The applications given in Chapter 7 are, to my mind, disappointing. Except for singular isoparametric elements in corner problems and first-order hyperbolic problems, the rest (seven) of the applications are in one space dimension. This hardly reflects the state of the art, either regarding applications or theory.

It is the privilege of a reviewer to quibble with minor details:

Exercise 1.15 (p. 20) is wrong as stated; rotation by 90° in the plane provides a counterexample.

On p. 23 the authors state: "It will be shown in later chapters that the most natural error bounds are defined in terms of Sobolev norms." Apart from the overall logic of this sentence, I quarrel with the word "natural". Most convenient error measure, yes; a lazy man's error measure, yes; but hardly the most natural error measure in general for a serious Numerical Analyst.

On p. 47 the complete quintic element is dismissed as being "of little practical use and will not be considered further". Fix and Strang in their 1973 book call the C^1 quintic "one of the most interesting and ingenious of all elements" (p. 82). Fashions change, or, should one take statements such as those seriously ...?

The corollary on p. 195, dealing with pointwise error estimates in piecewise linear finite elements for second-order elliptic problems, reproduces a well-known error for the exponent of the logarithmic factor. The examples of "sharpness" quoted are merely suggestive. A true example was constructed by Haverkamp in 1982.

The reference on p. 248 to Dupont's 1973 paper has nothing to do with "an alternative approach to the solution of hyperbolic equations". The article in question contains an extremely interesting counterexample.

In conclusion, this is a well-written and comprehensive text for a first course in finite elements for graduate students in Mathematics, or for self study for someone seriously interested in educating himself on the subject. It starts from scratch and quickly moves up to describe rather recent research.

L. B. W.

3[65–04].—WILLIAM H. PRESS, BRIAN P. FLANNERY, SAUL A. TEUKOLSKY & WILLIAM T. VETTERLING, *Numerical Recipes—The Art of Scientific Computing*, Cambridge Univ. Press, Cambridge, 1986, xx + 818 pp., 24 cm. Price $39.50.

The following quote from the Preface to *Numerical Recipes—The Art of Scientific Computing* (hereafter abbreviated *NR*) should help convey the spirit of the book: "... this book is indeed a 'cookbook' on numerical computation. However there is an important distinction between a cookbook and a restaurant menu. The latter presents choices among complete dishes in each of which the individual flavors are blended and disguised. The former—and this book—reveals the individual ingredients and explains how they are prepared and combined." To extend the analogy a bit, *NR* does not teach one to be a master chef, and it rarely recommends an occasional meal prepared by one.

The Preface claims the reader to need a "normal" undergraduate mathematics background and some computer programming experience, but no prior knowledge of numerical analysis. To indicate the scope of this book, a list of the chapter titles follows: 1. Preliminaries; 2. Solution of Linear Algebraic Equations; 3. Interpolation and Extrapolation; 4. Integration of Functions; 5. Evaluation of Functions; 6. Special Functions; 7. Random Numbers; 8. Sorting; 9. Root Finding and Nonlinear Sets of Equations; 10. Minimization or Maximization of Functions; 11. Eigensystems; 12. Fourier Transform Spectral Methods; 13. Statistical Description of Data; 14. Modeling of Data; 15. Integration of Ordinary Differential Equations; 16. Two Point Boundary Value Problems; 17. Partial Differenital Equations.

NR contains complete listings of approximately 200 Fortran subprograms implementing the numerical methods described in the text. There is a list of these subprograms by section after the table of contents and an alphabetized list at the end, with cross-references to other routines called. Pages 673–790 contain translations of those subprograms into Pascal. Machine-readable copies of these subprograms are available on DOS diskettes for the IBM PC and compatible computers at $19.95 per language. At first blush, this book appears to be merely a user's guide to the software, but this is not quite accurate. There are many instances in which the text contains valuable information on how and when to use the methods.

The scope of coverage is extremely ambitious. It is hard to know how to classify *NR*. This is not a mathematics book: It contains no proofs of the claimed properties of the methods under discussion. In its defense, however, *NR* does include numerous references to other literature where one may find out more about the methods. This is not a numerical analysis book: Although occasional lip service is paid to roundoff error and numerical stability, most of the programs are straightforward implementations of the formulas given in the text. That the authors are scientists or engineers (abbreviated s/e below), rather than mathematicians, is revealed by phrases like "down to the last possible epsilon of accuracy" (page 95), or "remains finite in some region where x is zero" (page 204).

