Economics 172A: Introduction to Operations Research **Winter 2008**
Instructor Vincent Crawford **Economics 319, 534-3452, vcrawfor@dss.ucsd.edu**
Office hours W 2:00-3:00 or by appointment

TA: Benjamin Kay (bkay at ucsd.edu), Economics 124, office hours MF 9:00-10:00

You should direct all email questions about course content to Benjamin Kay (bkay at ucsd.edu). He will try to respond to you by noon the following Monday. Please place "Econ 172A" in the subject line of your message. Face-to-face contact is the most reliable way to get an answer from me. Please do not expect me to respond to emails regarding course content.

Description: Economics 172A is the first course in the two-quarter Introduction to Operations Research sequence. It covers linear and integer programming, elements of zero-sum, two-person game theory, and specific combinatorial algorithms. Linear and integer programs are types of mathematical optimization problem. The class will introduce you to the problems, teach you how to formulate economic and business problems as linear or integer programming problems, teach you how to solve the problems, including some specific methods called combinatorial algorithms, and teach you how to interpret the solutions. Zero-sum, two-person game theory is the theory of how to make optimal decisions in situations of pure conflict, in which the outcome is influenced by another person's decision as well as one's own, and in which the other person is also trying to make an optimal decision. The class will teach you how to formulate situations of pure conflict as games and teach you how to use linear programming to solve for the optimal decisions.

Preparation: You should be comfortable with linear algebra, basic microeconomics, and the operation of a spreadsheet computer program such as Microsoft Excel. In order to enroll in the class you must have the prerequisites listed in the UCSD catalog: ECON 100A or 170A; and ECON 120A or ECE 109 or MATH 180A or MATH 183 or MATH 186; and MATH 20F. Note that credit is not allowed for both ECON 172A and MATH 171A.

Organization: Economics 172A meets from 8:00-9:20 a.m. on Tuesdays and Thursdays, in Center Hall, Room 214. Your grade will be based on written homeworks (10%); a midterm in class Thursday, February 7, the end of the fifth week (35%); and a final on Thursday, March 20 from 8:00-11:00 a.m. (55%). Exams will be given only at the scheduled times except for compelling (and fully documented) medical excuses. It is your responsibility to avoid conflicts. You may use calculators (but not other electronic devices) during exams, but you may not consult notes, books, or your classmates' exam papers. I take violations of academic honesty seriously. Any act of academic dishonesty will be reported to your academic dean, and will lead to a failing grade in the course and possibly dismissal from the university.

Course Material: Lecture notes and other course materials are linked on the course website, http://dss.ucsd.edu/~vcrawfor/econ172A.html. I will follow the lecture notes fairly closely. The exams will cover only material that is discussed in the lectures, lecture notes, or the problem sets. There are no required texts, but I have ordered copies of a recommended text, (HL) Hillier and Lieberman: *Introduction to Operations Research*, McGraw-Hill, for the bookstore, and more are on reserve in Geisel Library. This book is a useful supplement, but it is expensive and not essential. Most of the material is standard and you can find decent treatments in many other places.

Problem Sets: Problem sets will be announced in class and posted on the course website. Some problems will involve using standard spreadsheet computer programs, such as Microsoft Excel, to solve linear programming problems. You will need Microsoft Excel (with the "solver" option installed) to do these assignments. The program is available on the computers in Econ 100, but there is no need to go there if you have access elsewhere. The notes contain information about using Excel to solve linear programming problems. The use of Excel is not discussed in lectures. I encourage you to discuss your homework assignments with classmates, but you must write your answers independently. Problem sets should be turned in by the start of class on the announced dates, or put in the course mailbox in Econ Student Services by the same time. Except for documented medical excuses, late problem sets will not be accepted.

Outline and Readings: Below is a schedule of topics and associated readings in (HL) Hillier and Lieberman. (The page references are from the eighth edition; other editions do not differ greatly, and you should have little trouble finding the relevant reading.) "Problems" gives page and problem numbers in HL. The class website has links to some of Professor Sobel's old problem sets and examinations (and answers). (I have never taught this class before. Professor Sobel's class materials from the Fall 2007 offering of 172A are used with his permission.)

A. Linear Programming

I. Introduction and Problem Formulation (pdf)

HL pp. 1-23, 32–68; Problems p. 92: 3.1-7 to 3.1–10, pp. 95-97: 3.4-7 to 3.4-15

II. Graphical Solutions (pdf)

HL pp. 28–31; Problems pp. 92-93: 3.1-11 to 3.1-13

III. A Simplex Algorithm Example (pdf) (extra material, not covered in lectures or examinations)

IV. Using Excel to Solve Linear Programming Problems (pdf) (extra material, not covered in lectures or examinations)

Sample Spreadsheets:
Template (pdf); Solution (pdf); Sensitivity (pdf); Template in Excel Format (xls)

V. Problem Transformations (pdf) (extra material, not covered in lectures or examinations)

VI. Duality and Complementary Slackness (pdf)

HL pp. 209-225; Problems p. 277: 6.1-4 to 6.1-5, 6.1-10, p. 278: 6.3-5 to 6.3-6

VII. Sensitivity Analysis (pdf) Examples (xls)

HL pp. 229–275; Problems pp. 286-289: 6.8-1 to 6.8-7, p. 289-290: cases 6.1 to 6.4

VIII. The Transportation Problem (pdf) Examples (xls)

HL pp. 320–363; Problems pp. 366-367: 8.2-1 to 8.2-3, p. 370: 8.3-1 to 8.3-4

B. Two-Person Zero-Sum Game Theory (pdf)
HL pp. 659-675, Problems pp. 675-676: 14.1-1 to 14.1-3, 14.2-1, 14.2-3 to 14.2-6

C. Integer Programming (pdf)
Handout on the Hungarian Method for the assignment problem (pdf)
See also The Transportation Problem , pp. 8-13 (pdf)
Basics and Branch and Bound:
HL pp. 478-527, Problems pp. 535-536: 11.1-1 to 11.1-7, pp. 540-541: 11.6 to 11.6-8
Network Algorithms:
HL pp. 374-404, Problems pp. 428-431: 9.3-1 to 9.3-5, 9.4-1 to 9.4-3, 9.5.3 to 9.5-5