22[65–04, 65M60, 65N30].—I. M. SMITH & D. V. GRIFFITHS, *Programming the Finite Element Method*, 2nd ed., Wiley, Chichester, 1988, xii+469 pp., 23 $\frac{1}{2}$ cm. Price $49.95.

The major objective of this text is to present the reader with an understanding of how finite element concepts are realized in computer software. This is accomplished rather effectively by means of a software "building block" technique whereby relatively complex programs may be assembled from a library of relatively simple, special purpose subroutines, each capable of carrying out some important step in the finite element analysis process. This device allows the reader a rather clear view of the overall process, since programs can be written quite compactly making use of building block subroutines.

The author very thoughtfully starts out by assembling subroutines into relatively narrow, simple programs and progresses to broader, more complex programs by modifications and additions.

The building block subroutines are categorized as either "black box" routines or "special purpose" routines. Black box routines are those associated with standard matrix handling procedures, and, as the name implies, little explanation of the bases of these routines is provided. Special purpose routines, on the other hand, accomplish some significant step in finite element analysis. Although a theoretical basis of each of these routines is presented, these discussions often seemed too abbreviated to provide adequate background for the finite element novice. It is recommended that reading of this text either be preceded by reading of an introductory finite element text or accompanied by a thorough classroom presentation of the finite element method.

A number of example programs are presented in the various chapters of the text. These presentations are enhanced by the availability of a summary of the functions of each special purpose subroutine in an appendix and a listing of each of these subroutines in another appendix. The reader may have to bounce back and forth in these various areas of the text as he/she reads, but this becomes relatively easy as familiarity with the arrangement increases. It will likely be important to many readers that all subroutines are available for a nominal charge on tape or diskettes for many computational environments. Fortran 77 is the language of choice for all subroutines and programs. Reading of programs and subroutines is made easier by use of mnemonics for subroutine names as well as variable names.

In general, this book is clearly written and well presented with few typographical errors or awkward constructions. Some readers may dislike use of examples from both solid and fluid mechanics. Also some examples make use of inefficient analysis procedures.

The positive aspects of the book far outweigh the negative aspects. It presents the broad picture of the basis of finite element software very clearly. The detailed picture of the basis of various finite element concepts is sometimes left incomplete or fuzzy from the point of view of the novice.

This book will make a fine addition to the library of anyone interested in finite element computer programming. It is viewed as complementary to the more detailed presentations of the finite element concepts found in other texts.

V. J. MEYERS

School of Civil Engineering
Purdue University
West Lafayette, Indiana 47907

23[35L65, 35L67, 65N05, 65N30, 76G15, 76H05].—S. P. SPEKREIJSE, *Multigrid Solution of the Steady Euler Equations*, CWI Tract 46, Centrum voor Wiskunde en Informatica (Centre for Mathematics and Computer Science), Amsterdam, 1988, vi+153 pp., 24 cm. Price Dfl.24.20.

The subject at hand is the numerical solution of the compressible inviscid equations of fluid dynamics, the Euler equations. Only steady state solutions are desired, though knowledge of properties of the unsteady Euler equations is required to derive suitable methods. These equations are of great interest in aerodynamics and turbomachinery applications. One goal of numerical algorithm designers in the field of computational fluid dynamics is to produce efficient, robust solvers that can be used as design tools on a routine basis. The designer must be able to vary some parameter, for example a geometrical quantity, in a specified parameter set, and study how the solution varies. The millennium is not yet upon us, though it is perhaps in sight for problems in two space dimensions.

This compact book (153 pages) presents a large amount of material in a remarkably clear and concise fashion. From a derivation of the Euler equations and general material on the Riemann problem for hyperbolic systems in Chapter 1, the author moves to a long chapter concerned with upwind discretizations of the Euler equations. The key ingredient is an approximate Riemann solver; the author prefers Osher's. All the modern apparatus of upwind schemes is clearly presented here: numerical flux functions, approximate Riemann solvers, total-variation diminishing schemes, monotonicity, and limiters. Noteworthy is the author's new, weaker, definition of monotonicity for a two-dimensional scheme, which evades the negative result of Goodman and Leveque that total-variation diminishing schemes in two space dimensions are at most first-order accurate. The new definition of monotonicity still rules out interior maxima and minima (for scalar equations) but does not preclude second-order accuracy. The third chapter gives a very brief description of the multigrid algorithm and shows some numerical solutions of a first-order accurate discretization. Practitioners in the field have found in the past few years that multigrid algorithms converge well for first-order accurate discretizations of steady fluid flow equations. The convergence is helped along by a large amount of numerical viscosity. Unfortunately, this large amount of numerical viscosity leads to unacceptable inaccuracy in the computed solutions. Multigrid algorithms applied directly to second-order discretizations (which would give acceptable accuracy) tend to converge slowly, if they converge at all. This motivates the fourth and last chapter, in which defect correction is used. This allows one to produce a second-order accurate solution, even though only problems corresponding to first-order accurate discretizations need to be solved. It seems that this is the first time defect correction has been used in the solution of any problem in computational fluid dynamics. Perhaps the use of defect correction here will spark more interest in the technique.