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BOOK REVIEW

Fluid Dynamics: Theory, Computation and Numerical Simulation. By C. Pozrikidis. Kluwer, 2001. 688 pp. ISBN 0 7923 7351 0. € 176 or $194 or £121

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The aim of this book is "to offer an introductory course in fluid mechanics, covering traditional topics in a way that unifies theory, computation, computer programming and numerical simulation". This is an excellent idea in principle – numerical methods are now at least as important as analysis. But the author has set himself a daunting task. Computational fluid dynamics is a notoriously difficult subject, and I felt the combination of approaches was not entirely successful. Only the most elementary computational techniques are considered, and this limitation is probably inevitable, given the complexity of the subject. Another difficulty is that the approach is "truly introductory" which means that certain sections cover material on linear algebra and calculus which advanced undergraduates would be expected to know. This feature tends to slow down development of the theory.

Chapter 1 covers standard material on flow kinematics but also discusses the problem of computing particle trajectories given the velocity field, introducing the RK2 method. Chapter 2 looks in more detail into the various modes of deformation of a fluid particle and introduces the velocity gradient tensor. Most textbooks reverse the order of this material, starting with a general local analysis of rate of strain, then looking at particular examples. I find the normal order more natural but students might prefer Pozrikidis's approach. Generally I found the treatment somewhat unsatisfying because the nature of a second-order tensor is not precisely explained, the reader being referred to texts on matrix calculus. This is a strange gap in the analysis. After all, a second-order tensor can be quite simply defined as a linear transformation and its properties can then be easily established. Numerical applications are limited in this largely theoretical chapter, but there is some discussion of numerical differentiation. Generally I found the developments in chapters 1 and 2 unnecessarily long-winded. Chapter 3 focuses on irrotational incompressible flow, which naturally leads to the development of numerical methods for solving Laplace's equation.

Chapter 4 deals with the key relations between stress and rate of strain. The treatment is somewhat unsatisfying mathematically, since the constitutive equation is simply stated without a detailed justification. The necessity that the fluid be isotropic is not therefore made clear. On the plus side there is a good physical discussion of viscosity, with a detailed treatment of viscosity in a gas. The following chapter on hydrostatics includes a section on capillarity and some interesting applications of differential equation shooting methods to find free-surface profiles.

The numerical heart of the book is chapter 8, "Finite difference methods". The first example considered is uni-directional flow driven by a given pressure gradient. This simple case is used to illustrate the advantage of an implicit scheme, although there is no formal discussion of stability. The vorticity–stream function formulation is introduced, but the derivation of the vorticity boundary condition seems more difficult than necessary – a simple Taylor series expansion of the stream function gives the result almost immediately.

The last three chapters, which deal with low and high Reynolds number flow, contain some interesting material not often found in textbooks – Stokeslets, corner flows, instability of shear flows including a derivation of the Orr–Sommerfeld equation, vortex motion and vortex patches, aerodynamics and numerical vortex panels methods.

To summarize, I found this an original and interesting textbook. There is some theoretical weakness, and the finite difference section gives only a glimpse of the deep dark world of CFD. Nevertheless it would be a useful book for any student or teacher of fluid mechanics.

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