Economics 172B: Introduction to Operations Research, Winter 2002, Vincent Crawford

This part of the Introduction to Operations Research sequence covers two kinds of nonlinear mathematical optimization problems: nonlinear programming and integer programming. The class will teach you how to formulate economic and business problems as nonlinear or integer programming problems, teach you how to solve them, and teach you how to interpret their solutions. Economics 172A is an essential prerequisite.

Lectures are Tuesdays and Thursdays from 8:00-9:20am in HSS 2250. The textbook, which is required, is Hillier and Lieberman, *Introduction to Mathematical Programming* (2nd edition); copies have been ordered for the bookstore, and more are on reserve in Geisel Library. (Hillier and Liebermann's *Introduction to Operations Research* contains *Introduction to Mathematical Programming*. If you have access to that book or the first edition of *Introduction to Mathematical Programming* , you should have no trouble finding the relevant reading.) Other course information and materials, including this syllabus, my lecture notes, my midterm and final exams and homework problems and solutions from Spring 2000 (the only recent time I taught this course), are on the class web page, http://weber.ucsd.edu/~vcrawfor/econ172B.htm, linked to http://weber.econ.ucsd.edu/classes/. Note that unlike in Spring 2000, game theory is **not** covered in this offering of 172B; you can ignore that part of my lecture notes, old exams, homeworks, etc.

Your grade will be based on written homeworks (15%); a midterm in class on Thursday, February 7, the end of the fifth week, from 8:00-9:20 (30%); and a final on Thursday, March 21 from 8:00-11:00 (55%). Exams will normally be given only at the regularly scheduled times; it is your responsibility to avoid conflicts. If there is any reason why you cannot take the final examination at the scheduled time or if you require special consideration, you must talk to me during the first two weeks of class. If you do not do so, then you must take the final at the scheduled time and place. I take violations of academic honesty seriously. You may use calculators (but not other electronic devices) during exams. You may not consult notes, books, or your classmates' exam papers during exams. Any act of academic dishonesty may be grounds for failure in the course.

Homeworks will be announced in class and posted on the class web page. I encourage you to discuss your homework assignment with your classmates, but you should write your answers independently. Assignments should be turned in by the start of class on the announced date, or put in TA Herb Newhouse's mailbox in Economics 210 by that time; late assignments will not be accepted. Some questions use the MathProg software that comes with your textbook. This should be installed on the PCs in the Econ 100 PC lab, or you can install it on any IBM-compatible PC. I will distribute account information in class. The text also contains many good practice problems.

My office hours are Wednesday 2:00-3:00 in Economics 319 or by appointment (vcrawfor@weber.ucsd.edu, 858-534-3452)

TAs: Jim Brennan, Herb Newhouse, Sivan Ritz; office hours TBA

Outline and Readings (all in Hiller and Lieberman):

I. Nonlinear Programming

A. Preliminaries

Concavity and convexity of functions and convexity of sets, Appendix 2
Maxima and minima, optimal solutions and maximized value functions

B. Unconstrained optimization, Appendix 3

First- and second-order conditions
Sensitivity analysis and the envelope theorem
Computational methods: gradient, "zig-zag" gradient

C. Equality-constrained optimization (classical programming), Appendix 3

First- and second-order conditions, classical constraint qualification
Sensitivity analysis, interpretation of Lagrange multipliers, and the envelope theorem
Computational methods discussed under I.D. below

D. Inequality-constrained optimization (nonlinear programming), Chapter 13

First- and second-order conditions, Kuhn-Tucker constraint qualification
Sensitivity analysis, interpretation of Lagrange multipliers, and the envelope theorem
Computational methods: basis-guessing and reduction to classical optimization, gradient projection method, Lagrangean gradient method, quadratic programming, separable programming and linear approximation of well-behaved nonlinear programming problems

II. Integer Programming

A. Formulation and general discussion, Sections 12.1-12.4

Inadequacy of ignoring integer restrictions and rounding
Separable programming and approximation of nonconvex nonlinear programming problems by mixed integer-linear programming with set-up cost

B. Computational methods, Sections 12.5-12.8, 8.3 (review Sections 6.1-6.4 and Problem 8.2.22 as needed)

Branch-and-bound technique for mixed integer-linear programming,
Branch-and-bound technique and Hungarian method for assignment problem