Optimization Topics List

Revised July 2014

Starting in Fall 2014, we will adopt the reading list below. The format of the exam will be to answer 4 out of 5 questions drawn from material in the courses CS525, CS526, CS720, CS726, and CS730. (The course CS526 is equivalent to offerings of CS635 from Spring 2014 and earlier.) If one of these courses was not offered in the three semesters preceding a qualifying exam, the qualifying exam will not include questions based on that course.

Linear Programming

- Primal simplex method
- Dual simplex method
- Duality theory
- Parametric programming and sensitivity analysis
- Degeneracy
- Linear complementarity problems
- Interior point methods

Primary references

1. M. C. Ferris, O. L. Mangasarian & S. J. Wright, *Linear Programming with MATLAB*, SIAM, 2007
2. D. Bertsimas and J. Tsitsiklis, *Introduction to Linear Optimization*, Athena Scientific, 1997
3. R. J. Vanderbei, *Linear Programming: Foundations and Extensions*, Kluwer, 1996

Integer Programming

- Modeling
- Branch and bound methods
- Cutting plane methods
- Decomposition: Lagrangian relaxation and column generation. Benders decomposition.
- Polyhedral theory
- Valid inequalities

Primary references

1. G. Nemhauser and L.A. Wolsey, *Integer and Combinatorial Optimization*, Wiley, 1988.
2. L. A. Wolsey, *Integer Programming*, Wiley, 1998

Nonlinear Programming

- Optimality conditions:
  - first-order conditions (including Karush-Kuhn-Tucker conditions for constrained optimization)
  - second-order necessary and sufficient conditions
  - constraint qualifications
- Theorems of the alternative
- Geometry of convex sets
- Convex functions and their conjugates
- Duality
- Unconstrained optimization theory and algorithms:
  1. first-order methods
  2. line search and trust-region approaches
  3. Newton's method and variants
  4. quasi-Newton methods
  5. conjugate-gradient
  6. derivative-free optimization
  7. least-squares problems
  8. stochastic gradient methods
- Constrained optimization theory and algorithms
  1. Gradient projection methods
  2. Penalty and merit functions
  3. Augmented Lagrangian
  4. Sequential quadratic programming
  5. Interior-point methods
  6. Stability and sensitivity
  7. Semidefinite programming

Primary references

1. J. Nocedal and S. J. Wright, *Numerical Optimization*, 2d Ed., Springer, 2006
2. A. Ruszczynski, *Nonlinear Optimization*, Princeton, 2005.
3. S. Boyd and L. Vandenberghe, *Convex Optimization*, Cambridge University Press, 2004. (Available for download at `http://www.stanford.edu/~boyd/cvxbook/`)
4. R.T. Rockafellar, *Convex Analysis*, Princeton, 1970

Optimization Modeling

- Buliding optimization models within a modeling language
- Modeling techniques using binary and integer variables
- Large scale linear and nonlinear programming models and solution
- Visualization and interfacing optimization to applications

Primary references

1. A. Brooke, D. Kendrick, A. Meeraus, and R.Raman, *GAMS: A User's Guide* (available with other documentation at `http://www.gams.com/docs/document.htm`)
2. R. Fourer, D.M. Gay, and B.W. Kernighan, *AMPL: A Modeling Langauge for Mathematical Programming, 2d Ed.*, Duxbury Press, Belmont, CA, 2002.
3. H.P. Williams, *Model Building in Mathematical Programming, 4th Ed.*, Wiley, 1999.