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REVIEWS

Mechanics of Fluids. By B. S. MASSEY. Van Nostrand, 1968. 508 pp. £5. (Paperback £2. 5*s*.)

Engineering Fluid Mechanics. By J. E. PLAPP. Prentice-Hall, 1968. 654 pp. £6.

Each of these books is intended for students of mechanical or civil engineering and covers most of the material that is normally taught in a first-degree course. Students of aeronautical engineering will also find the books useful as an introduction to fluid mechanics but these students will need some additional reading in subjects such as aerofoil theory, boundary layers and supersonic flow.

In the book by Plapp the approach used is to proceed as far as possible from the general to the particular. Thus the Navier–Stokes equations are introduced at a fairly early stage and are then applied in various special situations to obtain the simple results of elementary fluid mechanics. The advantages of this approach have often been stated; it provides a firm foundation on which more advanced courses may be built, but many engineering students may prefer the more traditional approach (as in Massey's book) for their first introduction to fluid mechanics.

Plapp tends to put the emphasis on mathematical theory rather than physical description, although the mathematics he uses should be well within the capacity of normal engineering students. The book does not contain any flow photographs and the few sketches that he gives of separated flow are rather idealized. The units used are mainly $\mathrm{lb_f}$ slug ft sec °R but there is occasionally some confusion between mass and weight.

After an introductory chapter on fluid properties and the stress tensor, Plapp goes on to hydrostatics. Here there are some examples of his very general approach, which may perhaps be interpreted by some engineering students as the introduction of unnecessary complexity in simple problems. Thus, for example, the body force per unit mass is taken as a general vector, so that even the simple expression for the pressure difference between two points takes the form of an integral of a scalar product. Manometers are discussed briefly but it is not made clear that the quantity measured is the difference of $(p+\rho gz)$ and not the difference of p.

The next three chapters contain the main theoretical treatment of fluid dynamics. The Navier–Stokes equations and the equations of continuity and energy are introduced and the integral equations of continuity, momentum and energy are then developed. Bernoulli's equation for an incompressible fluid is derived in two alternative ways, from the energy equation and from the vector equation of motion for an inviscid fluid, but the relationship between the two identical but separately derived equations is not discussed. The last chapter of this group of three deals with circulation, vorticity, velocity potential, stream function, and simple flows due to vortices, sources and doublets. The use of complex variables is mentioned only briefly.

The chapter on similarity and dimensional analysis starts with some of the basic equations of fluid mechanics and reduces these to non-dimensional form. It is only after this that any general account of dimensional analysis is given and this is presented in a way which emphasizes the mathematics rather than the physical principles. The difficulties which students find in this subject are mainly in deciding which variables and hence which dimensionless groups should be included, and the book gives little help in this area.

The next four chapters deal in turn with laminar and turbulent flow, velocity and flow measurement, flow in closed conduits and flow in open channels. The order of this arrangement does not seem very suitable, for example weirs are discussed in the chapter on flow measurement before the general account of flow in open channels. Again, the chapter on laminar and turbulent flow deals mainly with pipes and channels (boundary layers are only briefly mentioned), yet this is separated from the chapter on flow in closed conduits by the account of flow measurement. In the chapter on flow in open channels the use of the Chézy coefficient and other coefficients that are not non-dimensional contrasts rather strangely with the mathematical rigour of other parts of the book.

The chapter on compressible flow is a satisfactory introduction to the subject but it is perhaps rather brief in relation to the length of the book. Only normal and not oblique shock waves are considered and as a result the discussion of the formation of shock waves in a convergent–divergent nozzle is incomplete.

Chapter 12, entitled 'Forces exerted by fluids on moving bodies', deals with a variety of topics. First, the result for inviscid flow leading to d'Alembert's paradox is derived and the relationship between lift and circulation in two-dimensional flow is obtained. There is then a very brief section on boundary layers, but this covers only about 20 pages and is almost the only place in the whole book where boundary layers are mentioned. This is followed by very brief accounts of aerofoils, three-dimensional wings, ship resistance and the general principles of propulsion systems.

