cavity flows, corner flows and wakes are particularly instructive. The subsequent chapter, concerned with stream function—vorticity formulation, is more limited since it is confined to two-dimensional flows. The final chapter on transport processes appears to be of more academic interest than the earlier three chapters, although it does contain interesting remarks on numerical techniques.

The main text concludes with an impressive list of references. As a whole, the book covers new ground in Computational Techniques for Fluid Mechanics. It is clearly written and aids the understanding of a valuable approach only partially appreciated by those presently working in Computational Fluid Dynamics. The inclusion of a set of examples at the end of each important section enhances the value of the volume as a graduate course text.

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3[15–02, 65F50].—I. S. DUFF, A. M. ERISMAN & J. K. REID, *Direct Methods for Sparse Matrices*, Monographs on Numerical Analysis, Clarendon Press, Oxford, 1986, xiii+341 pp., 24 cm. Price $42.50.

Iain Duff, Al Erisman, and John Reid have made an outstanding contribution to the literature on sparse matrices. *Direct Methods for Sparse Matrices* contains a wealth of information which is extremely well organized and is presented with exceptional clarity. The book will be a valuable addition to the libraries of practitioners whose problems involve working with sparse matrices; it also includes many fine exercises and is suitable for use as a textbook at the graduate or upper division undergraduate level. In addition, selected topics addressed in this book could profitably be included in courses not dedicated exclusively to sparse matrices, such as courses in data structures, algorithms, or numerical linear algebra.

Readers of *Direct Methods for Sparse Matrices* are assumed to be familiar with elementary linear algebra and to have some computing background. Other background material is included in the first four chapters. Students and general readers will appreciate finding that the concepts and techniques presented are illustrated with examples throughout. Practitioners whose primary goal in consulting this book is selection of library subroutines to solve their problems will find practical direction in the choice of library routines for specific problems. The authors draw on their extensive computational experience in making recommendations of one procedure over another for particular applications. Researchers will find a very well-organized survey of sparse matrix techniques along with abundant references to appropriate literature for more extensive exposition.

The first four chapters contain introductory material. In Chapter one, sparsity patterns are related to elementary concepts in graph theory, and issues associated with the efficient use of advanced computer architectures are introduced. Chapter two introduces data structures that are suitable for storing, accessing, and performing operations on sparse matrices and vectors. A summary of computational issues associated with Gaussian elimination performed on dense matrices constitutes Chapters three and four.

Means of exploiting sparsity in the solution of large linear systems are introduced in Chapter five, with emphasis on Gaussian elimination. This chapter contains an outline of the organization and objectives of available library routines. Chapter six contains explanations of informally stated algorithms for reducing general sparse matrices to block triangular form, along with a description of the class of matrices for which such reduction is likely to be possible and useful.

In Chapter seven, several heuristic strategies for selecting orderings of equations are presented in an attempt to maintain sparsity in matrix factorization without sacrificing stability of the factorization. Strategies discussed in this chapter are *local*, meaning that the selection process consists of choosing the ordering one equation at a time with the aim of keeping the amount of fill-in that occurs as a result of the current selection small; these strategies do not consider effects on subsequent steps. The Markowitz criterion, the minimum-degree strategy, and extensions and modifications to them are among the strategies discussed. Balance between maintaining sparsity and stability is also addressed, and specific recommendations are made. Chapter eight addresses preservation of sparsity through the *global* strategy of a priori permutation to desirable forms, such as band and variable-band matrices, block tridiagonal, bordered block diagonal, bordered block triangular, or spiked matrices. Several algorithms for ordering matrices to desirable forms are given, explained, and illustrated with examples. They include Cuthill-McKee, reverse Cuthill-McKee, Gibbs-Poole-Stockmeyer, one-way dissection, nested dissection, the Hellerman-Rarick procedures P^3 and P^4, and a variant due to Erisman, Grimes, Lewis, and Poole, termed P^5.

Implementation details of ordering and solution techniques are presented in Chapters nine and ten. The focus of Chapter nine is analysis of sparsity pattern along with numerical values, so that a matrix factorization is actually carried out as the analysis proceeds. Chapter ten considers analysis of sparsity patterns independent of the numerical factorization phase. Chapter nine details implementation of the Markowitz criterion combined with threshold pivoting for balance between preservation of sparsity and stability of the factorization, the Doolittle decomposition, and the solution phase for sparse linear systems. The authors also include in Chapter nine a discussion of the use of drop tolerances (dropping entries smaller than a specified absolute or relative tolerance) to preserve sparsity. Implementation details are given in Chapter ten for a solution process by phases of: ordering to preserve sparsity, symbolic factorization, numerical factorization, and solution. Special techniques for band and variable-band matrices are included here, along with a discussion of their ability to exploit vector and parallel architectures. A variation of the variable-band technique called the frontal method, and a generalization called the multifrontal method, are explained in detail.

In Chapter eleven, the solution of huge systems is approached through partitioning, tearing, and perturbation to a more easily solved system. Efficient implementation of the Sherman-Morrison-Woodbury formula to adjust the solution of the perturbed system is outlined. A cautionary note concerning the stability of such procedures is included.

The concluding chapter, Chapter twelve, is devoted to a collection of sparsity issues aside from the solution of sparse linear systems. Notable inclusions in this chapter are the Curtis-Powell-Reid algorithm for efficient calculation of sparse Jacobian estimates and an algorithm of Toint for updating sparse Hessian approximations for quasi-Newton calculations. (Unfortunately, positive definiteness of the approximate Hessian is not retained.) The open question of sparsity-constrained backward error analysis is also discussed.

Direct Methods for Sparse Matrices will be a valuable addition to the bookshelf of every reader interested in the solution of large sparse problems.

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4[62–04].—PETER LANE, NICK GALWAY & NORMAN ALVEY, *Genstat 5—An Introduction*, Clarendon Press, Oxford, 1987, xii+163 pp., $25\frac{1}{4}$ cm. Price \$45.00.

GENSTAT is a general statistics program designed to analyze data with the help of a computer. It combines the advantages of a programming language like FORTRAN with those of specialized "canned packages" like SAS or SPSS.

The Genstat 5 introduction by Lane, Galway & Alvey is designed to help the beginner getting started. It covers only the basic features and a few selected statistical methods like plots of data, linear regression, tabulation of data, and analysis of designed experiments. The reader is carefully guided from the first steps of reading and writing data to the actual statistical analyses and to the writing of more complicated Genstat programs. The numerous examples and exercises provide ample opportunity to gain experience with Genstat. I liked particularly the refreshing, nontechnical style in which the book has been written, and I am sure that students will find pleasure in learning to analyze data using this introductory guide. My only criticism of the book is its relatively high price.

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5[62Q05, 62E15, 62F07, 62J15, 62H10].—R. E. ODEH, J. M. DAVENPORT & N. S. PEARSON (Editors), *Selected Tables in Mathematical Statistics*, Vol. 11, Amer. Math. Soc., Providence, R.I., 1988, xi+371 pp., 26 cm. Price \$46.00.

This volume includes tables constructed by R. E. Bechhofer and C. W. Dunnett of selected percentage points of the central multivariate Student t distribution in which there is a common variance estimate on ν degrees of freedom in the denominators of the variates, and the numerators either are equicorrelated (Tables A and B) or have a certain block correlation structure (Tables C and D).

Tables A and B (which practically cover the volume) provide in the equicorrelated (ρ) case one-sided and two-sided equicoordinate 80, 90, 95, and 99 percentage