Department of Industrial and Systems Engineering
Spring 2011

Operations Research - Deterministic Modeling

(ISyE 323)

Lecture:	Tuesday and Thursday 11AM-12:15PM	3126 Mechanical Engineering Building
Section #1:	Wednesday 4:35–5:25PM	2109 Mechanical Engineering Building

Jeff Linderoth
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Basic techniques for modeling and optimizing deterministic systems with emphasis on linear and integer programming. Computer solution of optimization problems. Applications to production, logistics, and service systems. Prerequisites: IE 313, Math 222, and either Math 320 or 340.

Discussion Sections

Discussions sections play a crucial role in the learning process for this course. As such, your attendance in discussion section is mandatory. All three discussion sections will be led by the same teaching assistant.

Teaching Assistant: Chen (Mavis) Wang
Office: 3146 Mechanical Engineering Building
Office Hours: 11AM-12PM Monday. 2-3PM Monday.
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Course Materials

Required Texts

There is one required text.

Frederick Hillier and Gerald Lieberman. *Introduction to Operations Research*, Ninth (McGraw-Hill, 2005).

The textbook comes with a CD that contains a wide assortment of additional educational material and software that will be used during the course. We will follow the textbook fairly

closely, but I may augment lectures and exercises using other sources. Earlier editions of the textbook may contain the requisite material, but it is the student's responsibility to ensure that they are doing the correct homework assignments.

The Hillier and Lieberman book also comes with as a CourseSmart eBook version. Mcgraw-Hill ebooks can be purchased through the company's website: `http://www.mhhe.com/ebooks`.

Recommended Texts

There is one recommended text

Christelle Guéret, Christian Prins, and Marc Sevaux. Translated and revised by Susanne Heipcke. *Applications of Optimization with Xpress*, Revised Translation (Dash Optimization, Ltd., 2002). *The book is available* for free *from the XPRESS-MP software website. http://www.fico.com/en/Products/DMTools/xpress-overview/Pages/Xpress-Documentation.aspx.*

Web Site

The course web site will be available through the the `Learn@UW` system: `https://learnuw.wisc.edu/`. Course lecture notes and solutions to homework exercises will be posted there.

Course Overview

This three-credit course introduces students to basic techniques for modeling and optimizing systems under the assumption of certain knowledge of the system's parameters. These techniques include linear programming models and associated special structures such as network optimization, discrete (integer) programming, and nonlinear programming.

Objectives

After taking this course, my objective is that you will be able to do the following:

1. Write down an algebraic formulation of an optimization model that captures the main decision elements of practical problems;
2. Model a variety of basic problems as optimization models using Excel, and to solve them using Excel Solver;
3. Obtain experience in using an algebraic modeling language to model practical, large-scale problems;
4. Understand the simplex method for linear programming;
5. Understand the relationship between a linear program and its dual, including concepts such as complementary slackness and strong duality;
6. Perform sensitivity analysis to understand how changes in the problem's input impact the optimal solution output;
7. Understand the importance of networks for modeling many operations research problems;
8. Perform simple network optimization algorithms;

9. Understand how to model advanced logical constraints using integer decision variables;
10. Understand the branch-and-bound algorithm used in discrete optimization;
11. Understand the impact of convexity on an optimization instance's complexity;
12. Be able to deduce the optimality or non-optimality of a solution using KKT optimality conditions;
13. Understand the basic underpinnings of algorithms for nonlinear optimization;
14. Take an abstract decision problem, model it as an appropriate optimization problem, solve the model using computer-based software, and interpret the solution;

There are other course objectives that will become clear as the course proceeds, but those listed above are the most important. Also, the tests and assignments given in this course are specifically designed to measure your progress in the above areas.

Requirements and Grading

Lectures

For instruction, the course will contain twice-weekly lectures and a once-weekly discussion session. Learning is an interactive process. As such, attendance at lectures and discussion is mandatory, and a small portion of your grade will depend on your participation.

Homework

There will be (roughly) weekly homework assignments. The homework assignments are meant to ensure that you have mastered the material from the previous lectures and will help you to learn the skills and concepts listed under course objectives. An integral part of the learning process is a rigorous self-assessment of knowledge. Answers to the homework problems will be posted, and students are expected to assess their performance and seek additional help should it be required. Given the dire budget situation of the department and university, T/A and grader resources have been cut. Thus, the entire homework *will not* be formally graded by me, or the T/A. Some portions may be rigorously graded, and the remainder will be checked at a more cursory level.

Late homework is not accepted for grading. If there is an exceptional circumstance, you may contact me, and I may pass the homework along for grading for a reduced amount of credit

Exams

There will be two (in-class) quizzes. The first quiz is scheduled to take place on February 24, and the second quiz will take place on Aptil 19. The final exam will be held on May 13. All exams will be closed book and closed notes, though the exam itself may provide a sheet containing key formulae or concepts. The exact form of the information sheet will be discussed before each quiz or exam.

