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BOOK REVIEW

ENGINEERING FLUID DYNAMICS – AN INTERDISCIPLINARY SYSTEMS APPROACH, 1997. Clement Kleinstreuer, Cambridge University Press, Cambridge ISBN 0-521-49670-5.

Fluid dynamics is a difficult and challenging subject with many branches and specialisms. The compartmentalization of the subject into compressible and incompressible, viscous and inviscid, reacting and nonreacting, and so forth, of course is artificial, but is often useful in order to achieve valuable simplifications in particular classes of problem. It is also useful in teaching, where a broad appreciation of the whole subject can be fostered by building each new concept upon the secure foundation of a previous level of understanding. For the modern engineer, fluid dynamics is often a means to a more ambitious end involving heat transfer, mass transfer, chemical reaction or all three. Unfortunately, the link between the elements of fluid mechanics and the more complicated (and real) world of advanced thermo-fluid dynamics is not always well made in undergraduate or even postgraduate courses, and the gap is becoming steadily broader with the increasing use of techniques such as CFD in industrial practice. A more unified approach to fluid dynamics teaching seems attractive, and this book represents an attempt to provide a base for precisely that purpose.

The book contains five chapters and six appendices. Chapter 1 covers fluid kinematics, thermodynamic properties, transport properties, the stress tensor and vorticity dynamics in little more than 20 pages, followed by a further 15 pages of worked examples and homework problems. The material is presented at breakneck speed and in a rather haphazard manner, bringing in chemical thermodynamics and non-Newtonian fluids as part of the development. The mathematical level is certainly advanced, requiring a working knowledge of tensor algebra from the very beginning, and introducing the material derivative in half of one paragraph. Chapter 2 discusses the derivation of the governing equations in both integral and differential form using fairly standard control-volume methods, though once again no small detail is missed and the development includes conservation of chemical species. The notation becomes rather complicated, and there is a disappointing section on boundary conditions that does not really begin to address their crucial role in the analysis of virtually all practical flow systems. There is a lengthy section devoted to scaling theory, dimensional analysis and a general discussion of solution methods, and the chapter concludes with no fewer than 30 pages of problems and worked examples.

Some degree of specialization begins in Chapter 3, which deals mainly with incompressible viscous flow in its many different manifestations. Exact solutions of the Navier–Stokes equations are discussed in some detail and several very practical examples are presented. There is an extensive discussion of laminar boundary layers before turbulence is introduced. Many of the standard results of turbulence theory are covered, but the approach is oddly selective and the development is far from smooth. Again, a very long section is devoted to problems and examples. In Chapter 4 the subject is convective heat transfer, covering governing equations, analytical treatment of the thermal boundary layer and the establishment and use of empirical correlations. This is perhaps the most useful chapter, in that it provides much more detail on the all-important link between the fluid motion and the transport of heat than is usually found in texts on either fluid mechanics or heat transfer.

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Practical examples are plentiful in the body of the chapter as well as in the very comprehensive problems-and-examples section.

The final chapter contains a series of case studies on topics such as turbulent shear-layer flows, non-Newtonian flows, convection heat transfer and bio-fluid dynamics. Some of these are potentially very interesting as vehicles for teaching and especially for project-based work, but the level of complexity is very great in many cases, and the physically important points tend to become lost in a wealth of unnecessary detail. To a large extent, the potential for achieving a high degree of unification in the subject is wasted through the need to specialize simply in order to get the problem solved. The reader is left with the feeling that specialism is perhaps not such a bad idea after all.

In general, the book is well produced. The extensive mathematics are clearly reproduced and the Nomenclature section is particularly valuable in that it includes the dimensions of all relevant quantities. The figures by contrast are very poorly presented, with a very rough typeface that is visually incompatible within the main text. There are extensive references and a useful index.

In summary, this is a valiant attempt to unify a vast subject, but is pitched at rather too high a level to be useful in most University engineering courses, and is let down rather badly by its own idiosyncrasies.

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