BOOK REVIEWS

Items with a reviewer byline (coded R) are by AMR's corps of dedicated outside volunteer reviewers. AMR will attempt to get critical reviews of all relevant textbooks, reference works, and monographs. Items without a reviwer byline (coded N) are prepared by AMR in-house staff and are largely based on material such as a book's table of contents and editor's preface or foreword. In the interest of timeliness, most conference proceedings and multi-author contributed volumes will receive descriptive notes in the fashion. Books deemed to be somewhat peripheral to AMR's basic scope may simply be listed by title. Also listed by title when first received are books under review.

I. FOUNDATIONS & BASIC METHODS

9R1. An Introduction to Linear and Nonlinear Finite Element Analysis: A Computational Approach. - Edited by PK Kythe and Dongming Wei *(Dept of Math, Univ of New Orleans, New Orleans LA 70148-0001).* Birkhauser, Boston. 2004. 445 pp. ISBN 0-8176-4308-7. $79.95.

Reviewed by M Okrouhlik (Dept of Solids, Inst of Thermomech, Acad of Sci, Dolejskova 5, 182 00 Prague 8, Czech Republic).

The book is intended as a textbook for undergraduate and graduate students from engineering, geophysics, and applied mathematics. Very broad spectrum of engineering problems is covered—the examples are taken from structural, mechanical, electrical, and chemical fields. Generally, the book deals with linear and nonlinear problems in radiation, heat transfer, mechanics of elastic and plastic media, continuum mechanics, non-Newtonian fluid flows, and electromagnetics.

The book is composed of 14 chapters, 6 appendices, a bibliography, and subject index. Chapter 1 deals with weak variational formulation of a boundary value problem, Galerkin and Rayleigh-Ritz weighted residual methods. Chapter 2 presents one-dimensional local and global interpolation functions. Chapter 3 explains the Galerkin method and applies it to a one-dimensional second-order equation using liner and quadratic elements. Chapter 4 treats one-dimensional fourth-order equation (beam). Chapter 5 introduces linear triangular and bilinear four-node rectangular elements. Chapter 6 is devoted to two-dimensional problems with a single scalar variable. Stiffness matrix and load vector are derived. In Chapter 7 the two-dimensional boundary value problems as heat exchange, torsion, and seepage are treated. Chapter 8 deals with axisymmetric linear and nonlinear heat transfer problems in solid and fluids. Chapter 9 is devoted to transient problems and numerical time integration. Chapter 10 treats nonlinear problems in one dimension—radiation heat transfer, stress in elastoplastic bars, non-Newtonian fluid flow in between parallel plates, and turbulent flows in tubes. For the numerical solution the Newton method, the method of the steepest descent and conjugate gradient methods are used. Chapter 11 presents the steady-state problems of plane elasticity. Linear triangular and bilinear rectangular elements are treated; stiffness matrices and load vectors are derived. Assembling is clearly described but implementation considerations are not considered. Chapter 12 introduces the penalty method. It is applied to the treatment of both Newtonian and power law non-Newtonian Stokes flow. Chapter 13 deals with vibration analysis—elastic rods, Euler beams, and in-plane vibration of an elastic plate are treated. The last chapter contains the computer codes in Mathematica, Matlab, and Fortran. They form a vivid complement to selected problems appearing in the book. Results of computer runs are presented in the tabular form.

There are six appendices, labeled A to G, in the book. They contain useful complementary information and are subsequently devoted to overview of classical integration formulas, evaluation of stiffness matrices for triangular and rectangular elements for a chosen geometry, time-step marching algorithms (forward and backward difference schemes, Cranck-Nicolson formulas, Newmark method, etc). Also the concept of isoparametric elements is briefly explained, Green identities are shown and Gauss quadrature formulas are derived. In the last appendix the classical minimization methods (method of the steepest gradient and conjugate gradient method) are presented.

There are 87 examples and 148 exercises and 152 figures in the book. Solving the problems both SI and imperial units are used.

The finite element analysis is clearly presented with rigorous mathematical treatment of its background and accompanied by numerous examples. Finite element methodology is covered briefly being saliently combined with a proper computer implementation. Programs and subroutines written in Fortran, Matlab, and Mathematica, treating the examples presented in the book, form a consistent part of the book.

The book is carefully edited and printed. The only misprint I found is on p. 403 where there is a missing zero term in a matrix.

