

[Review published in *SIAM Review*, Vol. 58, Issue 1, pp. 164.]

Introduction to Nonlinear Optimization: Theory, Algorithms, and Applications with MATLAB. By Amir Beck. SIAM, Philadelphia, 2014. \$89.00. xii+282 pp., softcover. ISBN 978-1-611973-64-8.

This text provides an introduction to the theory and algorithms of finite dimensional optimization with many nice examples and descriptions of MATLAB code for doing particular procedures. It is an appropriate textbook for an introductory class on numerical optimization with modest mathematical prerequisites but appears also to be useful for those needing a self-study text. It hits a sweet spot in its balance of the mathematical analysis of optimization problems, the numerical computation of optima, and the development of codes for particular types of problems. The text includes a number of deftly chosen examples that illustrate condition issues, convexity and differentiability questions, and other observed phenomena.

The mathematical and computational prerequisites for the text are minimal; the book is accessible to anyone with some knowledge of linear algebra and multivariable calculus—and even the basic definitions of these topics are provided in Chapter 1. However, the book is definitely aimed at a mathematically capable audience, as much of the material is presented in a definition/theorem/proof format. Students who are not so interested in careful definitions and proofs may also learn from this text, as there are plenty of examples and exercises that illustrate the issues, as well as MATLAB and heuristic code for implementing various algorithms.

An issue for any introductory course is the selection of topics that can be adequately covered in the course. This text starts with four chapters devoted to unconstrained optimization: one each on optimality conditions, linear and nonlinear least squares problems, gradient methods, and Newton-type methods. The first three of these give nice succinct treatments with an emphasis on gradient-based methods. But there is no analysis of conjugate gradient

methods, and many will find the section on Newton's method too brief even for a first course. Most of the examples treat low-order polynomials with a concentration on quadratic and quartic functions. This is done in less than 90 pages, so an instructor using this as a text may well want to add more material on other algorithms or further develop topics such as step-length choices.

Chapters 6 through 12 introduce convex sets, functions, and optimization on convex sets. Again the treatment is selective and economical, with many specific examples and discussion of good algorithms for many problems. Chapters 10 and 11 give a good introduction to the KKT conditions and their applications to a range of examples. Finally Chapter 12 provides an innovative discussion of convex duality with some nice examples.

The material covered has been carefully curated and may not include many people's favorite topics or algorithms. This also means the text is only about a half to a third of the size of some of the currently standard texts, and nowhere near as intimidating. The book is well written, easy to follow, and likely to be quite attractive to those students who primarily want to write code for doing computations. There are full proofs of the main results so students can understand why various results hold, but there also are lots of examples and exercises that enable students to see how the results are used and what their limits may be. It covers a good range of topics in a student-friendly manner and in a way that encourages experimentation and computation with simple problems.

I definitely recommend that anyone teaching a first computational optimization course consider this as a possible text. While many instructors are likely to want to add some topics to the material covered here, this book provides a nice introduction to the theory and practice of computational optimization.

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