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Book Reviews

The Physics of Deformation and Flow. By E. W. Billington and A. Tate. McGraw-Hill, New York, 1981. pp. xx–626. Price $59.00.

REVIEWED BY DANIEL C. DRUCKER[1]

This is a most unusual book of great value to those entering the field or changing the direction of their research. It is unusual because of its broad coverage from advanced mathematics to simple experiments, from linear and nonlinear fluids, and linear and nonlinear elastic solids to plastic solids, and because of its aim to bring together, in a meaningful way and at a high level, both macroscopic and microscopic physical behavior within a broad set of current continuum mechanics approaches. A remarkable compartmentalization of approach is employed without comment in a most successful innovation. Each major section is written primarily from the viewpoint of those who developed that specific area in its present form. The authors exercise judgment in the choices they make of inclusion or omission but then carefully display the mathematics and the physical arguments to represent the school of thought (as of June 1979) without the distraction of contrary viewpoints. Consequently there is much with which each expert will disagree but much more that will prove helpful in achieving greater understanding. Ample reference is made to the relevant literature needed to follow up on the background presented.

The work of Truesdell, Toupin, and Noll, to which extensive credit is given, is preceded by a mathematical introduction to scalars, vectors, and tensors. Yet this approach sits side by side with other sections from other points of view including both those that are primarily physically based and those that are reminiscent of Love and Lamb in their detailed writing of scalar equations. Appropriate sections are interspersed that give descriptions of electronic, atomic, and interatomic structure and forces, dislocations and dislocation structure of solids, molecular structure of fluids, statistical mechanics, and the results of basic continuum experiments. A full chapter is devoted to crystal plasticity between two chapters on continuum plasticity. Impact, dynamic plasticity, and shock waves receive the attention to be expected from the great interest of the authors in these fields, but the writing here is just as concise and effective as in the closing chapter on fracture, and throughout the book. The authors certainly have done well to provide the continuum mechanics background that would be of great help to materials scientists and engineers as well as the "useful reminder to those involved in continuum mechanics that the ultimate test of abstract theories lies in the laboratory."

[1] Dean, College of Engineering, University of Illinois at Urbana-Champaign, Urbana, Ill. 61801.

Biomechanics. Mechanical Properties of Living Tissues. By Y. C. Fung. Springer-Verlag, New York, Heidelberg, Berlin, 1981. 433 pages. Price $23.85.

REVIEWED BY RICHARD SKALAK[2]

Biomechanics has grown rapidly in the last decade and it is a pleasure to report that in this book an acknowledged leader in the field has set down a connected account of much of the progress that has been made in recent years. The book includes a good bit of anatomy, physiology, and analysis of systems, such as blood flow in tubes and muscle contraction, which entails more than just physical properties in the usual sense. The balance of materials presented serves the purposes of the book very well. It will be especially appreciated by students of biomechanics. It can be expected that physiologists will also find it of interest. Established workers in other branches of theoretical and applied mechanics who wish to have an authoritative and collected introduction to biomechanics will also find the book valuable. It will be a welcome textbook in courses in biomechanics.

This book has a number of features that make it especially pleasurable to read. First is the open style and the alternation of biological background and analytical representation that gives a degree of integration which has been often lacking in both the mechanical and biological literatures. Second, there is a most interesting historical introduction in Chapter 1 which points out that biomechanics is a fairly old subject. Although biomechanics is a relatively new word, which means the application of mechanics to biology, it turns out that the word mechanics is somewhat older than the word biology.

Third, the exercises given in small print at the end of each chapter are unique in the biomechanical literature. In many cases they add to the content of the book by the ideas they suggest and the impetus to have the reader work out some of the details. Finally, as befits the subject, it may be seen from the reference lists in each chapter that a large fraction of the literature cited has been written in the last decade. Professor Fung is one of the few people who has kept up with the development of biomechanics on so many different fronts in the last decade and could single-handedly write this book for us.

There are some items in this book that probably deserve special mention as they are distinct contributions to the literature. One of these is the discussion of extreme values in relation to red blood cell sizes. Another is the consideration of the mechanics and thermodynamics of biological tissues in a single format. The discussion of inversion of stress-strain relations is an original and interesting contribution.

[2] James Kip Finch Professor of Engineering Mechanics, Director, Bioengineering Institute, Department of Civil Engineering and Engineering Mechanics, Columbia University, New York, N. Y.. 10027.

One of the virtues of a book like this is that the different parts of the subject can be treated with a uniform vocabulary and approach. The basic definitions of stress, strain, strain rate, and viscoelasticity are given in Chapter 2. While this information may not be new to graduate students in applied mechanics, it is useful to have it written down and connected to biomechanics in an orderly way. Chapters 3, 4, and 5 deal with flow properties of blood, red blood cells, the deformability, and the rheology of blood in the microvessels. These chapters will give a fresh survey of the complicated field of blood cell properties and blood rheology. These chapters are a good example of Professor Fung's ability to set down the main facts in clear form. There is a good bit of advanced analysis in the literature which is not given here in any detail. Examples would be the solution of Stokes equations for various particles in capillary flow and the many different models that have been studies for wave propagation in blood flow. Presumably these will be covered in two later volumes which Professor Fung has promised in the introduction to the present book.

