THE OHIO STATE UNIVERSITY **Autumn, 2000**
City and Regional Planning **J.M. Guldmann**

C&RP 870.01: STATIC OPTIMIZATION IN PLANNING

Credit: **5 hours**
Call No: **04178-6**
Place: **Brown Hall 274**
Time: **Thursday, 2:30- 5:30 p.m.**
Instructor: **Jean-Michel Guldmann**
281 Brown Hall
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COURSE OBJECTIVES

The purpose of this course is to introduce students to the theory, computer algorithms, and planning applications of optimization methods, also commonly known as mathematical programming (MP). The course will cover such topics as linear, integer, and nonlinear programming. A special emphasis will be set on network and transportation problems, and on applications in the areas of land-use, industrial location, environmental quality, and energy planning. The use of the computer package GAMS will further help the students to understand the algorithms, check the validity of fundamental theorems, and appreciate the potential of computers and MP to solve planning problems.

TEXTS

The books listed below are placed on reserve at the Science and Engineering Library and should be consulted. Other materials will be handed out during the quarter.

James Killen - Mathematical Programming Methods for Geographers and Planners - Croom Helm - St. Martin's Press, 1983.

Saul I. Gass - Linear Programming - McGraw-Hill, 1985.

Michael D. Intriligator - Mathematical Optimization and Economic Theory - Prentice-Hall, Inc., 1971.

Harvey M. Wagner - Principles of Operations Research - Prentice-Hall, Inc., 1975.

COURSE OUTLINE

1. Introduction to Optimization Methods

*** General usefulness of optimization techniques: examples of some practical applications in urban and regional planning.**

*** Short review of basic concepts in linear algebra (matrices, systems of equations and inequalities) and multivariable calculus (functions, derivatives, maxima and minima). Related economic concepts and applications (demand, production and cost functions; optimum of the competitive and monopolist firm).**

*** Formal presentation of the mathematical programming problem.**

Killen, J. - Chapter 1.
Intriligator, M.D. - Chapters 1 and 2.

2. Classical Programming

Optimization of a multivariable function subject to equality constraints. Use and interpretation of Lagrange multipliers. Economic applications: least-cost input mix for the firm subject to an output constraint, consumer's utility maximization subject to a budget constraint.

Intriligator, M.D. - Chapters 3, 7, and 8.

3. Linear Programming

*** Basic Theory: the primal and dual problems; the complementary slackness theorem; interpretation of the dual variables and sensitivity analysis.**

*** Presentation of the simplex algorithm: convergence proof and step-by step examples.**

*** Introduction to the GAMS computer package (available in the School of Architecture computer lab).**

*** Applications to land-use allocation, housing, transportation, environmental, and energy planning.**

Wagner, H.M. - Chapters 2, 3, 4 and 5.
Killen, J. - Chapters 4 and 5.
Intriligator, M.D. - Chapter 5.
Gass, S.I. - Chapters 1, 3, 4, 5 and 11.
Schlager, K.J. - "A Land Use Plan Design Model," JAIP, May 1965, pp. 103-111.

Herbert, J.D. and Stevens, B.H. - "A Model for the Distribution of Residential Activity in Urban Areas," Journal of Regional Science, Vol. 2, 1960, pp. 21-36.
Guldmann, J.M. and Shefer, D. - Industrial Location and Air Quality Control, John Wiley & Sons, 1980, Chapters 5, 8, 9.

4. Integer Programming

*** Need for integer (zero-one) variables: indivisible units, all-or nothing decisions, priority conditions, thresholds, discontinuities, exclusionary conditions, fixed costs.**

*** Branch-and-bound algorithms to solve integer programs: general concepts and step-by-step example.**

*** Use of the GAMS package.**

*** Examples of applications, including coverage, p-median and other location-allocation problems.**

Killen, J. - Chapters 6 and 7.
Wagner, H.M. - Chapter 13.
Koopmans, T.C. and Beckman, M. - "Assignment Problems and the Location of Economic Activities," Econometrica, 25, pp. 53-76.
Guldmann, J.M. - "Urban Land-Use Allocation and Environmental Pollution Control: An Intertemporal Optimization Approach," Socio-Economic Planning Science, Vol. 13, 1979, pp. 71-86.
Guldmann, J.M. - "Solar Energy and Access to Sunlight: An Optimization Model of Energy Supply and Land-Use Design," Environmental and Planning A, Vol. 12, 1980, pp. 765-86.

5. Network Models

*** Presentation of network design, shortest route, and network flow models. Examples of applications.**

Wagner, H.M. - Chapter 7.
Killen, J. - Chapter 2.
Pape, U. - "Implementation and Efficiency of Moore-Algorithms for the Shortest Route Problem," Mathematical Programming, Vol. 7, 1974, pp. 212-22.
Van Vliet, D. - "Improved Shortest Path Algorithms for Transport Networks,' Transportation Research, Vol. 12, 1978, pp. 7-20.

6. The Transportation and Related Problems

*** Presentation of assignment, transportation, and transhipment problems. Special solution methods.**

*** Use of the GAMS package.**

Killen, J. - Chapter 3.
Gass, S.I. - Chapter 10.
Wagner, H.M. - Chapter 6.

7. Nonlinear Programming

*** Basic theory: the case of no inequality constraints; the Kuhn-Tucker conditions and theorem; the interpretation of the Lagrange multipliers.**

*** Solution algorithms for the unconstrained and constrained cases: adaptive searches, gradient methods, linearization.**

*** Use of the GAMS package.**

*** Examples of applications, including location-allocation problems.**

Intriligator, M.D. - Chapter 4.
Killen, J. - Chapter 8.
Wagner, H.M. - Chapter 14 and 15.

COURSE REQUIREMENTS AND GRADING

1. **Homeworks will provide the students an opportunity to apply the techniques to small problems.**
2. **Computer exercises using GAMS.**
3. **There will be a final comprehensive exam.**

The weights are as follows:

Homeworks	**30%**
Computer Exercises	**30%**
Final Exam	**40%**