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Book Review

Laminar Flow Theory

P. A. Lagerstrom, Princeton University Press, Princeton, NJ, 1996, 268 pp., $19.95 (paperback)

This book is a reprinting of Lagerstrom's *Laminar Flow Theory*, first published in 1964 as a contribution to Volume 4, *The Theory of Laminar Flows*, in the Princeton Series on Jet Propulsion and High Speed Flow. In a preliminary form it existed as course notes used at the California Institute of Technology as early as 1952. Of course, the notes were continually revised, and a footnote indicates that the manuscript was completed in 1956, although the final work contains references as late as 1957. The original 1964 publication was delayed because other authors contributing to Volume 4 were tardy. Meanwhile the notes were widely distributed. At Berkeley the class notes I used in 1962 carried the remark "An influential source of material (for these notes) has been P. A. Lagerstrom's contribution on Laminar Flows, in the forthcoming Volume Four of the Princeton Series on High Speed Aerodynamics and Jet Propulsion." The current republication once again gives the fluid mechanics community, and in particular those in the aerospace industry, access to this timeless material.

Laminar Flow Theory is a milestone in the fluid mechanics literature because it introduces a new viewpoint into theoretical fluid mechanics. In essence, it organizes the theory by appropriately nondimensionalizing the governing system of equations and seeking limiting forms as the Mach number or Reynolds number takes on extreme values. Thus, the various special classes, for example, incompressible flows, were considered as asymptotic expansions of the exact answers. This viewpoint was reinforced by the publication in 1964 of Van Dyke's widely read *Perturbation Methods in Fluid Mechanics* (Academic Press). A significant contrast is that Van Dyke deals with asymptotic methods themselves, as illustrated by specific example problems, whereas Lagerstrom focuses on formulating theories as special classes of problems of the complete Navier–Stokes equations. The location and the period of time in which the Lagerstrom material was developed coincided with rapid advances in the aeronautics industry. Hence, the book deals mainly with streaming flows past closed bodies. Even then, the emphasis is on viscous flows with only occasional reference to classical aerodynamics.

Within the 268 pages there are only four chapters. The first is "Navier–Stokes Equations for a Viscous Heat-Conducting Compressible Fluid." Presented in clear language, the equations are developed with precise logic, starting with the general concepts and proceeding to the specific.

Chapter two is entitled "Review of Viscous Incompressible Fluids." It assumes the incompressible equations and begins with a discussion of problems that illustrate viscous diffusion and then proceeds to derive and discuss Stokes and Oseen approximations and their interrelationship. Boundary layers occupy three sections.

"Introductory Discussion of the Navier–Stokes Equations for a Compressible Fluid" is the third chapter. Here one finds a discussion of the possible ways to nondimensionalize the variables. Compressible Couette flow of a perfect gas is used as a vehicle to give limiting forms: $M = 0$, compressible flow; $M = 0$, incompressible flow; and $M = \infty$ hypersonic flows.

The final chapter, "Laminar Boundary Layers in Compressible Fluids," is a survey of the various transformations that are useful in compressible boundary layers. It gives results for Mach number effects on heat transfer and wall friction.

By way of a summary, let me say that this small book should be in the library of every serious scholar of fluid mechanics. Also, it would be valuable as a supplementary text for an advanced fluid mechanics course.

Ronald L. Panton
University of Texas