Bioviscoelastic fluids including protoplasm, mucous, saliva, cervical mucous, semen, and synovial fluid are treated in Chapter 6. Here again the main facts and adequate references are well summarized.

The next five chapters deal with soft tissues and are largely drawn from the research work of Professor Fung, his associates, and students. Chapter 7, on bioviscoelastic solids, is an especially long and important chapter. It contains informative descriptions of elastin collagen. It also contains general discussion of thermodynamics of elastic deformation, generalized viscoelastic relations, the complementary energy function, and inversion of stress-strain relationships. The idea of pseudoelasticity using a model of one elastic material in loading and another elastic material in unloading is developed. The reduced relaxation function is introduced and illustrated in this chapter by application to experimental data on rabbit mesentary. The notion of the reduced relaxation function is used repeatedly in the remainder of the book. It allows a reduction of a good deal of data on soft tissues which is highly nonlinear in its elastic behavior but linear in its viscoelastic response.

Chapter 8 deals with the mechanical properties of blood vessels. The arterial wall is another example in which the reduced relaxation function idea is useful. This chapter includes discussions of capillary blood vessels and the sheet flow in the alveolar walls of the lung which was developed by Professor Fung and his associates. The chapter closes with a discussion of the properties of the veins but does not go into the many interesting phenomena that occur when veins collapse. These will no doubt appear in later volumes.

The next three chapters, Chapters 9, 10, and 11 on skeletal muscle, heart muscle, and smooth muscles are like a minibook within the book, and surely represent a topic of great importance and particular interest. Here Professor Fung has tackled the difficult subject of describing the active contraction of muscles as well as their passive behavior when relaxed. Although some fault is found with Hill's classical three-element model, it is clear that the discussion is still an imcomplete one. These chapters show that the variety and complexity of muscles is very great and a complete description must take into account a variety of detailed anatomical features and biochemical influences. The chapter on smooth muscle is most interesting, probably because the spontaneous cyclic contraction has an air of independence and mystery about it.

The book closes with Chapter 12 on bone and cartilege. This is a comparatively short chapter but gives the main known facts about the structure, variability, and properites of bones. Although the strains are small because bones are stiff, the discussion of material properties is no less difficult than for soft tissues due to the complex heterogenity and anisotropy of bones. The questions of growth and resorption in bone are dealt with only briefly but at least more rationally than much of the literature. The last few sections on cartilege and lubrication of articular surfaces give the main effects leading to the very small coefficients of friction between typical articular cartilege surfaces. Synovial fluid was discussed previously in Chapter 6.

There are omissions which one could complain about except that the subject is so large that something must be omitted. Workers interested in the cornea or other parts of the eye or the ear will probably feel left out. One area which has received no mention is that of the brain and neutral system. This reviewer is convinced that neural mechanics is underdeveloped, say, compared to vascular mechanics and that the return on such development would be very much worthwhile. A discussion of teeth, the stiffness of their sockets, and the properties of the various components might also be of interest. Finally it should be pointed out that besides some data on frogs, almost all of properties discussed are of mammalian tissues. Fish, plants, seashells, and other interesting forms such as coral are not mentioned. Of course the inclusion of all of these topics might require another volume but people in agriculture and marine biology would probably like to see similar books for their fields.

This is a book that will surely be a standard text for some time. We will all be looking forward to seeing the two additional volumes which are promised in the Introduction. The next volume will be on the mechanics of circulation and respiration. A third volume on advanced biomechanics will include recent developments where advanced methods in contiuum mechanics and analysis have to be used. As Professor Fung has so aptly said in his preface, "Biomechanics at the level or current research cannot be bound by elementary mathematics." We will look forward to the forthcoming volumes to be as interesting and useful as the present first fine volume.

A Modern Course in Aeroelasticity. Edited by E. H. Dowell. By E. H. Dowell, H. C. Curtiss, Jr., R. H. Scanlan, and F. Sisto. Sijthoff and Noordhoff, Alpen aan den Rijn, The Netherlands, 1978. pp. v-464, Price $90.00.

REVIEWED BY R. M. BENNETT[3]

Aeroelasticity is an important hybrid field that treats the stability and response of flexible structures under fluid dynamic loading and includes the phenomena of flutter, divergence, buffeting, and gust response. The applications primarily involve aerospace vehicles but also include areas such as the civil engineering problems of the response of bridges, smoke stacks, and so forth, to wind loading. There are several well-known textbooks (references [1–4]) but they are several decades old and do not reflect recent developments and emphases. The two more recent books [5–6] are not available in English. This book is an effort to satisfy the need for a modern textbook.

Chapters 1–4 are by Prof. Dowell. After a brief introduction (Chapter 1, 2 pages), static aeroelasticity (Chapter 2, 44 pages) is considered. Deflection and divergence of a typical two-dimensional wing section are treated, followed by beam and surface representations of finite wings and by a brief section on the flow through flexible pipes. Chapter 3

[3] Aerospace Engineer, Unsteady Aerodynamics Branch, Loads and Aeroelasticity Division, NASA Langley Research Center, Hampton, Va. 23665.