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Book Review

Boundary Layer Analysis

Joseph A. Schetz, Prentice-Hall, Englewood Cliffs, New Jersey, 1993, 586 pp., $60.00.

This book is designed for a one-year course in boundary layers (laminar, transitional, and turbulent) and appears to be an outgrowth and extensive revision of Schetz's 1984 book *Foundations of Boundary Layer Theory for Momentum, Heat and Mass Transfer.* It may be considered a replacement for *Boundary Layer Theory* by Schlichting, which many of us have used for half a century for course and reference purposes. This new book is useful for classes since it contains homework problems and appendices with computer codes for the numerical solution of a variety of boundary-layer flows. It is also useful for reference since it contains an extensive, up-to-date bibliography. It is certainly appropriate that Schetz gives nearly equal attention to skin friction, a phenomenon largely dependent on the velocity distribution within the boundary layer, and to heat and mass transfer, phenomena dependent on the temperature and concentration distributions within the boundary layer as well.

The first four chapters are concerned with preliminaries: derivation of the equations of motion, their reduction to boundary-layer form, and the elements of turbulence and integral methods of solution. Here we can set forth two quibbles. To pages 16–19 might well be added a discussion of the existence and importance of higher order terms in the Reynolds number expansion. We know from the asymptotic analysis of van Dyke that only a systematic treatment of these terms leads to the correct effects of surface curvature, induced pressure gradients, external vorticity, etc., all higher order effects. Furthermore, in Chapter 2 there is no indication of the richness and variety of integral methods since the discussion is limited to the usual Karman-Pohlhausen and Thwaites-Walz contributions.

Chapters 4 and 5 are concerned with exact solutions for laminar boundary layers, low speed flows in the former and high speed in the latter. The numerical treatment of the equations for both similar and nonsimilar flows is carefully considered in Chapter 4; both finite difference and finite element methods are discussed. It would be worthwhile if, in these chapters, Schetz included a discussion of the asymptotic behavior of the solutions to the boundary-layer equations as the external flow is approached. This behavior is fundamentally important in, for example, the Falkner-Skan equation for adverse pressure gradients, can be important in numerical solutions, and can expose flawed formulations of variations of the usual boundary-layer flows. Included in Chapter 5 is a discussion of the compressible cases of the flat plate and stagnation point flows including, in the latter, real gas effects.

The ubiquitous and, from an applied point of view, important problem of transition from laminar to turbulent flow is treated in Chapter 6. Included are elements of stability theory, an extensive review of transition data including the influence of roughness, density stratification, and high speed. It is certainly useful to have one convenient source of these data.

Chapters 7–10 deal with the classical turbulent flows, i.e., boundary layers without and with streamwise pressure gradients, duct flows, and free shear flows. Again heat and mass transfer effects are included. In each topic Schetz presents first the classical, early solutions and then moves on to the contemporary k-ϵ and related one-and-a-half-order methods. Brief mention is made of Reynolds stress closure and the role of direct numerical simulations in assessing and improving turbulence theories. Chapter 10 contains a careful and valuable review of turbulent boundary layers involving density inhomogeneities, noting important uncertainties in our present understanding of variable density turbulence. For example, on page 434, following a discussion of the ad hoc incorporation of variable property effects in the inner region of high speed turbulent boundary layers we find: "No sound analysis has been presented to justify these assumptions. Instead, the justification for adopting them is the pragmatic argument that the models seem to 'work'." The impression left on the reader by pages 454–456 that high speed flows with chemical reaction represent a modest extension of previously treated problems is quite misleading; Schetz should have shared with the innocent his awareness of current research in turbulent combustion and the significant problems involved.

Up to this juncture in the book, attention is restricted to flows that can be described by at most two independent variables. The last chapter, Chapter 11, deals with the important problem of three-dimensional laminar, transitional, and turbulent flows, principally boundary layers, but including three-dimensional jets as well.

We are indebted to Professor Schetz for an excellent, up-to-date review of boundary layers, a useful book for the classroom and for reference.

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