Journal of Applied Mechanics

Book Reviews

Finite Elements, An Introduction. By E. B. Becker, G. F. Carey, and J. T. Oden. Prentice-Hall, Englewood Cliffs, N.J., 1981. 258 Pages. Price /24.95.

REVIEWED BY T. BELYTSCHKO[1]

The finite element method has been the topic of approximately 30 books and monographs that have been published over the last 15 years. Nevertheless, many instructors still have difficulties in finding a text for advanced undergraduate or beginning graduate courses which will develop a sound, fundamental understanding of the method. This book presents a significant advance in that direction for those who wish a more rigorous, mathematical development.

The book consists of six chapters. The first two are devoted to one-dimensional problems, emphasizing the development of a symmetric variational formulation for second-order, two-point boundary value problems and the smoothness required in the space of approximating functions. In the third chapter, a finite element program for one-dimensional problems is described, including the FORTRAN statements. Chapters 4 and 5 repeat the same material for two-dimensional problems, including shape functions for triangles and quadrilaterals and numerical quadrature. Chapter 6 presents an introduction to three-dimensional problems, fourth-order problems, and time-dependent problems.

A notable feature of this book is that it develops the weak, or variational form, from the partial differential equations, rather than simply presenting the variational form as given; the latter approach bothers many of the better students who usually wonder where the variational form comes from. The concepts in this book are all developed with rigor, clarity, and conciseness. Once a student has mastered this book, he will certainly have a broader understanding of the mathematics of the finite element method than would be obtained from more conventional treatments.

In using this book in my class, I found two types of response. Engineering students with a modest mathematical background found the book a little difficult as an introduction; it requires simultaneously tackling the concepts of the weak form, finite element approximations, and notation and concepts to which they are unaccustomed. On the other hand, mathematically inclined students tend to find this book delightful. In addition to its value as a text, it is also recommended to finite element specialists who wish to familiarize themselves with the more recent developments in the mathematical aspects of the method. Even recently I have received papers submitted to the ASME JOURNAL OF APPLIED MECHANICS that deal with the continuity requirements and natural boundary conditions in the Galerkin method; this book presents an unambiguous, consistent development at an introductory level.

This book is the first volume of a series of six on finite elements. If the quality of this volume is maintained in the forthcoming volumes, it should prove a valuable contribution to the finite element literature.

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Seismic Migration—Imaging of Acoustic Energy by Wave Field Extrapolation. By A. J. Berkhout. Elsevier, Amsterdam, 1980. pp. xii–339. Price $51.00.

REVIEWED BY Y.-H. PAO[2]

The purpose of this review is not to criticize Berkhout's book. Instead, it is intended to acquaint readers of the JOURNAL OF APPLIED MECHANICS with this seemingly mysterious topic.

Seismic migration is the construction of a vertical cross section of the ground from the time traces of signals recorded along a line of receivers. The signals are generated by either a single source, or a distribution of sources along the line of the receivers. Mathematically, the problem is formulated as the determination of the wave speed $c(x, y, z)$ and mass density $\rho(x, y, z)$ of an inhomogeneous half space $z \geq 0$, $-\infty < x, y < \infty$, from the known input at the surface, $P_0(x_0, y_0, 0, t)$, and the output $P(x, y, 0, t)$. The $P(x, y, z, t)$ satisfies a linear wave equation with a variable coefficient $c^2 \nabla^2 P = \partial^2 P/\partial t^2$.

The complexity of the problem apparently is far beyond the mathematical and computational tools currently available. In fact, this mathematical inverse problem may be ill-posed, for which the solutions are not stable, nonunique, or even nonexisting. Nevertheless, oil companies have to find oil, and do find them underground by seismic prospecting. Geophysicists specialized in this area have developed various approximate methods to map geological cross sections from records of map-generated seismic waves. The Migration is one of these methods.

A crude model for the cross section is a half space composed of many parallel layers, each having a constant wave speed $c(z_i)$, and density $\rho(z_i)$. A more refined model is to have nonparallel layers, and to allow c and ρ to vary laterally in x, y directions. Methods of seismic migration are developed to improve the lateral resolution of the data gathering and processing.

In this book, which is the first one devoted to the topic of seismic migration, the theory of migration is derived from first principles. Therefore, it contains some basic mathematics (Chapters 2–4) which are familiar to readers of the JOURNAL

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OF APPLIED MECHANICS. The ensuing chapters discuss three methods to extrapolate downward wave fields, and the imaging of the cross sections (the inverse techniques). Chapter 11 compared different approaches to migration. To readers of the JOURNAL OF APPLIED MECHANICS, it would be benefical reading Chapter 11 first before reading Chapter 1, as the latter is incomprehensible to anyone outside the field of seismic prospecting. The last chapter (Chapter 12) discusses the limits of lateral resolution.

