-see solutions* vs. *stochastic solutions*
- Formulate stochastic programs in a variety of contexts such as health care delivery, supply chain logistics, financial planning
- Prove fundamental properties of two-stage recourse problems including conditions for convexity, continuity, and differentiability
- Be able to characterize the feasibility properties of stochastic programs
- Implement and adapt state-of-the-art algorithms for two-stage and multi-stage stochastic linear programs including: L-shaped method, Integer L-shaped method, multi-cut L-shaped method, Nested decomposition, Regularized decomposition, Lagrangian decomposition based methods, and other methods discussed in class
- Identify and use concepts from the value of information including: expected value of perfect information (EVPI), and Value of the Stochastic Solution (VSS)
- Understand structural properties of stochastic integer programs with first and second stage integer variables
- Derive properties of upper and lower bounds (e.g. Jensen, Edmundson-Mudansky, moment based bounds), and statistical sampling based approximations to the recourse function
- Formulate and understand the structural properties of *robust optimization* models
- Be able to review current research papers on stochastic programming

Computing Requirements:
Access to a fast PC with a C/C++ compiler and CPLEX 10.0.

Grading:

There will be a homework assignment approximately every 2 weeks, which will carry 40% of the total grade. **All assignments are due on the due date with a 20% reduction in the grade for each day late.** There will also be an independent research project which carries 50% of the final grade. The remaining 10% of the grade will be based on in class participation, including presentation of a research paper review. Using the overall weighted average accumulated on all assignments, midterm and final exam, the final course grade will be determined as follows:

97 <= A+ <= 100
93 <= A < 97
90 <= A- < 93
87 <= B+ < 90
83 <= B < 87
80 <= B- < 83
77 <= C+ < 80
73 <= C < 77
70 <= C- < 73
67 <= D+ < 70
63 <= D < 67
60 <= D- < 63
F < 60

Academic Dishonesty Policy:

Dishonesty is unfair to everyone, especially those who do their work honestly. Academic dishonesty will be fully prosecuted and given to the University Judicial System. All work turned in with your name is assumed to be only your own work. If what you turn in duplicates others, then it is cheating (regardless of who copied who).

Assignment Format

Following are guidelines for composing and writing your homework and project reports. The answers you provide are important, however, you must show complete details of how you solved each problem. Your assignments should have the following features:

• Problem Definition
• Assumptions made
• Methodology (step by step) used in solving the problem
• Results achieved: in words, tables of data and/or graphs
• Conclusions
• Appendices (if required): computer programs, raw data, proofs and derivations, etc.

Note: If you write code for solving one or more of the assignment problems you must provide a **carefully commented** hard copy of the code

Format:

- Include a title page with assignment number and your contact information
- Staple multiple pages together
- Write legibly and double spaced on one side of the page,
- Leaving enough space for comments
- Hand in to me in class, at my office (Daniels 376), or in the ISE Department Office (Daniels 400)