AIAA JOURNAL
Vol. 44, No. 5, May 2006

# Book Reviews

*BOOK REVIEWS published in this section reflect the opinions of their individual authors. They are not necessarily the opinions of the Editors of this journal or of AIAA.*

## *Fluid Dynamics: Theoretical and Computational Approaches, 3rd Edition*

Z. U. A. Warsi, CRC Press/Taylor and Francis Group, Boca Raton, FL, 2006, 845 pp., $119.95

In keeping with what seems to be a common phenomenon, each edition of Prof. Warsi's book has grown, from 683 pages (first edition, 1993), to 726 pages (second edition, 1999), and now 845 pages in the present edition (2005). The preface states that the book follows the same overall plan and scope, with important topics added. These include new material on free-surface flows, laminar flow stability, and large eddy simulation, along with the addition of new exercise problems. To place this text in context, readers of this journal may compare it with another text of similar style and focus on the theoretical aspects of fluid dynamics: George Emanuel's *Analytical Fluid Dynamics, 2nd Edition* (reviewed in the *AIAA Journal*, Vol. 40, No. 8).

As stated in the original edition and reaffirmed subsequently, the aim and scope of the book is "intended for graduate students in both engineering and applied mathematics ... to grasp and assimilate a constructive framework of ... modern fluid dynamics." Part of this framework includes the necessary theoretical tools for developing a student's ability to tackle new problems once the fundamentals are understood. As instructors in the field well know, meeting this challenge in the modern age requires a variety of explanatory techniques. The author does aim for "sufficient generality of the derived results" using the method of vector and tensor analysis. The reader is free to formulate his or her own opinion as to whether this facilitates thinking in a way in which "even beginners should have no difficulty in understanding" and will gain "both the formulational and computational aptitudes." True to the title, the author introduces computational techniques and algorithms to enhance the ideas behind the concepts and to emphasize modern computational approaches to fluid dynamics.

One feature of the book worth mentioning is the author's "Mathematical Expositions," appearing as appendices to the core material. These very readable and fundamental chapters present much useful material for readers or instructors who wish to review basic mathematical aspects underlying the subject's foundations. The topics contained in these expositions include vector calculus, space and plane curves, coordinate transformations, potential theory (Green's formulas), and frame invariance. The latter is an advanced topic not found in most elementary texts in fluid dynamics.

Instructors looking for extra homework problems will find that each chapter contains a set of exercises to extend the ideas developed in the chapter text or to introduce material not covered in detail (the dreaded "it is left to the reader as an exercise ... "). The author's suggested coverage spans three possible one-semester courses: Viscous Incompressible Flow, Viscous Compressible Flow, and Basic Turbulence and Turbulence Modeling. This reviewer has not had the opportunity to use this book as a primary text. However, based on the material covered, it is quite possible that a good secondary development of the subject (e.g., graduate level) could be supported by Warsi's opus. The mathematical expositions are worth incorporating into classroom material for various aspects of fluid dynamics. The computational aspects are not sufficient in breadth or depth to use as a stand-alone introduction to computational fluid dynamics, although some parts may be useful supplements (e.g., Mathematical Exposition 8: Finite Difference Approximation Applied to PDEs).

The contents are laid out as follows: Chapter 1 (32 pages) begins with the usual kinematics, followed by the requisite development of the conservation laws in Chapter 2 (42 pages). The Navier–Stokes equations are detailed in Chapter 3 (86 pages; referring to all three balance equations of mass, momentum, and energy, as is now customary). The more specialized treatment begins in Chapter 4 (102 pages) with flows of inviscid fluids, covered in two parts (incompressible and compressible). Laminar viscous flow begins in Chapter 5 (226 pages) and is presented in three parts (exact solutions, boundary layers, and various approximations to the Navier–Stokes equations). The last and longest chapter, Chapter 6 (232 pages), deals with turbulent flow in three parts and treats stability theory, averaged equations, empirical results, boundary-layer results, and turbulence modeling. As an introduction to turbulence, this last chapter could probably stand on its own (with a review of Chapters 1–3) as the one-semester course suggested by the author. Experts in turbulence modeling would likely have their own opinion or preference. The nine Mathematical Expositions constitute the remainder of the text (113 pages in all). References are given at the end of each chapter, followed by a Problems section. The text also contains a reasonable appendix. The layout of the material and text formatting is acceptable, making use of the standard

boldface type to represent tensors, along with the use of subscripts/superscripts for components.

This reviewer first encountered the original first edition when searching for material to supplement notes for teaching a class on boundary-layer theory. The text contained just what was needed to supplement the course notes, including a detailed development of the transformed boundary-layer equations, leading to the Blasius equation representing incompressible flow over a flat plate (laminar), and second-order boundary layer theory. Most of Chapter 5 was very useful in supplementing the primary course text and notes. The introductory Chapters 1–4 contained much useful material as well.

One final remark: The rather lengthy table of contents allots about three section breakdowns per page of text (or so it seems). This makes the table of contents appear almost like a miniversion of the index; many subsubsections would have been nice paragraph descriptors in the text without taking up space in the contents page. Still, this reviewer will continue to make use of the book for instruction and regards it as a valuable resource of scientific background for aerospace research.

José A. Camberos
U.S. Air Force Research Laboratory