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Book Reviews

Modeling and Computation of Boundary-Layer Flows

Tuncer Cebeci and Jean Cousteix, Horizons Publishing, Long Beach, CA, 1998, 484 pp., $95.00

This is a comprehensive treatise on the modeling and simulation of laminar and turbulent incompressible boundary layers, written in a scholarly and coherent style by experts in the field. For those readers who wish to forego the remainder of this review, the conclusion can be stated straightforwardly. This is an excellent book on the topic and both an essential reference and outstanding educational text.

Chapter 1 presents a variety of examples of boundary-layer simulations in aerodynamics as motivation for the text. Topics include prediction of skin friction reduction, maximum lift coefficient for multielement wings, and degradation of performance due to icing. The authors present a descriptive summary of both the accomplishments and shortcomings of computational fluid dynamics (CFD) in treating these critically important problems in aerodynamics. Chapter 2 is a brief introduction to the conservation equations for incompressible viscous flow. The authors wisely choose to summarize the governing equations while leaving the reader to consult any of the multitude of fluid mechanics texts for rigorous derivation. Chapter 3 presents a classical derivation of the laminar and turbulent incompressible boundary-layer equations (two dimensional and axisymmetric) and introduces the concepts of displacement thickness, momentum thickness, and the momentum integral equation. Chapter 4 focuses on two-dimensional laminar boundary layers. The classical Falkner–Skan equation is derived, and solution by Keller's shooting method is presented together with the FORTRAN code. Numerical results for the Blasius equation are included. Self-similar free shear flows (axisymmetric jet, two-dimensional wake, mixing layer) are also included, as are integral methods (Pohlhausen and Thwaites). The Keller box scheme for the two-dimensional laminar boundary-layer equations is described in detail. Chapter 5 describes a boundary-layer program (BLP2) for solution of laminar and turbulent boundary layers with prescribed external pressure distribution. The Hess–Smith panel method is also included for computation of the inviscid pressure distribution on the body, and applications to a two-dimensional airfoil and prolate spheroid are presented.

Chapter 6 focuses on transition in two-dimensional flows. (See also the discussion of Chapter 11 later.) Following a brief physical description of transition in incompressible flow, the equations and boundary conditions of two-dimensional linear stability theory are derived. The e^n method is briefly introduced, and additional factors influencing transition (e.g., freestream turbulence, pressure gradient, surface heat and mass transfer, and surface roughness and curvature) are briefly discussed. A numerical algorithm for solution of the two-dimensional Orr–Sommerfeld equation is presented.

Chapter 7 describes a stability transition program to calculate the neutral stability curves in two-dimensional external flows. Results are presented for a flat plate, ellipse, and prolate spheroid. Chapter 8 concerns two-dimensional turbulent flows. Following a description of the composite nature of the incompressible turbulent boundary-layer and similarity laws, examples of zero-, two-, and Reynolds-stress equation turbulence models are presented. Head's integral method is described, and a computer program included. Similarly, a computer program is included for computation of two-dimensional turbulent flows using the Cebeci–Smith turbulence model. The chapter concludes with a discussion of several turbulent free shear flows and their associated power laws for velocity and width.

Chapter 9 presents three-dimensional steady and unsteady laminar and turbulent boundary layers. The streamline and body-oriented coordinate systems are discussed, and the governing equations in each case are presented. The application of Keller's box scheme to three-dimensional boundary layers is described, with careful attention to numerical issues associated with the domains of dependence and influence. Results are presented for infinite swept wing flows, an airfoil affixed to a flat plate, and a prolate spheroid. Similarly, the application of Keller's box scheme to unsteady two-dimensional boundary layers is presented. Chapter 10 describes the three-dimensional boundary-layer program (BLP3D) in detail. Chapter 11 discusses incompressible transition in three-dimensional flows, including the e^n method and a numerical method for solution of the three-dimensional Orr–Sommerfeld equation. Chapter 12 introduces interactive boundary-layer theory. In addition to a description of the numerical algorithm, results are presented for trailing edge flow of flat plates and airfoils at high Reynolds numbers.

All chapters (except the first) include problems that incorporate additional theoretical and numerical issues. A lucid description of each subroutine is presented for the several codes. It is to be hoped that a Web site will provide access to the FORTRAN programs. The references are extensive and include both classical and recent papers. To be sure, not every topic on boundary-layer theory, transition, or turbulence is included in the book (nor would it be possible to do so). Overall, the authors have shown laudable judgment in their choice of topics and excellence in their treatment thereof, while leaving for others in the field sufficient room for their contributions to eventually appear alongside *Modeling and Computation of Boundary-Layer Flows* in the scholarly collections of the field. In summary, this is an excellent book.

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Nonlinear Elasticity: Theory and Applications

Y. B. Fu and R. W. Ogden, Cambridge University Press, New York, 2001, 525 pp., $49.95

The field of nonlinear elasticity, sometimes called finite elasticity, has as its basis the classical linear theory of elasticity; the theoretical developments of Ronald Rivlin, Clifford Truesdell, Walter Noll, and others; and the experimental work of James Bell and others. Its applications have been especially important in soft elastic materials such as elastomers (rubberlike materials) and polymeric foams. A dramatic example emphasizing the importance of this field was the catastrophic failure of the O-ring seals of the solid rocket booster for the Space Shuttle *Challenger*.

This volume consists of 13 chapters (papers), which grew out of an International Workshop on Nonlinear Elasticity held at City University, Hong Kong, in April 2000. The first chapter, by R. W. Ogden, provides a good overview of the basic theory, including both elastostatics and elastodynamics, for use in the other chapters. This chapter has an exceptionally large list of references. Chapters 2–6 cover various aspects of solutions to boundary-value problems: hyperelastic Bell materials, "universal results," equilibrium solutions (for generalized Blatz–Ko materials), exact integrals (for incompressible Varga materials), and shear. Chapters 7 and 8 are devoted to membrane theory (including wrinkling) and elastic surface theory (including both Cosserat and Kirchhoff–Love theories).

Nonuniqueness of solutions is treated in Chapter 9 using singularity theory with application to nonlinear bifurcation analysis as a tool, and Chapter 10 covers nonlinear stability analysis via perturbation methods. Nonlinear dynamics, in particular nonlinear wave propagation in elastic rods, is the subject of Chapter 11. Chapters 12 and 13 deal with two different notions of pseudoelasticity. The first presents a theory of phase transitions by means of nonconvex strain-energy functions in finite thermoelasticity, and the other considers the effect of changing the constitutive law while deformation takes place and includes stress softening.

The quality of the printing is excellent, the drawings are adequate, and each chapter provides ample references to the literature. This book represents a good overview of research underway in both the mathematical and physical (mechanics) aspects of nonlinear elasticity at the start of this century. The price is reasonable, and so this volume should be in the library of all research scientists and engineers involved with large deformation of elastic materials and structures.

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