UMBC
Department of Civil and Environmental Engineering
ENCE 651 Water Resource Systems Analysis

Fall 2009
Course Syllabus

Instructor
Claire Welty, Ph.D., Professor of Civil and Environmental Engineering
Office: TRC 102, Phone: (410) 455-1766, e-mail: weltyc@umbc.edu
http://userpages.umbc.edu/~weltyc/
Office Hours: By appointment.

Lectures by C. Welty will be augmented by experts in the field.

Class Meeting Time: Friday 9 AM – 12 PM
Class Meeting Place: TRC 122

Texts
Loucks and van Beek. Water Resources Systems Planning and Management - An introduction to methods, models and applications, UNESCO, 2005. Download for free from: http://www.wldelft.nl/rnd/intro/fields/water-management/book.html

Mays, L. Water Resource Systems Management Tools, McGraw Hill, 2005.

Bradley, Hax, and Magnanti, Applied Mathematical Programming, Addison- Wesley, 1977. Out of print. Available used for $7.95 from amazon.com.

Software
LINDO - Free download for PC from **http://www.lindo.com**.

Grading 30% problem sets, 30% midterm, 30% final, 10% presentation

Problem Sets
Due per schedule handout; 10% off per day late.
No faxing of problem sets.
Problem sets should be done on 8-1/2 x11" (preferably engineering) paper with pages stapled together. (Alternatively can be typed and e-mailed as an attachment.)
No partial credit will be given for wrong answers if calculations are not shown.
See sample solved problem handed out in Lecture 1 for level of detail expected.
Rules regarding significant digits are to be followed (see http://en.wikipedia.org/wiki/Significant_figures; http://www.physics.uoguelph.ca/tutorials/sig_fig/SIG_dig.htm).

Exams Midterm: October 23, 2009; Final exam: December 18, 2009. Closed book exams; formula sheets provided by instructor.

Plagiarism Policy Problem sets submitted for grading are to be each student's own work. Plagiarism will not be tolerated. Students turning in plagiarized work will receive a grade of zero on such work.

Objectives of Course (1) To understand concepts and algorithms for optimization using linear, integer, mixed integer-linear, nonlinear,and dynamic programming; (2) to understand and be able to use the LINDO optimization software package; (3) to understand the concepts of optimization as applied to water resources problems; and (4) to enable understanding of peer-reviewed literature on the topic of application of optimization techniques to water resource systems.

Course Outline

I. Introduction and Motivation (Loucks et al., Chapters 1, 2, 3; Bradley, Hax, and Magnanti, Chapter 1; Start Chapter 2)
- A. Motivation
- B. Water resource systems analysis as a discipline

II. Introduction to LP: A Solved Example (Minimize costs of wastewater treatment subject to assimilative capacity of a stream and regulatory constraints) (Loucks et al., Chapter 4, Section 5)
- A. Problem statement
- B. Problem formulation
- C. Graphical representation of decision space
- D. Finding the problem solution
- E. Beyond optimality: Information provided by an LP solution
- F. Solutions other than optimal unique ones

III. Classification of Mathematical Programming Models (Loucks et al, Ch 3)
- A. General Form
- B. Linear Programming
- C. Integer Programming
- D. Nonlinear Programming
- E. Static vs. Multistage Models
- F. Deterministic vs. Stochastic Models

IV. Solving Linear Programs by the Simplex method (BHM, Chapters 2-4)
- A. Characteristics of the Simplex Algorithm
- B. Overview of the methodology by steps
- C. Determination of shadow prices from final tableau
- D. Dealing with equality constraints
- E. Recognizing and unbounded objective function
- F. Recognizing a decision variable that is nonunique

V. Practice LP Problem Formulation -- Water Supply Problem
- A. Problem statement
- B. Solution formulation

VI. Example LP Application: Groundwater simulation-optimization

VII. Network Models (BHM, Chapter 8)

VIII. Integer Programming (BHM, Chapter 9)
- A. Definition
- B. Important Applications
- C. Formulation Considerations
- D. Example Solution Technique -- Branch and Bound

IX. Nonlinear Programming (BHM, Chapter 13; Loucks Ch 4, Section 3)
- A. Wastewater treatment problem revisited with nonlinear costs
- B. Solution techniques
  1. Piecewise approximations of nonlinear functions
  2. Lagrange multipliers
  3. Gradient search techniques

X. Dynamic Programming (BHM, Chapter 11; Loucks et al., Ch 4, Section 4)
- A. Introduction

B. General Description/ Key Features
C. Mathematical Description
D. Example Problems
E. Effect on Solution of Discounting Future Returns

XI. Fuzzy Optimization (Loucks et al Ch 5)

XII. Data-Based Optimization (Loucks et al. Ch 6)
A. Artificial Neural Networks
B. Genetic Algorithms

XIII. Optimal Control (Mays Ch 1)

XIV. Uncertainty and Reliability Analysis (Loucks Ch 8 – 9; Mays Ch 2)

XV. Example applications (Mays, Ch 3-6 and journal articles)
A. Regional water supply planning
B. River-reservoir system operation
C. Water distribution system operation
D. Irrigation water delivery
E. Groundwater remediation

Course Schedule

Week	Date	Topic	Reading	Assignments due
1	9/4/09	I. Introduction and Motivation; II. Introduction to LP: A Solved Example	Loucks Ch 1-3; Ch 4, Sec 5; Mays Ch 1 BHM Ch 1; Ch 2 start	
2	9/11/09	II. Introduction to LP: A Solved Example, Cont'd III. Classification of Mathematical Programming Models IV. Solving Linear Programs by the Simplex Method	BHM Ch 1-2	Problem Set 1
3	9/18/09	V. Practice LP Formulation – Water Supply Problem VI. Example LP Application – Groundwater Simulation-Optimization	Gorelick and Wagner 1986	Problem Set 2
4	9/25/09	VII. Network Models	BHM Ch 8	Problem Set 3
5	10/2/09	VIII. Integer Programming	BHM Ch 9	Problem Set 4
6	10/9/09	IX. Nonlinear Programming	Loucks Ch 4, Sec 3 BHM, Chapter 13	Problem Set 5
7	10/16/09	X. Dynamic Programming Review for midterm (optional)	Loucks Ch 4, Sec 4 BHM Ch 11	Problem Set 6
8	10/23/09	Midterm	--	--
9	10/30/09	XI. Fuzzy Optimization XII. Artificial Neural Networks and Genetic Algorithms	Loucks Ch 5 -6	Problem Set 7
10	11/6/09	XIII. Optimal control	Mays Ch 1	Problem Set 8
11	11/13/09	XIV. Uncertainty and reliability analysis	Mays Ch 2	Problem Set 9
12	11/20/09	XV. Example applications	Mays Ch 3-6 and journal articles	Problem Set 10
13	12/4/09	XV. Example applications, cont'd	Mays Ch 3-6 and journal articles	Problem Set 11
14	12/11/09	Class presentations	Journal articles	Write-up
15	12/18/09	Final exam		--