REVIEWS AND DESCRIPTIONS OF TABLES AND BOOKS

The numbers in brackets are assigned according to the revised indexing system printed in Volume 28, Number 128, October 1974, pages 1191–1194.

10[3.10, 3.20].—J. J. DONGARRA, J. R. BUNCH, C. B. MOLER & G. W. STEWART, *LINPACK User's Guide*, SIAM, Philadelphia, Pa., 1979. Price $14.00, $11.20 to SIAM members.

This book is more than a guide for users of LINPACK subroutines. LINPACK is a package of well-structured, portable, Fortran subroutines that solve linear systems of equations and some related problems. The related problems include ordinary least-squares, inverses, determinants, and the condition estimator for the solution of linear systems of equations. The software, and thus this guide for users, addresses computations for dense matrices.

The preface presents the background and the goals of LINPACK, a three-year project sponsored jointly by the National Science Foundation and the Department of Energy. The introduction gives an overview of the linear systems problems in LINPACK, the structure of the subroutines, the naming conventions and the software design. General numerical properties having to do with rounding errors, accuracy of computed results, and detection of singularity are discussed. The introduction contains an especially good discussion on the need and strategies for scaling; a section that should be studied by originators of linear systems problems.

The book contains eleven chapters, references, and four appendices. Each chapter addresses a particular decomposition, and most of the chapters contain background numerical information, algorithmic details, directions for use of the subroutines, and programming and performance details. LINPACK includes subroutines for LU decomposition, QR orthogonal factorizations by Householder transformations, Cholesky decomposition, and the singular value decomposition. Matrices of special structure are treated separately and include positive definite symmetric, symmetric indefinite, positive definite band, triangular, and tridiagonal matrices. A separate chapter treats updating QR and Cholesky decompositions. The notation used in the chapters on QR and the singular value decompositions is taken from the statistical model, $y = X\beta + e$. The notation in other chapters follows that of standard numerical linear algebra, $Ax = b$.

The four appendices include the Basic Linear Algebra Subprograms, timing data, program listings for the real single precision subroutines in LINPACK, and the BLA listings. LINPACK, itself, contains single and double precision real and complex versions of the software, which can be obtained on tape from the National Energy Software Center or from International Mathematical and Statistical Libraries, Inc.

The subroutines in LINPACK are well-documented. The LINPACK *User's Guide* will be useful to the naive or sophisticated user of LINPACK. Furthermore, the book will be extremely useful to teachers and students of linear algebra. Students in computer

0025-5718/80/0000-0126/$02.50

science can gain a lot of information about numerical computation and mathematical software by reading this book. Potential users of software for linear systems are well-advised to use the LINPACK subroutines rather than attempting to write software for linear systems in specific applications.

We offer a few criticisms of LINPACK and the *User's Guide.* Figures 1–7 are awkward to read because of the condensed form in which they are printed. The subroutines in LINPACK use the Basic Linear Algebra Subroutines, and the overhead of their subroutine calls degrades the computation time for matrices of reasonably low order. The preprocessor, TAMPR, used to generate type and precision for LINPACK could have generated code without the Basic Linear Algebra Subroutines. Such code would be useful in practice.

Finally, strict portability requires that machine-dependent constants not be used. Practice shows, however, that the skewness of the range of arithmetic (given side-effects of underflow) on many machines presents problems in orthogonal factorizations used in iteratively reweighted and nonlinear least-squares. Perhaps subsequent editions of *LINPACK User's Guide* will indicate how LINPACK subroutines can be modified to avoid such side-effects in applications subsystems.

VIRGINIA KLEMA

Laboratory for Information and Decision Systems
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

11[2.05.5].—J. GILEWICZ, *Approximants de Padé,* Lecture Notes in Math., Vol. 667, Springer-Verlag, New York, xiv + 511 pp. Price $21.00.

The importance of Padé approximants in various fields of mathematics, physics and chemistry is now well known. The literature on the subject is quite extensive and, although several books recently appeared, it was necessary to write a synthesis including topics connected with the subject such as totally monotonic functions, to make the definitions precise and to study in detail some questions such as the block structure of the Padé table and algorithms for computing its elements.

Gilewicz's book is a very dense one which covers all these problems and also many others. It is certainly the most extensive treatise on the subject now available (a book by G. A. Baker, Jr. and P. R. Graves-Morris will appear in the near future).

The first four chapters deal with the mathematical concepts which are useful for the remainder of the book. Chapter 1 is an introduction to sequences and series, extrapolation processes, convergence acceleration, difference operators, Hankel determinants and the c-table. Chapter 2 is a complete study of totally monotonic functions and sequences. It contains very nice results, obtained with M. Froissart, on necessary and sufficient conditions for a function to be totally monotonic and on infinite interpolation. A correct proof of a theorem by S. Bernstein is given. The connection with totally monotonic sequences is extensively studied, which leads to new results for such sequences. Chapter 3 deals with the properties of two classes of functions for which the convergence of sequences of Padé approximants has been proved and also with the