Nonlinear Programming - Course Syllabus

MSC 380.8 – unique # 04075

ORI 391Q.1 – unique # 17605

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Instructor

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Course Objectives

A. Theory: understand the derivation and uses of the Kuhn-Tucker first order necessary conditions for optimality, second order optimality conditions, saddle points, and the Lagrangian dual problem. Also, understand basic convexity results, and convergence and rate of convergence results for various algorithms.

B. Algorithms: understand the derivation and comparative advantages of the following classes of algorithms:
   a. Generalized Reduced Gradient (GRG)
   b. Successive Quadratic Programming (SQP)
   c. Successive Linear Programming (SLP)
   d. Penalty and Barrier Methods, Exact and Inexact
   e. Interior Point Methods.

   Use given implementations of these algorithms, observe and analyze the results.

C. Applications
   a. Learn to use stand-alone Fortran or C NLP solvers to solve problems coded in Fortran or C.
   b. Learn to use the Excel Solver and GAMS.
   c. Understand the relative advantages and limitations of the above tools.
   d. Learn about several important current NLP application areas, including

- gasoline blending, refinery models
- electric power: hydroelectric planning, optimal load flows
- financial applications: Markowitz asset allocation, multi-period models, robust optimization
- optimal control
- water resources models
- others of interest to the class.

e. Improve your skills as a modeler by formulating a variety of problems in several modeling languages, solving, and analyzing and understanding the solution. Learn principles of good modeling as well as things to avoid.

Instructional Methods

The basic approach is to learn by doing. We will organize small learning groups, who work together to solve problems in class. These problems are stated on the plan for each class. Last years plans are on the course website, and are a reasonable guide to those used in the current year. We then discuss the problem solutions. This is interspersed with lecture segments when needed. There will also be occasional outside speakers, who will explain how they use course topics in their work.

Course Materials

TEXT: LINEAR and NONLINEAR PROGRAMMING by S. Nash and A. Sofer, McGraw-Hill, 1996.

Supplementary Readings: Readings packet at Paradigm Publishing, corner of 24th St. near Guadalupe

WEBSITES: This year's syllabus and last year's session plans are available at www.utexas.edu/courses/lasdon. You will also visit several optimization websites as part of this class, and will be asked to report on what you found in the next class. Some of these sites are:

1. 1. www.frontsys.com This is the Frontline Systems website. Frontline and Lasdon jointly developed the Excel Solver, and Frontline markets enhanced Solvers for Excel.
2. 2. www.optimalmethods.com.
This is the Optimal Methods website, which markets NLP software.
3. 3. www.modeling.com. This is the COMPASS Modeling Solutions Website. One of their products is AMPL+, which is a leading algebraic modeling language for optimization.
4. 4. http://plato.la.asu.edu/guide.html. This is a site developed by Hans Mittlemann at Arizona State Univ. and P. Spellucci of Technical University Darmstadt. It contains much info on a broad range of optimization topics. It contains links to many other sites and downloadable software and papers.

5. 5. http://www.ece.nwu.edu/OTC/. This is the website of the Optimization Technology Center at Argonne National Laboratories. It contains much information, plus software. It also allows you to submit an optimization problem to them and get a solution. See readings for more information.
6. 6. www.gams.com. This is the GAMS Development Corporation website. GAMS is another widely used algebraic modeling language for optimization, which we will use in this course.
7. 7. www.ampl.com. This is another AMPL site.

See the readings packet, readings 3, for listings of the first page of some optimization websites.

The Grading Process

Midterm Exam 1/3, Final Exam 1/3, Homework and Cases 1/3

Class Schedule and Assigned Readings

See the class plans on the course website for a detailed schedule of each of last years classes. A summary is provided below.

Class	**Topic**	**Readings** (**T=Text, R=Readings Packet**
1-2	Introduction to NLP, convexity, Basic NLP algorithm convergence and converge nce rate	T chap. 1-2, R 1-4
3-4	Unconstrained optimization: Newton's method, line search and trust region methods to ensure convergenc	T chap. 10, R 5,9
5-6	Unconstrained optimization: steepest descent, quasi-Newton and conjugate gradient methods	T chap. 11-12, R 6-8
7	Use of Fortran or C GRG solver, finite difference derivatives, automatic differentiation	T11.4, R10
8	Spreadsheet optimization	Use of Excel Solver, R 24
9	The GAMS modeling language	R 31
10-11	Constrained problems-necessary and sufficient conditions	T 14.5, R 11-12
12-13	Saddle points, duality, Lagrangian relaxation	T 14.8, R 13
14	Midterm exam	
15	NLP application: minimizing interconnection Delay i VLSI design	Invited speaker from CS, Handout
16-17	Reduced gradient methods	R 14-16
18	Penalty and Barrier methods	T chap. 16, R17
19	Successive quadratic programming (SQP)	T 15.5, R 18-19

20	Successive linear programming (SLP), algorithm comparison, available NLP software	R20-22, 24-25
21	Interior point methods	T chap. 17, R 23
22	Optimization models in electric power systems	R28
23-24	Mixed integer programming models	R30
25-26	Asset allocation, Markowitz mean-variance portfolio models, other financial models	R29
2 Lectures: applications and modeling exercises (throughout course)		R26, Handouts