Although *NR* exhibits moments of brilliance and includes a wealth of valuable information for the practicing s/e, I am afraid that a specialist in the area represented by almost every chapter will find something to find fault with. Several examples should help illustrate the unevenness in coverage in *NR*. In addition to the standard methods, Chapter 2 includes sections on solving Vandermonde and Toeplitz systems and sparse linear systems (one of the few times the reader is referred to existing quality software). It includes an algorithm for singular value decomposition, billed as "the method of choice for ... linear least squares problems", but not the less expensive QR factorization. (QR is mentioned as an alternative in Chapter 14, but there is no way the reader could figure out how to use it from the material in this book.) Although Chapter 4 includes a treatment of integrals with singularities not normally found at this level, there is no mention of adaptive quadrature, which is the basis of much current software in this area. Chapter 15 exhibits an obvious bias against predictor-corrector methods, ignoring the success of many respected software packages based on such methods and downplaying the shortcomings of Runge-Kutta methods. It is almost as though the authors are saying, "If you can't write it yourself, you shouldn't use it."

Some aspects of the programming style also make *NR* not a source of quality mathematical software. In most cases, encountering an erroneous input or reaching an unexpected case simply results in a program stop. Many of the routines depend heavily on saved internal variables, without even the benefit of an explicit SAVE declaration. Most routines use locally declared temporary storage, rather than input work arrays. (Notable exceptions are the routines in Chapter 8, which appear to have been taken largely from another source.) Further, the size of such arrays and the precision to which constants are given make it clear that the authors have in mind the solution of small problems on small machines. (However, the routines generally do not use double precision!) The authors would do well to read *Sources and Development of Mathematical Software*, Wayne R. Cowell, Ed., Prentice-Hall (Englewood Cliffs, NJ, 1984), and the references therein.

Despite comments to the contrary in the Preface, *NR* is not a textbook, for it contains no problems and very few examples. It is a reference book intended for the practicing s/e. In the Preface, the authors state: "Our purpose in this book is ... to open up a large number of computational black boxes to your scrutiny. We want to teach you to take apart these black boxes and to put them back together again, modifying to suit your specific needs." It is this aspect that makes this reviewer feel most uncomfortable. If one could be assured that the s/e would read all of the accompanying text, then in *most* cases he/she would be in a position to make intelligent use of these methods. Providing the software plus easy-to-modify example programs makes it easy to use them as "black boxes" (despite the authors' stated aversion to such) and/or transfer them to larger machines. However, *NR* contains virtually no information on how these methods will behave on large problems. *Caveat emptor*! Do not view *NR* as a bargain source of software.

There are a number of instances where one could take issue with the authors' choice of, or justification for methods. Unfortunately, however, there are also a number of instances of factual errors or misstatements. A list of them has been compiled by the reviewer and is available upon request.

This reviewer hereby acknowledges the assistance of his colleagues Mark Durst and Alan Hindmarsh in evaluating this book.

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4[65–04].—WILLIAM T. VETTERLING, SAUL A. TEUKOLSKY, WILLIAM H. PRESS & BRIAN P. FLANNERY, *Numerical Recipes Example Book* (*FORTRAN*), Cambridge Univ. Press, Cambridge, 1985, viii + 192 pp., $23\frac{1}{2}$ cm. Price $18.95. *Numerical Recipes Example Book* (*Pascal*), Cambridge Univ. Press, Cambridge, 1985, viii + 236 pp., $23\frac{1}{2}$ cm. Price $18.95.

As the title implies, *Numerical Recipes Example Book* is a set of examples to illustrate the use of the subprograms described in *Numerical Recipes* (hereafter abbreviated *NR*). The chapters are numbered and titled exactly the same as *NR*. Each chapter begins with a summary of the routines described in the corresponding chapter of *NR*. This is followed by a sequence of examples, in the same order as the routines in *NR* that they exercise. The nth example in chapter m has the name DmRn. An index shows which *NR* routines are demonstrated by which