Introduction to Theoretical and Computational Fluid Dynamics

By Constantine Pozrikidis, Oxford University Press, 1997, New York, 675 pp., $75.00

This excellent textbook by Professor Pozrikidis wonderfully fulfills its author's stated mission of providing a balanced treatment of theoretical *and* computational approaches to the enga ̧-ing field of fluid dynamics. As e-searchers, practitioners, educators and students of this field, we are all aware of the large selection of advanced textbooks available for the study of fluid dynamics. However, it is generally true that books which are suitable for learning the fundamental concepts contain very little, if any, coverage of computational methods. Similarly, specialized texts for computational fluid dynamics are usually not appropriate for a first graduate course in fluid mechanics, aimed at introducing the concepts. The principal strength of this textbook is that it successfully bridges the gap between fundamental concepts and numerical techniques, both of which are needed for proper analysis of fluid motion.

The book focuses on incompressible laminar flows of Newtonian fluids. Chapter 1 provides a thorough introduction to the kinematics of fluid flow, making full use of vector and tensor calculus and differential geometry (which are separately reviewed in an appendix). The chapter includes unique and insightful descriptions of material lines, surfaces and volumes; curvature; streamline coordinates; vortex lines and vortex sheets, in addition to the more standard topics. Chapter 2 further discusses kinematics in terms of vorticity and expansion rate, also introducing the scalar and vector potentials and the stream function. Green's functions and multipoles are also introduced, as are integral representations and vorticity-induced flows. Chapter 3 introduces the stress tensor and provides a complete derivation of the conservation laws describing fluid motion in their various forms. A very detailed and illuminating description is provided (more so than in any other textbook) of the boundary conditions at solid surfaces and fluid interfaces, including such issues as vorticity at a free surface. Chapter 4 introduces hydrostatics, with an emphasis on determining the shapes of free surfaces governed by the Young-Laplace equation. Chapter 5 analyzes a number of fundamental flow fields which can be found analytically or by simple numerical computation: steady and transient unidirectional flows, stagnation point flows, rotating disk flows, point force and point source flows, and so on. Chapter 6 provides a surprisingly thorough introduction to the subject of low-Reynolds-number hydrodynamics, including the fundamental singular solutions, boundary integral representations, reciprocal theorem, generalized Faxen relations, unsteady Stokes flows, and lubrication equations among others. Chapter 7 on irrotational flows, together with Chapter 10 on the boundary-integral method for potential flow, provides one of the most complete treatments of two- and three-dimensional potential flows using analytical and numerical methods in the literature. Chapter 8 describes boundary layers, including axisymmetric and three-dimensional ones with unsteady effects. Chapter 9 provides a nice introduction to (linear) hydrodynamic stability analysis for internal, external, interfacial and free-surface flows. Chapter 11 focuses on vortex motion and so-called vortex methods. Finally, the last two chapters, 12 and 13, focus primarily on finite-difference methods. The former introduces the methods in the context of the unsteady convective-diffusion equation, providing a fairly comprehensive review of the relevant explicit and implicit numerical methods in one, two and three space dimensions. Chapter 13 applies the finite-difference method to incompressible fluid flow, using the vorticity-stream function formulation, the marker-and-cell method in the primitive variables, the pressure Poisson equation, operator splitting, and so on.

Most sections have two sets of homework problems, the first being of a theoretical nature (to be solved by paper and pencil) and the second being computational in scope and requiring the preparation of a computer program by the student. Each chapter also includes a separate comprehensive list of references, providing a good resource for pursuing a topic in more depth. Theoretical topics not covered in the book include turbulence, compressible flows, waves, and non-Newtonian fluids; numerical methods which are not discussed include finite-element, finite-volume, and spectral methods. However, the topics which are covered (outlined above) are introduced at a fundamental level and with deep insight and understanding for both analytical and numerical treatments.

In the short time that I have had a copy of the book, I have found it to be a valuable resource to me and to my graduate students. As an active researcher and educator in fluid dynamics for the past 15 years, I still find that each time I read a section of this book, I learn something new or gain additional insight. Professor Pozrikidis should be congratulated for this truly valuable contribution to our profession. This textbook will be of immense value to students, researchers and practitioners of fluid dynamics.

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The Surface Science of Metal Oxides

by V. E. Henrich and P. A. Cox, Cambridge University Press, Cambridge, U.K., 1994, 464 pp. hardcover $99.95; paperback $39.95

Over the past several decades, the use of ultra-high-vacuum surface spectroscopic techniques to study the structure, reactivity, and electronic properties of well-defined surfaces of macroscopic single crystals has led to an increasingly detailed understanding of the physical properties of the surfaces of metals and to a lesser extent semiconductors. Only recently, however, have these studies been extended to include another technologically important class of materials, metal oxides. In *The Surface Science of Metal Oxides* Henrich and Cox provide an excellent introduction to this emerging area of study.

The book begins by providing a brief overview of the technological importance of metal oxides and a historical perspective on the study of their surfaces. Chapter 2 focuses on the structure of metal oxides. Since the surface structure of a material is related to its