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Book review

INTRODUCTION TO CONTINUUM MECHANICS

Sudhakar Nair. Cambridge University Press, 2009, ISBN 13: 978-0-521-87562-2, £42·00, 252 pp.

On first seeing this text my initial reaction was 'Oh no, not yet another book on continuum mechanics'. However, on reading the text I was pleasantly surprised and found it to have several features which make it a useful guide to the subject. It is clear from the layout of the book that it has evolved from material which the author has developed in teaching a course on continuum mechanics over a considerable period of time. As stated by the author, the students on this course come from a wide engineering background and this is reflected in the contents of the book.

The text covers both solid and fluid mechanics and gives a brief introduction to advanced material behaviour involving viscoelasticity and plasticity. The book is well structured, easy to read and explicitly presents some fundamental derivations not found in comparative publications. The basic tensor mathematics required are provided in the early chapters and an attractive feature is the series of examples and exercises (some 150) that are included. This increases its potential as a course text.

After a brief introduction, Chapter 2 summarises Cartesian tensor algebra and introduces the concepts of eigenvalues and polar decomposition. Chapter 3 is devoted to more general tensors, including curvilinear concepts. Chapter 4 deals very briefly with integral theorems and Chapter 5 is concerned with aspects of deformation, involving definition of the deformation gradient, strain tensors, polar decomposition, stretch and rotation. Useful examples related to polar decomposition and evaluation of the square root of a matrix are provided. Chapter 6 introduces the reader to rate effects, summarising the concepts of material derivatives, strain rate, deformation rate, spin, vorticity and rotation rate of the principal axes.

Chapter 7 deals with the fundamental laws of mechanics and includes a brief summary of the conservation and balance laws, material frame indifference and objective measures of rotation. Fundamental properties of the stress tensor are considered in Chapter 8. Through introduction of the Cauchy stress tensor the principles of transformation and objective stress rates are illustrated. Local conservation and balance laws are then explained, followed by definition of the first and second Piola–Kirchhoff stress tensors to illustrate material description of the equations of motion.

Chapter 9 is devoted to consideration of energy and entropy constraints. After introduction of classic thermodynamic principles, the importance of the Clausius–Duhem inequality is discussed. Chapter 10 sets up, in a unified sense, the fundamental requirements that constitutive relations must obey and then for Cauchy and Green elastic materials the general form of the material laws is developed, in addition to that of a Stokes fluid.

With the fundamental theory given up to this point, the remainder of the book considers specific material types. Chapter 11 formulates the essential relations for a hyperelastic material, which is an important class of finitely deforming solids, culminating in an example on rubber elasticity. Fluid dynamics is considered in Chapter 12 where Newtonian and inviscid fluids are discussed before treating incompressible and compressive forms of the Navier–Stokes equations.

In Chapter 13 the essential relations of viscoelastic materials are discussed, with some brief details of specific models provided. Finally Chapter 14 summarises the fundamental relations of plastically deforming solids. This synopsis follows conventional approaches to be found in numerous texts, apart from introduction of the endochronic theory of Valanis.

The text is relatively short (some 230 pages) and a considerable range of material is included. Criticism could, therefore, be levelled at the depth of treatment of some aspects of the topic, but the advantage of the book is the unified way in which continuum problems from both solid and fluid mechanics is succinctly addressed. Another feature is the large number of exercises posed, which will endear the text to teachers of the subject at a postgraduate level.

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