unsolved problems considered are Artin's conjecture on primitive roots and the Hardy-Littlewood conjectures on primes of special forms.

In discussing the frequency of Mersenne primes, the author in 1962 wrote on page 198, "A reasonable guess is that there are about 5 new (prime) M_p for $5000 < p < 50000$". In the 1978 additional chapter, Shanks stood by that guess even though four prime M_p had been found for $5000 < p < 21000$. Since 1978 three new prime M_p have been found for $21000 < p < 50000$, so that Shanks's 1962 prediction erred on the low side. Even Shanks has feet of clay.

It is natural to compare the work under review with another book on elementary number theory which has both a historical and an algorithmic emphasis, namely, Ore's Number Theory and its History. While Ore's book makes considerably easier reading and is therefore probably more suitable for beginners, Shanks's book penetrates more deeply and gives a better feeling for contemporary research, both theoretical and computational.

PAUL T. BATEMAN

Department of Mathematics
University of Michigan
Ann Arbor, Michigan 48104

2[3.10, 3.35].—MAGNUS HESTENES, *Conjugate Direction Methods in Optimization*, Springer-Verlag, New York, 1980, x + 325 pp., 24 cm. Price $29.80.

Conjugate direction methods are playing an increasingly important role in solving optimization problems and large sparse linear systems of equations. Magnus Hestenes' book on *Conjugate Direction Methods in Optimization* concentrates on deriving algorithms for finding critical points of real valued functions. The book gives a unified treatment of a large number of conjugate direction methods and their properties and is a rich source of research material and ideas.

The text is based on lectures given at the University of California, Los Angeles, and several other conferences. Valuable as it is, it will probably not be widely used for graduate or advanced undergraduate students. The typographical layout and especially the treatment of indices makes the reading difficult. An attempt to distinguish between vectors and scalars would have improved the readability.

The text consists of four chapters. The first, *Newton's Method and the Gradient Method*, contains introductory material only partially needed in the subsequent chapters. The results in the introductory chapter are somewhat misleading, like Theorem 4.1 and its proof. This result shows that a quasi-Newton method (called a modified Newton method)

$$x_{k+1} = x_k - H_k g(x_k)$$

for solving $g(x) = 0$ is (Q-) superlinear convergent if and only if $L^* = 0$ provided $\{x_k\}$ converges to a solution x^*. Here

$$L^* = \limsup_{k \to \infty} \|I - H_k G(x^*)\|$$

and $G(x^*)$ is the Jacobian matrix. This is wrong and could have been corrected by defining superlinear convergence in terms of the errors $\{x_k - x^*\}$ and not in terms of L^*.

The remaining three chapters are: *Conjugate Direction Methods*, *Conjugate Gram-Schmidt Processes* and *Conjugate Gradient Algorithms*. These chapters contain a unified treatment of each class of methods first derived for quadratic problems and then generalized to nonquadratic problems. The algorithms are stated in a concise manner with equivalent formulations mentioned in the text. The exercises at the end of each section are a valuable supplement and an integral part of the text.

There has long been a need for a book making this material available. Rich as the book is in algorithms, it is a valuable contribution to both theoretician and practitioner. Rounding errors are frequently discussed and alternative choices of the parameters are suggested. However, there are no complete error analyses. This is even more apparent when the matrix-vector product of the Hessian matrix and a vector is replaced by a finite difference approximation involving only gradients. This points to an open research area.

A textbook is still needed to cover a major area omitted; namely, solving large and sparse linear systems of equations and the use of preconditioning matrices. The references are incomplete and contain numerous misprints. The index should have been expanded to serve as a cross-reference and an author index should have been included.

TROND STEIHAUG

Department of Mathematics
Rice University
Houston, Texas 77001

3[2.10, 4.00].—A. H. STROUD, *Numerical Quadrature and Solution of Ordinary Differential Equations*, Appl. Math. Sciences, Vol. 10, Springer-Verlag, New York, 1974, xi + 338 pp., $25\frac{1}{2}$ cm. Price \$12.50.

The subtitle of this book reads "A Textbook for a Beginning Course in Numerical Analysis"; therefore one must not expect a monograph on the subject area specified in the title.

As an introduction, the text has a number of definite didactic merits. The level of mathematics used does not go beyond basic calculus and algebra, there are motivating and explanatory analytic and numerical examples throughout the book, proofs are either presented in all details, or omitted altogether (with references to relevant presentations). Thus, the text should be suitable for self-study as well as in the classroom. On the other hand, for an introduction to Numerical Analysis, the near neglection of round-off and the total neglection of the concept of condition is an essential weakness.

The selection of the material shows a wise restriction to fundamental problems and methods; even so there are a number of commendable features: One is the systematic use of Peano kernel error terms, with a detailed discussion of their implications, including a large number of graphs of Peano kernel functions for the situations under discussion; this also leads to a more qualified evaluation of the merits of Gauss quadrature formulas. The Riemann sum character of reasonable quadrature formulas is pointed out.