From the reviewer's point of view the book has high educational value stemming from the fact that a very large spectrum of engineering topics is covered. As such the book might well be a good purchase both for university libraries and individuals.

9R2. Beyond Perturbation: Introduction to the Homotopy Analysis Method. - Edited by Shijun Liao *(Shanghai Jiao Tong University, Shanghai, China).* Chapman and Hall/CRC Press, Boca Raton FL. 2004. 322 pp. ISBN 1-58488-407-X.

Reviewed by SA Sherif (Dept of Mech and Aerospace Eng, Univ of Florida, 232 MAE Bldg B, PO Box 116300, Gainesville FL 32611-6300).

This book deals with a very interesting mathematical technique that is rather powerful. While perturbation methods work nicely for slightly nonlinear problems, the homotopy analysis technique addresses nonlinear problems in a more general manner. Through this method, the author demonstrates that a nonlinear problem that normally has a unique solution can have an infinite number of different solution expressions whose convergence region and rate are dependent on an auxiliary parameter. The method provides for ways to control and adjust the convergence region. This makes the method particularly suited for problems with strong nonlinearity.

The book is comprised of two parts. Part I contains Chapters 1 through 5, while Part II contains Chapters 6 through 18. The first part covers the basic ideas and concepts of the method, while the second part focuses on applications of the method to different situations. In addition to introducing the method in Part I, the author discusses the relation of the method to other analytical methods as well as the advantages and limitations of the method. Applications discussed in Part II are varied in scope covering areas such as simple bifurcation of nonlinear problems, nonlinear eigenvalue problems, the Thomas-Fermi atom model, free oscillation systems with both odd and quadratic nonlinearities, Blasius' viscous flow, boundary layer flows with exponential and algebraic properties, von Karman's swirling viscous flow, and nonlinear progressive waves in deep water.

The book should serve as an excellent reference to researchers, engineers, and interested individuals in helping them tackle nonlinear problems in an analytical fashion. It has a good subject index and an outstanding list of bibliography with 136 references cited. The book is very well written and is relatively easy to follow to the mathematically literate person. I highly recommend that it be acquired by interested individuals and libraries throughout.

II. DYNAMICS & VIBRATION

9R3. Bifurcation Theory: An Introduction With Applications to PBEs (Applied Mathematical Sciences 156 Series). - Edited by H Kielhofer *(Inst for Math, Univ of Augsburg, Universitatsstr 14, Raum 2011, Augsburg D-86135 Germany).* Springer-Verlag, New York. 2004. 346 pp. ISBN 0-387-40401-5. $69.95.

Reviewed by HW Haslach Jr (Dept of Mech Eng, Univ of Maryland, College Park MD 20742-3035).

This unified exposition of the single-parameter bifurcation response of an operator on infinite dimensional space is organized into three sections: an abstract development of local and then global bifurcation and applications to elliptic and parabolic partial differential equations.

The local bifurcation theory, taking up about half the book, depends on the breakdown of the implicit function theorem and is based on the Lyapunov-Schmidt reduction for infinite dimensional spaces. The case that the Fréchet derivative has a one-dimensional kernel includes the saddle-node and the various types of pitchfork bifurcations. A principle of exchange of stability is proved. A Hopf bifurcation theorem for periodic solutions is first proved for ordinary differential equations and then for retarded functional differential equations. A center manifold theorem is used for Hopf bifurcation of Hamiltonian, reversible, and conservative systems. A principle of exchange of stability for Hopf bifurcations is proved, and the stability of global continuation of solutions is examined. A principle of exchange of stability for period-doubling bifurcations is developed. The Newton polygon method is described for problems with a one-dimensional kernel in both the degenerate and nondegenerate cases. Floquet exponents are used to create a principle of exchange of stability for degenerate Hopf bifurcations. Some results are given for higher dimensional kernels of the Fréchet derivative and multiparameter bifurcation.

The global bifurcation theory, subject of the second section, is based on the local index of the operator F, obtained from the Leray-Schauder degree which takes the place of the Brouwer degree of finite-dimensional problems. The crossing number, which is related to a change in Morse index, is defined from the index of the operator. Then if $D_xF(0,\lambda)$ has an odd crossing number for a particular value of the bifurcation parameter λ, that value of the parameter gives a bifurcation point. A degree is defined for a class of Fredholm operators that includes some classes of elliptic operators and for potential operators, and global bifurcation theorems proved, often using Rabinowitz's theorem.

