Journal of Applied Mechanics

Book Reviews

Structural Modelling and Optimization. By D. G. Carmichael. Ellis Horwood Ltd., Chichester, England, 1981. 306 Pages. Price $69.95

REVIEWED BY J. E. TAYLOR[1]

This unique book on optimal structural design features a broad, nicely integrated, and well-documented exposition on mathematical methods in optimization. Special attention given to details of organization have resulted in a form and style of presentation that is both unusually orderly and functionally effective. The author states that his book is "aimed at the graduate student and reference text level." It should in fact prove to be unusually useful as a source book for serious analysts in any of the various disciplines where methods of optimization or control theory are applied.

The author's object in preceding the material on optimization with a treatment of modeling is to establish right at the start a well-organized scheme for the representation of structural analysis. Thus the material of Part A of the book serves to fix the technique and nomenclature for analysis in a style identified as an "engineering systems approach." Topics by chapter title are: A Basis for Modelling (multilevel and single level systems representations are discussed), Single Level State Space Modelling, Model Decomposition, and Staged Systems.

A discussion of "design," stated in general terms, is provided in the 25-page second section of the book. Ideas related to design "in a systems sense," and to the "design process" are presented. A definitive statement on the theory of optimal control is given along with a detailed description of the "The Optimal Control Problem." This material reflects the author's uniform commitment to relate his presentations wherever possible to the style and methods of control theory. A basis for categorization of problems is introduced here as well. The categories are identified with the respective form of equations for analysis: ordinary differential, partial differential, algebraic, and difference.

The major substance of the book is comprised of the material in Part C, entitled, "Deterministic Optimization." A rather comprehensive treatment of mathematical methods is provided in chapters titled: Mathematical Programming, Dynamic Programming, Pontryagin's Principle: Variational Calculus, Singular Control, Multicriteria Optimization, Multilevel Optimization, Lyapunov Theory in Design (to accommodate treatment of stability problems), and Energy and "Optimality Criteria" Based Design. Example structural optimization problems are included in most of these chapters.

Treatments in the text are tied together chapter-by-chapter to developments in the literature via the brief discussions furnished in separate sections entitled, Notes, Comments, and Bibliography. Those sections collectively comprise a valuable annotated listing of roughly 800 references.

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Recent Developments in Thermomechanics of Solids. Edited by G. Lebon and P. Perzyna. Springer-Verlag, New York, 1981. 415 Pages. Price $43.70

REVIEWED BY W. O. WILLIAMS[2]

This book presents the texts of three courses presented at the International Center for the Mechanical Sciences (CISM) at Udine. The utility of such courses may be questionable; because the audience usually includes people with no knowledge of the subject and also specialists in the subject, the lecturer feels obliged to begin with very elementary ideas and proceed to very specialized ones, satisfying neither audience. With this in mind one can say that the virtue of such lectures is that they may give a flavor of the subject and a view of its breadth and may also serve as an introduction to the specialized literature. The three presentations here, to varying degrees, possess both of these virtues.

K. Wilmanski in the article "Thermodynamic Foundations of Thermoelasticity" gives an (unfortunately) brief sketch of his ideas for thermodynamics of continua based on accessibility and inherited states. He proceeds to describe the axiomatic derivation of the field equations due to Gurtin and Williams and then introduces constitutive relations, using the scheme of Müller to deduce the equations for a rigid heat conductor including dependence on temperature rate. He then discusses the conductivity types of such materials, following Chadwick and Curie, briefly relating these to the type of heat conduction equation (hyperbolic under some natural restrictions). A final section discusses waves in such materials.

P. Persyna in "Thermodynamics of Dissipative Materials" aims toward viscoplastic materials. He begins with another brief exposition of the axioms of the field theory, then goes on to discuss a class of simple materials (within the format of Noll's "New Theory") whose local states are described by configuration and the vaguely described "method of preparation." He then introduces materials whose state is described by internal state variables, dividing these into those related to internal friction and those related to thermoactivated mechanisms. The next section relates these to rate-type theories, which leads to a discussion of the internal variable description of viscoplasticity. The corresponding evolution equations are related to the behavior of dislocation and there is some discussion of experimental results. This section is quite interesting and has many references to the literature. Finally he presents a brief discussion of rate-independent plasticity theory.

G. Leblon in "Variational Principles in Thermomechanics" begins with a not completely precise but very clear description of basic variational calculus. He emphasizes the approximation of variational and quasi-variational

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problems by various methods. An appendix discusses finite element methods. The chapter on applications in classical mechanics and elasticity is almost too comprehensive. He discusses least action, Hamilton's principle, as well as all of the standard variational principles of infinitesimal elastostatics, elastodynamics, and finite elastostatics. Several examples are given. The chapter on heat conduction is likewise very complete. He discusses the stationary equations, both linear and nonlinear, the nonstationary linear equations, both the standard parabolic equations and the hyperbolic equations, and finally several results for nonstationary nonlinear theory. The chapter on coupled thermoelasticity skims over several variational principles from the recent literature. This set of notes could easily form a text for a graduate engineering course, as the presentation is very concise and thorough.

