

Algebraic, Geometric, and Combinatorial Methods for Optimization

MSRI summer graduate workshop

August 2–13, 2010

Bibliography prepared by Matthias Koeppel

1. Suggested reading as a preparation for the workshop

On **basic convexity** (convex sets, faces, extreme points, duals) and **linear programming**:

- Barvinok, A. (2002) A course in convexity, Graduate Studies in Mathematics 54, AMS, Providence, RI.
Chapters 1, 2 and 4.

Alternative source for convexity facts:

- Schneider, R. (1993) Convex bodies: The Brunn–Minkowski theory, Encyclopedia of Mathematics and its Applications 44, Cambridge University Press, Cambridge.
Chapter 1 and Section 2.1.

On the basics of **general integer programming**:

- Bertsimas, Weismantel, “Optimization over Integers”
- Nemhauser, G. L. & Wolsey, L. A. (1999) Integer and combinatorial optimization, Wiley, NY

Additional texts on **mathematical optimization**:

Ben-Tal, A. & Nemirovskii, A. S. (2001) Lectures on modern convex optimization:

Analysis, algorithms, and engineering applications, MPS-SIAM Series on Optimization, SIAM: Mathematical Programming Society, Philadelphia

Boyd, S. P. & Vandenberghe, L. (2004) Convex optimization, Cambridge University Press, Cambridge

Chvátal, V. (1983) Linear programming, A Series of Books in the Mathematical Sciences, W. H. Freeman, NY

de Klerk, Etienne (2002) Aspects of semidefinite programming: Interior point algorithms and selected applications, Applied Optimization 65, Kluwer, Dordrecht

Lee, J. (2004) A first course in combinatorial optimization, Cambridge Texts in Applied Mathematics, Cambridge University Press, Cambridge

Schrijver, A. (1986) Theory of linear and integer programming, Wiley-Interscience series in discrete mathematics and optimization, Wiley, Chichester

Shevchenko, V. N. (1997) Qualitative topics in integer linear programming, Translations of Mathematical Monographs 156, AMS, Providence, RI

On **polytopes**:

Grünbaum, B. (2003) Convex polytopes, 2nd ed., Graduate Texts in Mathematics 221, Springer, NY

Hibi, T. (1992) Algebraic combinatorics on convex polytopes, Carlaw, Glebe, Australia

Sturmfels, B. (1996) Gröbner bases and convex polytopes, University Lecture Series 8, AMS, Providence, RI

Ziegler, G. M. (2007) Lectures on polytopes, Corrected and updated printing of the 1st edition, Graduate Texts in Mathematics 152, Springer, NY

On the basic notions of **computational complexity**:

- for instance:
Papadimitriou, C. H. & Steiglitz, K. (1982) Combinatorial optimization: Algorithms and complexity, Prentice Hall, Englewood Cliffs, NJ
- or any other source

On enumerative combinatorics and **generating functions**:

Beck, M. & Robins, S. (2007) Computing the continuous discretely: Integer-point enumeration in polyhedra, Undergraduate Texts in Mathematics, Springer, NY

Stanley, R. P. (2002) Enumerative combinatorics, 1, Cambridge Studies in Advanced Mathematics 49, Cambridge University Press, Cambridge

Stanley, R. P. (1999) Enumerative combinatorics, 2, Cambridge Studies in Advanced Mathematics 62, Cambridge University Press, Cambridge

2. Focused and advanced reading on the topics of the workshop

For part 1 and 2, on nonnegative polynomials and sums of squares, and geometric facts about the cone of PSD matrices, and real algebraic geometry: (papers)

Bochnak, J., Coste, M., & Roy, M.-F. (1998) Real algebraic geometry, Springer, Berlin

Ramana, M. & Goldman, A. J. (1995) Some geometric results in semidefinite programming, *Journal of Global Optimization* 7(1):33–50, DOI: 10.1007/BF01100204

Reznick, B. (2000) Some concrete aspects of Hilbert's 17th problem, in Real algebraic geometry and ordered structures (Baton Rouge, LA, 1996), Delzell, C. N. & Madden, J. J., eds., *Contemporary Mathematics* 253, pp. 251–272, AMS, Providence, RI

For part 3, on n-fold integer programming:

- Shmuel Onn, *Nonlinear Discrete Optimization: An Algorithmic Theory*, Zurich Lectures in Advanced Mathematics, European Mathematical Society, in press, 2010

- Shmuel Onn, Theory and applications of n-fold integer programming: http://ie.technion.ac.il/~onn/Preprints/n-fold_ip.pdf
- Shmuel Onn, Lectures on Nonlinear Discrete Optimization: <http://ie.technion.ac.il/~onn/Nachdiplom/>

For part 4, on geometry of numbers and rational generating functions:

M. Köppe, Lecture notes “Geometry of Numbers and Rational Generating Function Techniques for Integer Programming”, available on the MSRI website

Barvinok, A. (2008) Integer points in polyhedra, Zurich Lectures in Advanced Mathematics, European Mathematical Society, Zurich

Beck, M. et al., eds. (2008) Integer points in polyhedra, AMS-IMS-SIAM Joint Summer Research Conference on Integer Points in Polyhedra: Geometry, Number Theory, Representation Theory, Algebra, Optimization, Statistics (Snowbird, UT, 2007) *Contemporary Mathematics* 452, AMS, Providence, RI

J. A. De Loera, R. Hemmecke, M. Köppe, and R. Weismantel. Integer polynomial optimization in fixed dimension. *Mathematics of Operations Research*, 31(1):147–153, 2006b.

J. A. De Loera, R. Hemmecke, M. Köppe, and R. Weismantel. FPTAS for optimizing

polynomials over the mixed-integer points of polytopes in fixed dimension. *Mathematical Programming, Series A*, 118:273–290, 2008a. doi: 10.1007/s10107-007-0175-8.

J. A. De Loera, R. Hemmecke, and M. Köppe. Pareto optima of multicriteria integer linear programs. *INFORMS Journal on Computing*, 21(1):39–48, Winter 2009b. doi: 10.1287/ijoc.1080.0277.

M. Köppe, S. Verdoolaege, and K. M. Woods. An implementation of the Barvinok–Woods integer projection algorithm. *Information Theory and Statistical Learning (ITSL 2008)*, Las Vegas, Proceedings, 2008b.

3. Relevant Internet resources

- Convex Algebraic Geometry wiki: <http://math.berkeley.edu/~philipp/cagwiki>
- Software package *LattE macchiato*: <http://www.math.ucdavis.edu/~mkoeppelatte/>
- Software package *4ti2*: <http://www.4ti2.de/>