

Optimization Topics List

Revised October 2014

Starting in Spring 2015, we will adopt the reading list below. The format of the exam will be to answer 4 questions drawn from material in the courses CS525, CS635, CS720 and CS726.

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
- Theorems of the alternative
- Geometry of convex sets, convex functions and their conjugates
- Unconstrained optimization theory and algorithms:
 1. first-order methods, including stochastic gradient methods
 2. line search and trust-region approaches, including conjugate-gradient
 3. Newton's method, quasi-Newton methods and variants
 4. derivative-free optimization
 5. least-squares problems
- Constrained optimization theory and algorithms
 1. Duality and constraint qualifications
 2. Gradient projection methods
 3. Penalty and merit functions

Primary references

1. J. Nocedal and S. J. Wright, *Numerical Optimization*, 2d Ed., Springer, 2006
2. A. Ruszczyński, *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

- Building optimization models within a modeling language
- Modeling techniques using binary and integer variables
- Large scale linear and nonlinear programming models and solution
- Modeling economic problems within a modeling language
- 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 Language for Mathematical Programming*, 2d Ed., Duxbury Press, Belmont, CA, 2002.
3. H.P. Williams, *Model Building in Mathematical Programming*, 4th Ed., Wiley, 1999.