Instabilities and Catastrophes in Science and Engineering. By J. M. T. Thompson. Wiley, New York, 1982. pp. xvi-226. Price $34.95.

REVIEWED BY H. H. E. LEIPHOLZ[3]

The author of this book is a well-known expert in the field of stability of mechanical systems. Therefore, in writing this work, he was able to draw a wealth of facts and examples from his previous research. Yet, having pursued the development of stability theory in general, i.e., in mathematics and science, and having studied most recent results, for example, in the context of catastrophy theory, he was able to add important results coming from other branches of science to his results in engineering, so that the book has become a broad, most impressive, and stimulating survey of modern stability theory. Should anybody, student or even experienced specialist, like to have a fascinating introduction into the state of the art, the ramifications of stability theory, a hint on the new and promising onset of further development, and a survey on present applications of stability theory to various problems in a set of most diverse fields of engineering and science, he should read this book.

In spite of its broad scope, the book is written sufficiently rigorously so as to satisfy the specialist, and at the same time, sufficiently challenging so as to attract any reader to areas described in the book that should be new to him.

Some of the important modern topics dealt with in the book are: catastrophe theory, stability of nonconservative systems, dynamics of a strange attractor, etc. Fields of applications touched on are: structural engineering, astrophysics, nuclear physics, biochemistry, ecology, hydrodynamics, space mechanics, and neurology. The book is highly recommended to anybody interested in instability phenomena and stability theory.

Mechanics of Brittle Fracture. By G. P. Cherepanov. (Translation by A. L. Peabody, edited by R. DeWit and W. C. Cooley, from the 1974 Russian edition by Nauka Press, with 1977 supplementary material from the author.) McGraw-Hill, New York, 1979. pp. viii-939. Price $97.00.

REVIEWED BY J. R. RICE[4]

This is a translation of the 1974 Russian edition, with supplements provided by the author in 1977. Cherepanov is among the most original and imaginative contributors to the flowering of fracture mechanics theory in the late 1960s and 1970s. This book fairly reflects his remarkably diverse interests and insights.

Crack mechanics, mostly elastic, forms the central theme. There are strong sections on singular fields, plane elasticity solutions to crack problems, energy release-rate calculations, and self-similar elastodynamic solutions, and there is also a brief catalog of elastic crack solutions. In addition there is much contact, if not always developed very completely, with adjacent areas of physics and chemistry, ranging from principles of bonding to optically induced fracturing to ion transport in electrolytic solutions within crack spaces. Supplementary discussions and applications also have a wide scope. For example, there is a discussion of path invariant integrals not only as energy release-rate representations in fracture growth, but also as applied to dielectric phenomena and fluid dynamics. The fracture phenomena and mechanisms discussed include fatigue, environmentally influenced fracture, micromechanisms in fiber-strengthened composites, erosion, drilling, rockburst mechanisms, and much more. There is no shortage of speculation, and one cannot help but wish that the author had been a little more self-critical before jumping to facile explanations of plainly more subtle phenomena, for example, in the fatigue and corrosion cracking areas.

The flavor throughout the book is intensely personal, and one will be disappointed if it is approached as a compendium of all that is useful and permanent in the worldwide development of fracture mechanics. In the foreword to this English translation, Cherepanov warns his readers, and perhaps hopes thereby to deflect some critics, that his works have been ". . . criticized for paying too little attention to the points of view and works of others." He continues: "Unfortunately, I was unable to overcome this shortcoming in the present edition as well, as it represents primarily the results of my own work." The latter quote is certainly accurate, except perhaps that in many places the work could, with more accuracy, be called his synthesis in recapitulation and extension of the results of others. The referencing to others is often offhand, although in aggregate there are 475 references cited (of which 85 are to Cherepanov's papers). The selectivity leaves the book less strong than it could be on elastic-plastic frature phenomena, on unsteady crack dynamics, and on connections with fracture phenomena from the materials science viewpoint, e.g., as developed in the books by Knott and by Lawn and Wilshaw. Similarly, it is less successful than the book by Brock on structural applications. Yet this book is distinctly different in flavor from any of those three, and certainly stronger in basic mechanics.

Elementary Finite Element Method. By C. S. Desai. Prentice-Hall, Englewood Cliffs, N.J. pp. xiv-434. Price $22.95.

REVIEWED BY S. KELSEY[5]

The professed aim of this book is to provide a broad, but practical introduction to the finite element method, suitable for the undergraduate engineering student or other finite element novice. The method is presented, not as a development of matrix methods of structural analysis (a historical view) nor as a technique for the approximate solution of differential equations (a mathematician's view), but as a general and coherent approach to the analysis of physical behavior by discrete modeling.

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