Batchelor, G. K.

An introduction to fluid dynamics. 2nd pbk-ed. (English) Zbl 0958.76001

Cambridge Mathematical Library. Cambridge: Cambridge University Press. xviii, 615 p. (1999).

Fluid mechanics is usually concerned with the macroscopic study of motions of fluids and gases based upon the continuum hypothesis. The mathematical analysis is based on fundamental principles of mechanics, including Newton's laws of motion and momentum and energy principles. This reprinted book [for the first edition see the author, An introduction to fluid dynamics. Cambridge: At the University Press 1967. XVIII (1967; Zbl 0152.44402)] provides an introduction and systematic treatment of fluid dynamics. In order to help to acquire the physical understanding and analytical treatment, the author gives a comprehensive treatment of almost all basic inviscid and viscous fluid flow problems in various geometric configurations. Unlike currently available text books on fluid dynamcs with emphasis on the solution techniques, Batchelor makes a serious attempt to discuss the basic mathematical and physical principles, methods and results, theorems and proofs, so that the treatment reflects the unity of applied mathematics and physics.

This classical text has seven chapters, several appendices, a list of references, and a subject index. Chapter 1 deals with physical properties of fluids, special attention is given to distinctive properties of liquids and gases, volume forces and surface forces acting on a fluid, mechanical equilibrium of a fluid, classical thermodynamics and transport phenomena. Kinematics of the flow field is the main topic of chapter 2. This chapter includes specification of the flow field, conservation of mass, relative motion near a point, vorticity distribution, two- and three-dimensional flow fields extending to infinity, and irrotational solenoidal flows.

Chapter 3 is devoted to basic equations governing the motion of fluids. Included are the expression for stress tensor, Navier-Stokes equations, changes in the internal energy of fluid in motion, Bernoulli's theorem for a steady fluid flow, and the complete set of equations governing the motion of fluid. Chapters 4 and 5 are concerned with the motion of incompressible viscous fluid, flows at small and large Reynolds numbers, steady and unsteady unidirectional flows, Ekman's layer at a boundary in a rotating fluid, Oseen equations, viscosity of a dilute suspension of small particles, vorticity dynamics, boundary layer flows, jets, free shear layers and waves, oscillatory boundary layers and flow systems with a free surface. Special attention is given to the effects of viscosity. Irrotational flow theory and its applications are discussed in chapter 6 in some detail, with emphasis on applications of Bernoulli's theorem and momentum theorem, axisymmetric irrotational flows due to moving bodies, large gas bubbles in liquid cavitation in the free-streamline theory, and steady jets and cavities. The final chapter discusses rotational flows of effectively inviscid fluids with many examples of applications in geophysics, aeronautics, and in other fields. Particular attention is paid to steady axisymmetric flows with swirls, to flow systems rotating as a whole, and to the vortex system of a wing.

In summary, the first three chapters can be regarded as a solid background for the study of any branch of fluid dynamics. This is followed by a systematic treatment of the motion of viscous fluid and the properties of flows at high Reynolds number, so that the viscosity can vanish in the limit which leads to the study of inviscid fluid flows. In opinion of the author, this unconventional approach to fluid dynamics is more natural and effective from both mathematical and physical points of view.

This book gives an excellent introduction to fluid dynamics, especially to the dynamics of incompressible viscous fluid flow which is at the center of fluid dynamics by virtue of its fundamental nature and its practical importance. Particular attention is paid to the correspondence between observations and various analytical models of fluid flows. Many interesting and important photographs of fluid flows are included in order to help the students who do not have an opportunity of observing flow phenomena in a laboratory. The book also contains exercises at the end of each chapter. In comparison with many currently available books, I find this book by Batchelor especially stimulating and useful for students of applied mathematics and engineering.

Reviewer: L.Debnath (Orlando)

MSC:

76-01	Introductory exposition (textbooks, tutorial papers, etc.) pertaining to fluid mechanics	Cited in **2** Reviews Cited in **433** Documents
76Dxx	Incompressible viscous fluids	
76Bxx	Incompressible inviscid fluids	
76U05	General theory of rotating fluids	

Keywords:

inviscid flows; fluid dynamics; viscous fluid flows; vorticity dynamics; boundary-layer theory; irrotational flow theory; asymmetric flows; physical properties of fluids; solenoidal flows; stress tensor; Navier-Stokes equations; Bernoulli's theorem; Ekman's layer; rotating fluid; Oseen equations; dilute suspension; free surface; effects of viscosity; cavitation; free-streamline theory; jet

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