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Book Reviews

Mechanics of Liquids and Gases, Sixth Edition

L. G. Loitsyanskiy, Begell House, Inc., New York, 971 pp., $130.00

Forty or fifty years ago there were relatively few books devoted to fluid mechanics. In the succeeding years, that shortage has been addressed many times over, with the consequence that a veteran faculty member responsible for courses in the subject will have been offered a large number of texts and will have collected a long shelf of complimentary copies presenting the subject at various levels. We now have available a blockbuster volume of nearly a thousand pages devoted to fluid mechanics and many of its subfields.

Professor Loitsyanskiy was born in 1900, was graduated from the Physico-Mathematical Department of the University of St. Petersburg in 1921, and has had a long and distinguished career in the Soviet Union devoted to fluid mechanics and theoretical mechanics. He "... has authored more than 120 scientific works in the fields of applied mathematics, dynamics of viscous fluids, theory of boundary layer and turbulence." He is known in turbulence for the Loitsyanskiy invariant related to the permanence of the fluctuations of large scale in isotropic, homogeneous turbulence.

The volume under review is the sixth edition. We are not told when the first edition was published, but the second appeared in 1957 and was translated and issued in English by Pergamon Press in 1966. "The 6th edition incorporates significant advances towards the solution of problems in boundary layer theory, dynamics of viscous fluids and theory of turbulence." These advances include the addition of Chapter 16, which is concerned with "computational hydrogasdynamics." The English translation was edited by Dr. Robert H. Nunn.

A survey of the contents establishes that "Mechanics of Liquid and Gases" covers the standard topics in the broad area of fluid mechanics, but not all possible topics, as we discuss in some detail later. Thus the first five chapters are devoted to mathematical preliminaries and to development of the conservation and transport equations for fluids. Indicative of the comprehensive coverage of theoretical considerations, Chapters 1 and 2 include a rather thorough introduction to vector and tensor analysis and a detailed treatment of the kinematics of a continuum, respectively.

The contents of the remaining 11 chapters are briefly outlined. Chapter 6 concerns one-dimensional gas dynamics, concluding with a treatment of an idealized shock tube. All the elegant theorems and machinery for treating two-dimensional potential flow, conformal mapping, and complex variables, are discussed in Chapter 7. Chapter 8 concerns planar supersonic flows including shock and expansion waves, hypersonic similarity of thin airfoils, the method of characteristics, and the hodograph method. Three-dimensional flows, including finite wing and lifting surface theory, are dealt with in Chapter 9. Viscous flow problems are first encountered in Chapter 10; the elementary flows given by exact solutions of the Navier–Stokes equations are treated there. Stokes flow and lubrication theory are considered in Chapter 11, and Chapter 12 is devoted to the laminar boundary layer. Here the standard similarity solutions for boundary layers, free jets, and wall jets are given, along with the usual moment methods of solving nonsimilar flows. Chapters 13 and 14 concern turbulent shear flows, starting with a discussion of transition and of the standard methods for closing the moment equations at the first level. Integral methods for obtaining solutions for turbulent boundary layers are discussed. Viscous gas flows, e.g., high-speed laminar boundary layers, are considered in Chapter 15. Finally, as mentioned earlier, Chapter 16 provides an introduction to computational fluid dynamics. Throughout, not surprisingly, references are made to Russian literature not widely known in the West, so that some developments usually attributed to Western scientists are assigned to Russian authors.

It will be recognized from this summary of contents that *Mechanics of Liquids and Gases* covers more material than the usual introductory text in fluid mechanics. Indeed, one would have to put together an introductory fluids book, a viscous flow book, a gas dynamics book, a supersonic aerodynamics book, and an introductory computational fluid dynamics book to obtain the same coverage. However, a critical examination indicates some significant shortcomings. Here are several examples thereof: Chapter 6, which is concerned with one-dimensional flows, does not include the important topic of generalized flows with friction, heat addition, area change, etc. The derivation of the boundary-layer equations in Chapter 12 follows the usual physical arguments presumably used by Prandtl in 1904. Although these arguments must be given in a text of this nature, it is now widely recognized that a second derivation based on asymptotic methods is essential if readers are to understand the fundamental basis of the theory. Furthermore, we now know that such methods provide the only reliable derivation of the second-order equations that account, for example, for the effects of surface curvature and vortical interactions. In the same chapter, discussion of the important problems of heat transfer and buoyancy is minimal. The treatment of turbulence in Chapter 13 is devoted solely to turbulence phenomenology with no discussion of turbulence spectra, spectral transfer, turbulent scales, etc., material important for understanding the basis for that phenomenology. In Chapter 14 current methods of analyzing turbulent flows, including the well-known k–ϵ theory, are discussed only briefly. Thus a reader must look elsewhere to obtain a perspective on the treatment of turbulent shear flows by current moment methods. There is no discussion of the important results of direct numerical simulations. Finally, reference to relevant experiments in fluid mechanics is scarce throughout; the first nod toward experiment is a brief discussion of a pitot-static tube on page 99 as an application of the Bernoulli equation.

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