The study of numerical integration is restricted to standard methods (Newton-Cotes, Gaussian) and simple problems (no singularities, infinite intervals), and again the error analysis is emphasized. Romberg integration is presented but is not completely analyzed.

The treatment of linear equations is consistent with the author's philosophy, emphasizing error analysis, efficiency, and condition estimation (the latter at an elementary level). Convergence theory for iterative methods is presented in a manner so as to be understood without extensive matrix theory background, although matrix notation might be used more advantageously. The author has chosen to avoid eigenanalysis completely.

Many of the usual methods for the solution of a single nonlinear equation are considered; a simplified version of the Dekker-Brent algorithm nicely incorporates features of false position, secant, and bisection. The effect of rounding on interval methods, often overlooked in numerical analysis texts, is explained here. The author also discussed informatively the problem of starting iterative schemes, both in the search for real and complex roots.

The study of differential equations, initial and two-point boundary value problems, concludes the text. The presentation is not elaborate, only the most common Runge-Kutta and linear multistep methods being considered, but many important ideas of stability, error estimation and stepsize control are covered. While the difficulty of solving stiff equations is mentioned, there is no attempt to discuss methods appropriate for these problems.

This text is well-written, reasonably error free, and well-suited for a course to advanced undergraduate students, particularly those with a strong attraction to computing, since many of the exercises require significant programming for their successful completion, while many others require mathematical derivations not performed in the text.

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8[65M10, 65N10].– THEODOR MEIS & ULRICH MARCOWITZ, *Numerical Solution of Partial Differential Equations*, Appl. Math. Series 32, Springer-Verlag, New York, 1981, viii + 541 pp., $23\frac{1}{2}$ cm. Price $24.00.

This book, a translation of the German edition published in 1978, resulted from courses of lectures given at the University of Cologne. It consists of three parts and a set of appendices containing computer programs implementing some of the methods described in the text.

Much of Part I, which is entitled "Initial value problems for hyperbolic and parabolic differential equations", comprises a discussion of stability theory for difference schemes. There is an in-depth treatment of Lax-Richtmyer theory, and an extensive section devoted to Fourier transforms of difference methods for pure initial value problems with constant coefficients. The difference methods discussed are all classical and can be found, for example, in Richtmyer and Morton's book, as can much of the stability theory. In Part I, there are also brief sections on characteristic methods and extrapolation methods for first-order hyperbolic equations.

In the second part, which is considerably shorter than the first, as also is Part III, methods for solving elliptic boundary value problems are considered. Finite difference methods are presented in a very general framework which tends, unfortunately, to conceal their relative simplicity. The discussion is devoted almost entirely to problems with Dirichlet boundary conditions; very little mention is made of the treatment of derivative boundary conditions in this chapter, indeed, throughout the book. The section on variational methods is rather superficial, the examples given of finite element methods being designed to show that, with certain choices of approximating subspaces and basis functions, one obtains well-known difference methods. The merits of the finite element method are listed but none of the difficulties associated with Dirichlet boundary conditions, regions with curved boundaries, numerical integration, etc., are mentioned. Following the section on variational methods, there is a rigorous treatment of global and piecewise Hermite polynomial interpolation. The rationale given for the inclusion of this topic, which is treated more extensively than the finite element method, is rather sketchy. The authors do use the approximation properties of piecewise Hermite polynomials of degree $2m - 1$ derived in this section to prove that the use of such functions in the finite element method yields an approximation whose error is $O(h^{2m-1})$ in the L^2-norm. It is well known that this is a suboptimal estimate. The authors do state "In many practical cases it has been observed that the convergence order is actually $O(h^{2m})$", but make no reference to the derivation of the optimal estimate, which is rather straightforward. Part II concludes with a very brief section on collocation methods and boundary integral methods. No mention is made of finite element collocation methods. Moreover, the portion of this section devoted to boundary integral methods, less than four pages of text, consists solely of a discussion of a special case of the so-called indirect boundary integral equation method based on the simple layer potential, and only one reference, to a paper published in 1963, is cited.

Part III, "Solving systems of equations", begins with a lengthy discussion of Newton's method and some of its variants for nonlinear systems. For the iterative solution of linear systems, the authors describe the method of successive over-relaxation in considerable detail, deriving the optimal value of the iteration parameter. The method's popularity is attributed to the fact that "with the same programming effort as required by the Gauss-Seidel method, one obtains substantially better convergence in many important cases". The authors may feel that this is sufficient justification for not mentioning iterative methods other than the three basic ones, Jacobi, Gauss-Seidel and successive over-relaxation. The generalization of successive over-relaxation to nonlinear systems is also described. Direct methods are discussed in the latter part of this chapter. A detailed description of the Gibbs-Poole-Stockmeyer method for band width reduction for sparse systems is provided along with sections on the Buneman algorithm and the Schroder and Trottenberg reduction method.

For students unfamiliar with partial differential equations and functional analysis, four sections containing some basic material from these areas are included. It is this reviewer's opinion that, even with this material, students lacking a strong background in these subjects will find the book extremely heavy going. In the main the presentation is unduly theoretical, and many concepts are introduced with little or no motivation. Furthermore, much notation is used without definition, there is a paucity of illustrative numerical examples, and no exercises are provided.

In the set of appendices, computer programs are provided which implement some of the techniques mentioned in the text, or minor modifications of them. The manner in which these codes are presented lacks uniformity and tends to confuse. In all but one of the appendices, subroutines defining test examples are given. On occasions, the test example coded is not the example discussed in the description of the use of the code. Also, for some of the test examples, a driving program is not provided.

The list of references is surprisingly short, containing fewer than forty papers, the remaining references being books and theses. One reason for this is that the authors fail to give explicit credit for many of the methods and theorems appearing in the text, for example, the high order correct method of Douglas (page 108) and Kahan's Theorem (page 365).

The book covers many interesting topics, but the reviewer has serious reservations regarding its suitability as a text in a numerical analysis course. The authors present a rather limited view of the subject, concentrating almost entirely on difference methods. Few techniques are presented which could be labelled as modern computational tools, and as a result it is unlikely that anyone wishing to solve partial differential equations will find much of value in this book. In short, the book does not appear to be a serious competitor to other available texts which discuss more recent developments in the numerical solution of partial differential equations.

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9[65H99].–C. B. GARCIA & W. I. ZANGWILL, *Pathways to Solutions, Fixed Points, and Equilibria*, Prentice-Hall, Englewood Cliffs, N. J., 1981, vii + 479 pp., $23\frac{1}{2}$ cm. Price $32.00.

In recent years, the subject of the numerical solution of nonlinear equations has been enriched by ideas from topology. Iterative methods such as Newton's method have been given a global setting, existence theorems from topology have been given constructive proofs, and both combinatorial and differential methods have been utilized to construct solution algorithms and computer programs for the solution of nonlinear systems. The book of Garcia and Zangwill gives a spritely survey of work in this area, with emphasis on path following as a theoretical and algorithmic tool. In addition, there is extensive material on applications to nonlinear programming, equilibrium programming, economic modelling, game theory, and network models.

The book contains 22 chapters and three appendices and is divided into four parts. Part I contains an exposition of the ideas of continuation and degree theory, including the Basic Differential Equation, a device which has been effectively