Syllabus: 16:711:550 Nonlinear Optimization

Rutgers University, Spring 2013, Prof. Jonathan Eckstein

All class policies subject to change at instructor's discretion.

Quick Overview:

Time:	Currently scheduled for Wednesdays 1:40-4:40pm
Place:	RUTCOR 166
Instructor:	Jonathan Eckstein (visiting professor from Rutgers University)
E-mail:	`jeckstei@rci.rutgers.edu`
Websites:	Most material at `http://eckstein.rutgers.edu/nlp`. Limited-release material will be placed on Sakai or BlackBoard.
Office:	RUTCOR 155
Telephone:	(732) 445-0510 at RUTCOR; (848) 445-0510 at the business school
Office hours:	Tuesdays 2:30-4:00pm and additional times by appointment
Textbook:	• Required: *Nonlinear Optimization* by Andrzej Ruszczyński, Princeton University Press, 2006 (abbreviated "AR:NO" below) • Optional: *Nonlinear Programming*, Second Edition, by Dimitri Bertsekas, Athena Scientific, 1999
Software:	MATLAB, including the symbolic toolbox, which should be installed in the RUTCOR computer lab and may also be downloaded from `http://software.rutgers.edu`.
Exams:	I am planning to give one midterm and a final, both probably take-home exams.
Homework:	Will be assigned every week or two, and will be a mixture of mathematical exercises and coding simple algorithms in MATLAB.
Grading:	To be determined; tentatively 30% homework and 35% for each exam.

Background Material and Additional Resources

The course does not assume prior background in optimization. However, it does assume knowledge of elementary linear algebra, real analysis, and multivariable calculus. Some resources you may find helpful in reviewing this material include

- *Principles of Mathematical Analysis* by Walter Rudin, McGraw-Hill, 1953/1976.
- *Linear Algebra and Its Applications* by Gilbert Strang, Harcourth Brace Jovanovich, 1988.

Course Content

The aim of this course is to convey a solid understanding of the theoretical and practical fundamentals of nonlinear optimization. In contrast to some earlier times I have taught this course and the elective I have taught on *Convex Analysis and Optimization*, I will not attempt to rigorously prove every result discussed in the class. In some cases I will refer you to the textbook for proofs, and just give an interpretation of the results in class, or just sketch the key ideas in proofs you can find in the textbook of reference material. In other cases and where I think they will be illuminating, I will give full proofs in class. Throughout the semester, we will review and introduce some basic concepts from real and convex analysis as they are needed. Our planned topics are as follows:

1. Unconstrained optimization
    a. Elements of convex analysis
        i. Convex sets
        ii. Convex functions
    b. Local optimality conditions for differentiable unconstrained problems
    c. Line search algorithms
    d. Gradient and related methods
    e. Algorithm rates of convergence
    f. Newton methods
    g. Conjugate gradient / quasi-Newton methods

2. Optimality conditions for constrained optimization problems
    a. More elements of convex analysis
        i. Projection and separation
        ii. Cones, polars, and duals
        iii. Recession, feasible direction, tangent, and normal cones
    b. Simple abstract optimality conditions for functions and sets
    c. Constraint qualifications, metric regularity, and separation
    d. Lagrange necessary condition, Lagrangians

3. Langrangian duality for nonlinear optimization

4. Constrained optimization methods
    a. Gradient projection methods (possibly expanding on AR:NO)
    b. Reduced gradient / feasible direction methods
    c. Penalty methods
    d. Newton / SQP methods
    e. Barrier methods
    f. Augmented Lagrangian methods