The applications forming the third section begin with results on elliptic operators of second order acting on scalar functions. An example using the degenerate Newton polygon is developed. The particular case of the Cahn-Hilliard energy that describes a binary alloy is solved by taking the mass as the bifurcation parameter and applying a symmetry constraint to obtain a one-dimensional kernel. Then local bifurcations of the free nonlinear vibrations described by the nonlinear wave equation with the period as bifurcation parameter are examined in the one-dimensional case and some extensions are given to higher dimensions. Results are also obtained for the wave equation on the unit sphere. A Hopf bifurcation is analyzed for a nonlinear parabolic problem in which the principle of exchange of stability holds. Finally global bifurcation and continuation results are given for quasilinear elliptic problems and are applied to the Euler-Lagrange equation for the Cahn-Hilliard energy problem.

This mathematics book requires substantial mathematical background. The book is directed to advanced readers rather than beginners so that some basic ideas are not defined. The author has separated the abstract description in the first two sections from the applications with the goal of clarity and allowing the results to be available for any application, but at the risk of making it harder to understand the significance of some of the ideas. In many applications to models of physical behavior, the hypotheses of the various theorems are quite difficult to verify. The book is very useful as a reference because it collects and organizes the bifurcation analysis of infinite-dimensional operators. It could also be used as a text in an advanced course on bifurcation theory with an emphasis on partial differential equations.

9R4. Wave Processes in Solids With Microstructure (Stability, Vibration and Control of Systems, Series A). - Edited by VI Erofeyev *(Russian Academy, Russia).* World Science Publications, Singapore. 2003. 255 pp. ISBN 981-238-227-5.

Reviewed by A Giannakopoulos (Dept of Civil Eng, Univ of Thessaly, Pedion Areos 38334, Volos, Greece).

The book presents a good account of the mathematics of wave processes in solids with microstructure. The Introduction sets the general outline of the book and presents a good historical background on the topic. The Introduction includes the major part of a valuable list of references, especially from the extensive work of the author. The first chapter gives the main constitutive and equilibrium equations for the specific mathematical models of solids with microstructure (Cosserat, Le Roux, and two-solid mixture). The second chapter presents dispersion and dissipation analysis for various types of traveling waves (longitudinal, shear, surface, and noise). The analysis follows from classical assumptions of the traveling waveforms that influence directly the kinematics (displacements and/or rotations). In some cases, nonclassical assumptions are used successfully. The second chapter includes quasi-harmonic wave interactions (nonlinear resonant and high frequency interactions of waves). Chapter 3 introduces the damaged medium and the magnetoelastic medium. The context of this chapter is somehow out of the essential theme of the book. The author should have tried to show more connections of the context of Chapter 3 with the rest of the book (as he has done successfully with Chapter 7). Chapter 4 clarifies the results for the Cosserat continuum, Chapter 5 for the two-components mixture and Chapter 6 for the micromorphic solids in Mindlin's spirit. Chapter 7 makes a successful connection of the medium with dislocations, with Cosserat type of continuum. Finally, Chapter 8 describes wave problems of micropolar fluids. The last chapter seems to be written in a rather uncoordinated way with the co-author mentioned in the Preface. It definitely needs thorough revision. The bibliography is very extensive and very adequate, however, there are also some references that have not been linked to the text. The index suffers also from link problems with the text. It is on the positives of the book the realistic examples that are presented, although it is not always clear why the models do better than traditional models with direct inhomogeneities and anisotropies.

There are numerous typos and occasionally severe language problems in the text, which make the book very difficult to follow in certain cases. Symbols often change meaning, sometimes even in the same chapter, creating confusion. A careful and dedicated reader can overcome these problems. The book is on a topic that has a lot of renewed interest. It can serve as an advanced textbook to complement wave mechanics standard books. The book can also serve as reference, but the reader is advised to read several key papers beforehand, to get a clear picture of the mathematical models of solids with microstructure, especially from the constitutive point of view. The book can be of general interest and should be in libraries that specialize in wave mechanics. It is recommended to researchers that have special interest in topics of mathematical treatment of solids with microstructure, keeping in mind that issues of initial and boundary conditions are not covered in the book.