Grading Scheme

- 5% Participation
- 30% Homework
- 20% Quiz #1
- 20% Quiz #2
- 25% Final Exam

Course Statements

Homework Submission Policy

Homework exercises will be assigned in most weeks as a means to help you understand the concepts and to give you practice in applying them. They will generally be due on Tuesday; and you should bring the assignments to class with you.

You are encouraged to discuss the course work, including homework, with other students. However, it is *imperative* that you understand the material on your own. You (obviously) can't ask your study-partners for help on the quizzes and exams, so it is up to the student to ensure that they have *individually* mastered the material. An effective way of ensuring this is to work on the homework assignments alone before seeking help or collaborating with others. If it is perceived that homeworks are being completed by teams, a modification of the course grading allocation may be necessary.

Schedule Conflicts

Sometimes students have legitimate conflicts that prevent them from taking an exam at the scheduled time. In accordance with University policy, I request that you notify me of any such conflicts within the first two weeks of class. If for some reason you become aware of such a conflict after the first two weeks of class, I request that you notify me as soon as you become aware of the conflict. In such cases, I will work with you to schedule a make-up exam, provided that you have made a reasonable effort to give me advance notice of your conflict.

Computing

You will need to make use of the Microsoft Excel spreadsheet program throughout the course, and you will also need to use other software for PC-compatible machines. This software and tutorials are on the CD that comes bundled with the course textbook.

In this course, we will also be using a software system called *XPRESS-IVE*, and the *Mosel* algebraic modeling system available from FICO: `http://www.fico.com/en/Products/DMTools/xpress-overview/Pages/Xpress-Optimizer.aspx`. The recommended book above may serve as a software manual for Mosel, but hidden inside are valuable, practical modeling tips and practices. A student version of this software is available for free from the web site. A commercial version of the XPRESS-IVE package is available on the CAE Windows machines.

Academic Integrity

You are encouraged to share ideas with each other on class assignments. Again, I *strongly* encourage all students to attempt the homework assignments by themselves first, as this is the quickest path to mastery of the material. Again *you must write up the homework assignments by yourself.* If the T/A, Grader, and I suspect that students are not completing the homework independently, then we reserve the right to give all suspected parties zero on the homework assignment or modify the grading scheme to discount your homework scores.

AT NO TIME ARE YOU ALLOWED TO OBTAIN, LOOK AT, OR CUT AND PASTE FROM THE SPREADSHEET, SOURCE CODE, OR PROBLEM SET OF ANY OTHER INDIVIDUAL, WHETHER THEY ARE IN THE CLASS THIS SEMESTER OR NOT. YOU ARE EXPRESSLY FORBIDDEN FROM SHARING ELECTRONIC FILES OF ANY TYPE BY ANY MEANS WITH ANYONE.

As to quizzes and exams, you are all grown-ups. **Do not cheat!** Improper behavior during quizzes and exams will be dealt with in the harshest manner allowable to be under the disciplinary penalties set forth in the University of Wisconsin Policy for Academic Misconduct: (`http://www.wisc.edu/students/saja/misconduct/UWS14.html`). Also, be aware that academic integrity requires you to let the instructor know if you think you see incidents of misconduct.

Obtaining Help

The T/A and I will do our best to answer email questions in a timely fashion. However, it is easy to become overwhelmed handling such requests. Thus, we make two requests of you if you are asking for help via email

1. Please only ask for help if you have given some significant thought about the problem on your own
2. Please allow us to include the entire classlist on responses to questions, as it may save us from having to answer the same question multiple times

(Tentative) Chronological Syllabus

There is some flexibility in the schedule, depending on our progress through the various chapters and my assessment of your mastery of the material. However, I anticipate that the homework due dates and the dates for the exam and quizzes will not change. Any changes will be announced in class.

Part I: **Linear Programming** *Jan. 18–Feb. 24*

Basic linear programming modeling. Graphical Solution technique, and properties of solutions. The Simplex method. of Excel Solver and an Algebraic Modeling Language

Readings: Chapters 1, 2, 3, 4, 5

Homework #1: Due: 2/1

Homework #2: Due: 2/8

Homework #3: Due: 2/15

Homework #4: Due: 2/22

Quiz #1: 2/24

Part II: **Analysis of Linear Programming Solutions** *Mar. 1–Mar. 10*

Duality and sensitivity analysis for linear programs

Readings: Chapters 5 and 6

Homework #5: Due: 3/8

Homework #6: Due: 3/22

Part III: **Discrete Models** *Mar. 22–Apr. 19*

Network models. Formulating discrete decision problems with integer variables. The impact of modeling on solution techniques.

Readings: Chapters 9 and 11

Homework #7: Due: 3/29

Homework #8: Due: 4/5

Homework #9: Due: 4/12

Quiz #2: 4/19

Part IV: **Nonlinear Programming** *Nov. 30–December 14*

Nonlinear models, Algorithms, Karush-Kuhn Tucker Conditions, and the impact of convexity.

Readings: Chapter 12

Homework #10: Due: 5/3

Final Exam: May 13