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Book Review

Low-Speed Aerodynamics, Second Edition, by Joseph Katz and Allen Plotkin. Cambridge Aerospace Series, 2001; 613 pages.

REVIEWED BY A. T. CONLISK[1]

This is truly a unique and comprehensive book designed for a one year course in low Mach number aerodynamics. Perhaps because I am not an aeronautical engineer I appreciate the comprehensive nature of the book in which the subject matter ranges from a basic discussion of high Reynolds number fluid mechanics to a comprehensive discussion of three dimensional flow past relatively complex aerodynamic bodies.

The authors have made a conscious decision to restrict themselves to the limit of low Mach number, unlike more conventional aerodynamics books such as the book by Bertin, *Aerodynamics for Engineers, Fourth Edition* (2002) which devotes a considerable amount of space to compressible and even hypersonic flow. In my view, this is not a weakness of the book; the fundamentals of aerodynamics are presented in great detail and the inclusion of detailed computer programs, at the time of its first publication was relatively rare. There is a healthy mix of theory and analytical methods owing to the years of experience of Professor Plotkin and computational methods primarily provided by the years of experience of Professor Katz.

The text is a second edition and is over 600 pages in length; not only is it useful as a textbook, but it also serves as a ready reference book for incompressible aerodynamics. Graduate students find it easy to read and comprehensive enough so that they can initiate a research effort essentially independently. At the same time, the text provides fundamental insights into basic incompressible fluid mechanics with aerodynamic applications. In particular, I have not seen the extensive discussion of 3-D panel methods discussed in such detail anywhere else. At the same time a chapter on the fundamental theory of the laminar boundary layer has been added in this, the second edition, a unique feature in a book tailored to aeronautical engineers. In addition, complete computer programs written in Fortran for two and 3-D panel methods are provided in an appendix allowing the easy development of special purpose computer programs by the reader.

In my view, the book may be divided into four parts. Chapters 1–3 present the basics of incompressible fluid mechanics. Much of this material appears in undergraduate textbooks a fact which adds to the book's completeness. Chapters 4–8 describe the basic theory of linearized potential theory while Chapters 9–13 describe the numerical implementation of the basic theory. Chapters 14 and 15 while not necessary for completeness of the text add to its usefulness by presenting the basics of viscous flow theory and full 3-D implementation of the methods described in the previous chapters.

Chapters 1–3 provide a basic introduction to the fundamentals of fluid dynamics. Chapter 1 begins with a discussion of the notion of flow lines which and dimensional analysis and the presentation of the governing equations which often appears in undergraduate texts in fluid dynamics. Chapter 2 introduces the concept of vorticity and circulation in incompressible flow with a short derivation of Bernoulli's equation. Much of the material in this chapter appears in undergraduate texts and their presence in this text reinforces the theme of a self-contained presentation which permeates the entire text. An exception to this is the discussion of the Biot-Savart Law, the basic building block of 3-D aerodynamics. Chapter 3 provides an introduction to potential theory leading into Chapters 4 and 5 which discuss the flow over three-dimensional wings and 2-D airfoils respectively. Chapter 6 describes 2-D potential flow analysis using complex variables; this classical analysis is supplemented by a detailed discussion of the force on the airfoil obtained both by the Kutta-Joukowski law and by an integration of the pressure distribution. Airfoils with finite trailing edges are also considered.

Chapters 1–6 comprise what may be stated as the fundamental portion of the text except for Chapter 14, which discusses boundary layer theory, a chapter which was added in the 2nd edition. Chapters 7–12 present solution methods for the basic problems in two and 3-D aerodynamics.

Chapter 7 introduces the concept of 2-D thin aerofoil theory which leads into singular perturbation theory. This treatment is somewhat unusual in classical aerodynamic texts yet the discussion of thin aerofoil theory in terms of singular perturbations is extremely enlightening. Following the theme of Chapter 7, the 3-D, slender wing is presented. Here the fundamental notion of a lifting-line is introduced and the formulas for the loads on the airfoil are also calculated.

Chapters 9–12 provide a lucid introduction to the classical numerical analysis appropriate to thin airfoils in both two and three dimensions. First, 2-D panel methods are described in Chapter 9 where the airfoil is described by a lumped vortex element. In Chapter 10, the various kinds of singularities which may be used to represent airfoils, including source, doublet and vortex distributions. Along with the basic theory of singularity elements, the various methods of approximation of the strength of the elements is discussed.

Chapter 11 presents several examples of the numerical solution of the 2-D theory first introduced in Chapter 9. Here specific examples of a flat plate and cambered airfoils are solved numerically. Both Dirichlet and Neumann boundary conditions are treated. A minor note: Fig. 11–36 is considerably out of date and should be redone.

Building on the basic numerical methods in two dimensions, 3-D methods are described in Chapter 12. Significant attention is paid to the horseshoe vortex and vortex ring models for flow past a 3-D fixed wing.

In a rather lengthy chapter, Chapter 13 several examples of unsteady problems are presented. It is shown that the methods described previously for the steady problem may be readily extended to the unsteady problem. The sudden acceleration of a 2-D flat plate and a pitching wing are considered explicitly. The 2-D thin airfoil theory presented in Chapter 5 is completely redone for unsteady flow.

A unique feature of this book is the discussion of boundary

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layer theory in Chapter 14. The boundary layer on a curved surface is discussed first; this problem corresponds to the viscous flow near the leading edge of an airfoil. Next the basic theory of similarity solutions is presented corresponding to the viscous flow on the airfoil away from the leading and trailing edges. The von Karman integral approach is also presented and the first order interaction between the boundary layer and the outer inviscid is described.

The book concludes with a Chapter on applications, including a basic discussion of separated flow and high angle of attack aerodynamics. Problems ranging from 2-D unsteady flow past a 2-D flat plate airfoil to the 3-D flow past an entire aircraft are presented. An extensive set of references follows the chapter so that the reader may look up the original references.

This book is a significant contribution to the aerodynamic literature. Several of my students have been able to begin their research careers in aerodynamics by reading and digesting this book. It is certainly a significant contribution to modern aerodynamic theory and numerical computation of aerodynamic flows over both simple 2-D and complex 3-D shapes.