6.252/15.084 - Nonlinear Programming

Spring 2017 - Syllabus

This course introduces students to the fundamentals of nonlinear optimization theory and methods. Topics include unconstrained and constrained optimization, linear and quadratic programming, Lagrange and conic duality theory, interior-point algorithms and theory, Lagrangian relaxation, generalized programming, and semidefinite programming. Algorithmic methods used in the class include steepest descent, Newton's method, conditional gradient and subgradient optimization, interior-point methods and penalty and barrier methods.

Lecture: Tuesdays and Thursdays 11AM-12:30PM, MIT E25-111.

Recitation: Fridays 10:30AM-11:30AM, 11:30AM-12:30PM, MIT 34-303.

Instructor: Dr. Amir Ajorlou, E18-423 (IDSS),
E-mail: `ajorlou@mit.edu`, Homepage: `http://www.mit.edu/~ajorlou`.
Office hours: stop by my office, or email me to set an appointment.

Teaching Assistant: Dogyoon Song, 32-D666,
E-mail: `dgsong@mit.edu`.
Office hours: Tuesdays 6pm - 7:30pm, LIDS lounge (Stata D tower, 6th floor).

Prerequisites: Besides general mathematical maturity, the minimal suggested requirement for the course is linear algebra (e.g., 18.06 / 18.700). Some knowledge of linear programming (e.g., 6.251/255) could be beneficial, but certainly not required.

Bibliography: The course textbook is "Nonlinear Programming" (3rd ed.) by Dimitri P. Bertsekas [Ber16]. Occasionally we may also use a few additional book chapters and research papers. Other recommended references are listed at the end of this syllabus.

Lecture notes: All handouts, including homework, will be posted in the course learning module:

`https://learning-modules.mit.edu/class/index.html?uuid=/course/6/sp17/6.252`

Requirements: Homework 30%, Midterm 30%, Final Exam 40%.

Homework: Problem sets will be handed out in an approximately biweekly basis, and will be due one week later, at the *beginning of the lecture* on their respective due dates.

We expect you to turn in all completed problem sets on time. Late homework *will not be accepted*, unless there is a prior arrangement with the instructor.

Collaboration policy: We encourage working together whenever possible: in the tutorials, problem sets, and general discussion of the material and assignments.

Keep in mind, however, that for the problem sets the solutions you hand in should reflect your *own* understanding of the class material, and *should be written solely by you*. It is *not* acceptable to copy a solution that somebody else has written.

Course Syllabus (Preliminary. Dates to be updated.)

Lec.	Time	Topic	Readings
1.		Introduction / Applications	
2.		Unconstrained Optimization and Optimality Conditions	1.1
3.		Gradient Methods - Convergence	1.2
4.		Rate of convergence. Heavy ball method.	1.3
		No classes (President's day - Monday's schedule)	
5.		Newton's method and variants	1.4
6.		Conjugate direction methods, Quasi-Newton methods	2.1, 2.2
7.		Incremental methods, coordinate descent	2.3, 2.4
8.		Optimization over a convex set, projection	3.1
9.		Feasible directions and gradient projection	3.2, 3.3
10.		Lagrange multipliers - KKT conditions	4.1
11.		Sufficient conditions and sensitivity analysis. Inequalities.	4.2, 4.3
12.		Convex Analysis (convex sets, convex functions, etc)	Notes
		Midterm exam	
		No classes (Spring break)	
		No classes (Spring break)	
13.		Convex duality, separation, weak duality	6.1
14.		Strong duality, applications	6.2, 6.3
15.		Penalty and multiplier methods	5.2
16.		Conic and semidefinite programming	Notes
		No classes (Patriot's day)	
17.		Interior point I (logarithmic barrier)	Notes
18.		Interior point II (primal-dual)	Notes
19.		Relaxations of hard problems	Notes
20.		Branch and bound, Lagrangian relaxation	6.5
21.		Nondifferentiable optimization, subgradients	7.1
22.		Proximal and Augmented Lagrangian methods	7.3
23.		Alternating Direction Methods of Multipliers	7.4
24.		Subgradients and cutting planes	7.5
25.		TBA / Review / Additional topics	
26.		Final exam (take home).	

References

[Ber16] D. P. Bertsekas. *Nonlinear programming.* Athena Scientific, 3rd edition, 2016.

[BNO03] D. P. Bertsekas, A. Nedić, and A. E. Ozdaglar. *Convex analysis and optimization.* Athena Scientific, 2003.

[BSS06] M.S. Bazaraa, H.D. Sherali, and C.M. Shetty. *Nonlinear programming: theory and algorithms.* Wiley-Interscience, 2006.

[BT97] D. P. Bertsekas and J. N. Tsitsiklis. *Introduction to Linear Optimization.* Athena Scientific, 1997.

[BTN01] A. Ben-Tal and A. Nemirovski. *Lectures on modern convex optimization.* MPS/SIAM Series on Optimization. Society for Industrial and Applied Mathematics (SIAM), 2001.

[BV04] S. Boyd and L. Vandenberghe. *Convex optimization.* Cambridge University Press, 2004.

[Nes03] Y. E. Nesterov. *Introductory lectures on convex optimization: A basic course*, volume 87. Springer, 2003.

[NN94] Y. E. Nesterov and A. Nemirovski. *Interior point polynomial methods in convex programming.* Studies in Applied Mathematics. SIAM, 1994.

[NW99] J. Nocedal and S. J. Wright. *Numerical Optimization.* Springer, 1999.