Most of the book is confined to two-dimensional scalar wave field $P(x, z, t)$. The three-dimensional case of scalar waves, $P(x, y, z, t)$ apparently is still not within the reach of prospecting seismologists, let alone the case of vector elastic waves, including P and S-wave conversions, in inhomogeneous media. This points a direction of research of a literally very rich area for readers of JOURNAL OF APPLIED MECHANICS who are well versed in the subject of wave propagations in solids.

Free Vibration Analysis of Rectangular Plates. By D.J. Gorman. Elsevier, North Holland, 1982. 324 Pages. Price $60.00.

REVIEWED BY A. LEISSA[3]

This work is a summarization and generalization of a number of previously published papers by Professor Gorman dealing with the free vibrations of rectangular plates. It presents the most comprehensive set of published analytical results to date for rectangular plates governed by classical plate theory; that is, the plates are limited to be homogeneous, isotropic, and thin, undergoing vibrations of amplitude less than the thickness, and free of inplane initial stresses. The book makes no comparisons with the voluminous numerical results found elsewhere in the literature, but stands upon the author's own accurate calculations.

Chapter 2 presents comprehensive eigenfrequencies for the six cases of rectangular plates having two opposite sides simply supported and the others simply supported, clamped, or free. These problems have "exact" solutions in the sense that the eigenfrequencies are obtained from frequency determinants of finite size, in this case having orders no larger than four, arising from the well-known Voigt-Levy solution of the equation of motion. For each of the six cases, 64 frequencies are presented for a/b and b/a = 1, 1.25, 1.5, ,2, 2.5, and 3 where a and b are the plate dimensions. For plates having free edges (3 cases), results are given for two values of Poisson's ratio (0.333 and 0.5).

Chapters 3-7 deal with the remaining 15 cases of plates having combinations of clamped, simply supported, and free edges. The method of superimposing infinite series of Voigt-Levy solutions previously developed by the author and others is utilized to solve these problems. Convergence studies were made to establish the accuracy of the frequencies to four significant figures. Numerical results for frequencies are given typically for the first 10 modes in each case, for values of a/b and b/a as listed in the foregoing. Where free edges are involved, Poisson's ratio is set at 0.333.

The last chapter is devoted to a series of problems involving rectangular plates having added point masses or supports, or line supports. Again the superposition procedure is used to solve the problems and results for frequencies are given.

Although the results for frequencies given throughout the book are typically quite comprehensive, considerably less information is supplied about the corresponding mode shapes.

The reviewer recommends the book highly to individuals who are interested in applying the superposition method to the analysis of eigenvalue problems for rectangular regions and/or who desire extensive, accurate numerical results for the free vibration of rectangular plates governed by classical theory.

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Shock Waves and High-Strain-Rate Phenomena in Metals. Edited by M. A. Meyers and L. E. Marr. Plenum, New York, 1981. pp. xiii-1101. Price $95.00.

REVIEWED BY U. S. LINDHOLM[4]

This large volume (1100 pages) constitutes the proceedings of an international symposium held in Albuquerque, N. Mex. in June, 1980. There are a total of 58 papers divided into topical areas titled: High Strain Rate Deformation; Dynamic Fracture; Adiabatic Shearing; three sections on Shock-Waves Experimental Techniques, Fundamentals, and Microstructural and Mechanical Effects; Dynamic Compaction of Powders; and Explosive Metal Working and Welding. The editors have done an exceptionally fine job of editing and organizing the diverse papers in such a format that the volume presents a comprehensive state-of-the-art review of the subject while fulfilling the editors objective of making it a lasting reference and potential text for graduate education. The latter objective is achieved by a number of chapters contributed by the editors themselves as well as seven appendices providing supplemental basic information required for the design of shock-loading systems. The volume also achieves a balanced perspective for each topic from the points of view of physics, metallurgy, and mechanics.

In summary, this reviewer feels that this is perhaps the best collection of papers on the subject matter seen in recent years and reflects considerable extra effort by the editors to make it a self-contained treatise. It is well worth examination by all those active or interested in dynamic deformation or fracture.

Modern Fluid Mechanics. By Shih-I. Pai. Science Press, Beijing; distributed by Van Nostrand Reinhold Company, New York, 1981. pp. xx-570. Price $37.50.

REVIEWED BY J. S. WALKER[5]

This book on theoretical fluid mechanics falls into the large gap between the teaching textbooks on classical fluid mechanics and the research-oriented monographs that summarize recent developments in specific fields. The four chapters on basic concepts assume a knowledge of the traditional treatment and provide a novel and unifying approach to fluid properties, statics, dynamics, and dimensional analysis. The kinetic theory of gases is used to link continuum and molecular models. Throughout these chapters the author prepares the reader for the specific topics that follow.

The four chapters on specific areas of research treat gas

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