someone, with an interest in applications, who is unwilling to learn elementary functional analysis. Euler would feel completely at home with this text.

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26[65-02, 65Kxx, 90Cxx].—R. FLETCHER, *Practical Methods of Optimization*, 2nd ed., Wiley, Chichester, 1987, xiv+436 pp., $23\frac{1}{2}$ cm. Price $53.95.

The development of optimization methods played a particularly vigorous role in the surge of numerical mathematics following the advent of electronic computing. Constrained optimization took center stage, first starting in the late 1940's with the development of linear and nonlinear programming by Dantzig, Charnes, Frisch, Zoutendijk, just to name a few. In the late 1950's Davidon's variable metric method, its subsequent analysis and independent work by Fletcher and Powell, yielded an entirely new perspective on the endeavor of unconstrained optimization, which at the time—hard as it is to comprehend now—was largely considered routine. Both aspects of optimization have been enriched by progress in numerical linear algebra, and their methodologies are indeed unthinkable without it.

This flourishing field, as described by one of its foremost pioneers, is the topic of this meticulously crafted book. It provides a concise, coherent, and no-nonsense description of the major practical techniques, together with evaluations and recommendations based on the author's extensive experience. His discussions touch on many alternatives and extensions to key ideas, placing them also in historical context. Experience and experiment are stressed throughout, and the text is correspondingly interspersed with illuminating numerical examples. Key theorems are stated and proved rigorously. A rich variety of exercises at the end of each chapter deepens the understanding and furnishes important additional detail. The entire material is supported by a carefully selected, yet complete, bibliography. There are only very occasional lapses into technical jargon, my favorite being "all pivots > 0 in Gaussian elimination without pivoting" (page 15). All in all, a highly recommended reading for those acquainted with the fundamentals of numerical linear algebra and multivariate calculus.

The division into two parts, on "unconstrained" and "constrained" optimization, respectively, reflects two different flavors of methodology. Each part had previously been published as separate volumes [1], [2], with the first part reprinted twice. The second edition, now combining both volumes, deepens the descriptions of key subjects in the first part and expands the subject matter of the second. Thus, in the first part, the Dennis-Moré characterization of superlinear convergence in nonlinear systems has been included and the important Chapter 2 has been substantially reorganized. In the second part, a section on "network programming", as well as a brief discussion of Karmarkar's interior point method, have been added. The reader will also find many new and stimulating questions in the problem sections. The second edition offers definitely more than the first edition, while retaining the focus and the crispness of the previous exposition.

Chapters 1 through 6 form the first part. The emphasis is on finding "local" minimizers using local differential information, explicitly in the form of separately computed gradients, or implicitly by utilizing difference information. The thorny problem of determining "global" minimizers is only occasionally mentioned. Chapter 1 contains introductory material. The important Chapter 2 surveys the general structure of the methods and pays well-placed attention to the principles and algorithms for "line search", a feature in many of the subsequently discussed methods. Chapters 3 and 4 on Newton, quasi-Newton, and conjugate gradient methods form the core of the first part on unconstrained optimization. The final two chapters round out that material, featuring among others: trust regions, Levenberg-Marquardt techniques, the Newton-Raphson method and Davidenko continuation methods for solving systems of nonlinear equations, the theory of superlinear convergence.

Chapters 7 through 14 form the second part. Here "constrained optimization" is first and foremost the optimization of functions, generally excluding the large field of combinatorial optimization. Chapter 7 is again introductory. Chapter 8 features linear programming with emphasis on the simplex method and some of its variations such as "product form" and LU-factoring of the basis and Dantzig-Wolfe decomposition. Lagrange multipliers, first- and second-order optimality conditions, convexity and duality are introduced in Chapter 9 preparatory to the description of classical nonlinear programming in Chapters 10 through 12: quadratic programming, linearly constrained optimization, zigzagging, penalty and barrier functions, sequential quadratic programming, feasible directions. Integer programming is only briefly discussed, stressing branch-and-bound techniques. It shares Chapter 13 with sections on geometric programming and optimal flows in networks. The final Chapter 14 offers a unique self-contained treatment of nondifferentiable or, rather, piecewise differentiable optimization.

The book is a classic and invaluable for the practitioner as well as the student of the field.

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1. R. FLETCHER, *Practical Methods of Optimization, Vol.* 1: *Unconstrained Optimization*, Wiley, Chichester, 1980.

2. R. FLETCHER, *Practical Methods of Optimization, Vol.* 2: *Constrained Optimization*, Wiley, Chichester, 1981.

27[90–01, 90B99].—PANOS Y. PAPALAMBROS & DOUGLASS J. WILDE, *Principles of Optimal Design—Modeling and Computation*, Cambridge Univ. Press, Cambridge, 1988, xxi+416 pp., 26 cm. Price $49.50.

For anyone interested in modeling, model building, and in particular, optimization models and the interaction between optimization and the modeling process, this book is a must. It combines classical optimization theory with new ideas of