Journal of Applied Mechanics

Book Reviews

Biomechanics: Motion, Flow, Stress, and Growth, by Y. C. Fung. Springer-Verlag, New York, 1990. 567 pages. Price: $69.00.

REVIEWED BY S. C. COWIN[1]

This book is the third in a series of volumes by Y. C. Fung on biomechanics. The first two were *Biomechanics: Mechanical Properties of Living Tissues* (1981) and *Biodynamics: Circulation* (1984). In these books the author describes the constitutive behavior of biological tissues, the functional mechanics of the body's organs, and related engineering problems. The present volume, like the previous two, summarizes the application of an enormously wide spectrum of mechanics and thermodynamics to physiology and the engineering of biologically related problems. The mechanics applied includes rigid-body mechanics, mechanical vibration theory, viscous and perfect fluid theory, linear and nonlinear elasticity, wave propagation in fluid and solid media, multiphase mixture theory, chemical thermodynamics, and numerous subtopics of mechanics. The problems addressed cover the spectrum from birds flying and fish swimming to oxygen transport, human impact tolerance, and the engineering of activities at the cellular level.

The introductory chapter describes the principles of mechanics, the modeling of phenomena, and the nature of the practical problems to be dealt with, e.g., basic physiology, prostheses, sports techniques, etc. Chapter 2 discusses the mechanics and modeling of whole bodies or whole body segments. Chapter 3 reviews the mechanics of the fluid dynamic forces that act on bodies moving through the fluid and Chapter 4 applies these results of classical mechanics to the mechanics of flying and swimming. The flight of birds and insects is compared with the flight of aircraft. The mechanics of hovering as well as the swimming of very small flagella are described. The circulatory system is considered in Chapters 5 and 6. Chapter 5 describes blood flow in the heart, lung, arteries, and veins while Chapter 6 addresses the microcirculation, blood rheology and blood flow in the lung. Respiratory gas flow, convection, diffusion, gas exchange, and pulmonary function tests are the topics of Chapter 7. Chapters 8 and 9 concern molecular diffusion and mass transport, fluid movement in interstitial space and across capillary blood vessel walls, filtration and transport across cell membranes. Chapter 10 is a presentation of nonlinear elasticity including the first report I have seen of an additive decomposition of the deformation gradient into a symmetric and an orthogonal matrix of tensor components. This additive decomposition is an analog of the multiplicative polar decomposition theorem used in continuum mechanics to separate the rotational and deformational components of a motion. Chapter 11 concerns residual strains in the arterial walls, stress and strain in the heart and lungs, with some emphasis on the mechanics of the lung. Chapter 12 addresses the topics of strength of biological tissue, injury and repair of organs, trauma due to impact loads, and tolerance of organs to impact and vibratory loads. The final chapter discusses the adaptation of biological tissue and their cells to environmental loading, and the healing of tissue. The discussion of biological adaptation centers on bone adaptation and blood vessel adaptation.

This book is an anthology of modern biomechanics, containing excellent descriptions of most of the topics in the field. It is best read a few topics at a time. The spirit of the book is the wonder of nature and the intellectual excitement of investigating and explaining biological mechanisms, as is easily seen from the problems at the ends of the chapters. For example, Problem 4.13 poses the following question: "An airplane has to rev up the engine to produce the maximum power to take off. How does an eagle take off? One would have to consider the aerodynamic, structural, muscle dynamics, kinematics, metabolic, and energy factors." As another example Problem 8.10 poses a question: "The beautiful flower of water lilies opens up in the sun and closes up when the sun sets. This is a mechanical event of which I know no literature. So let's speculate. Propose a possible explanation, and possible experiments, and quantitative analysis to verify your hypothesis." This volume provides explanations, experiments, and quantitative analysis to explain many of nature's secrets; it also suggests and encourages hypotheses for the investigation of other of nature's secrets.

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Stability of Structures: Elastic, Inelastic, Fracture, and Damage Theories, by Z. P. Bazant and L. Cedolin. Oxford University Press, Oxford, U.K., 1991. 1010 pages. Price: $79.00.

REVIEWED BY J. W. HUTCHINSON[2]

Bazant and Cedolin have made a major contribution to mechanics by writing their book on structural ability. The subject is huge and long overdue for a text, and it surely took an act of courage to undertake this effort. As one who was active in the area of structural stability in the 1960s and 1970s, this reviewer saw so much fine work developed during this period which never found its way into any texts or monographs, and it seemed as if no one would rise to the task. Bazant and Cedolin have done so. Their book is truly a major accomplishment. In its nearly one thousand pages the book covers both the elastic and inelastic buckling of columns, frames, plates and shells, and it also has extensive treatment of aspects

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