In the final chapter on fluid machinery the energy and momentum relationships are given, similarity is discussed and the principal classes of turbine, pump, fan, coupling and torque converter are briefly described.

In contrast to Plapp, Massey adopts the approach that has been traditional in engineering teaching, in which simple results are often derived directly and not always as particular cases of general results. The treatment here is detailed and thorough, although at a fairly elementary level, and the emphasis is on physical description rather than mathematics. Unfortunately the book is marred by a number of passages which are seriously misleading; if these could be deleted it would be an excellent book.

Various systems of units are used, $\mathrm{lb_m}$ ft sec, $\mathrm{lb_f}$ ft sec and S.I., but the discussion of units and dimensions is always rigorously correct and the use of different systems should be illuminating and should not lead to any confusion.

The first four chapters deal with fluid properties, hydrostatics, Bernoulli's equation and the equations of continuity, energy and momentum for steady flow. All these topics are well explained and illustrated by simple applications.

The fifth chaper is entitled 'Two kinds of flow' and in this the author departs

from the conventional approach. He starts by describing Reynolds' experiments on laminar and turbulent flow in pipes, going on to discuss in general terms the development of turbulence at high Reynolds number. Unfortunately he does not associate this clearly with shear flows and he gives the impression that any flow will become turbulent at a high Reynolds number. (This would be a dismal prospect for designers of large low-turbulence wind tunnels!) In discussing critical values of the Reynolds number for transition from laminar to turbulent flow he gives correct values for pipes and channels but then gives a value of about 1·0 'for flow round the outside of a sphere'. This value is too low even for the development of turbulent flow in the wake, while for the boundary layer on a sphere it is wrong by a factor of about 10^5.

The next two chapters are entitled 'Laminar flow' and 'Turbulent flow in pipes', but in fact both of these deal with pipe flows and not with boundary layers, jets or wakes. The first of these chapters includes an account of some flows at very low Reynolds numbers and some lubrication theory. The second chapter follows the conventional approach and includes some discussion of roughness, bends, sudden enlargements and diffusers.

The short chapter on physical similarity is satisfactory except for a suggestion that in considering the flow of a compressible fluid γ is important only when there are density changes that are not isentropic. The next chapter is entitled 'The flow of an ideal fluid' and deals with the stream function, velocity potential flow nets, sources, sinks and doublets. There is also a brief discussion of aerofoils and of wings of finite span. The references in this chapter to separation may cause some confusion, since the chapter is otherwise concerned with the flow of an inviscid fluid and the part played by the boundary layer is not explained. There is some trouble of the same kind in the discussion of the flow past a circular cylinder with circulation, the effects of rotation of the cylinder (in a real flow) are mentioned without any reference to the important effect of the boundary layer.

Many of the difficulties that have been mentioned could have been avoided if the next chapter, on boundary layers and wakes, had been placed much earlier in the book. Although many of the essential features of boundary-layer flow are satisfactorily explained in this chapter, there are some passages which are seriously misleading. The Karman vortex street is given as the cause of 'the phenomenon of "flutter" which is a serious problem on aircraft'. There is a section in this chapter on the effect of compressibility on drag in which it is stated that when the velocity is high enough for compressibility effects to be important the Reynolds number is usually 'high enough for viscous effects to be insignificant'.

The next chapter on flow with a free surface discusses friction in channels, critical depth, surges, hydraulic pumps and weirs. Waves on deep water are not considered. It seems a pity that in this chapter so much use is made of the (dimensional) Chézy coefficient instead of a dimensionless friction coefficient.

The next two chapters deal with flow of compressible fluids and with unsteady flow in pipes. The first of these contains only the minimum material needed for a mechanical engineering degree course and should perhaps be supplemented by further reading for some students. There appears to be some confusion about the

effects of viscosity and thermal conductivity on shock waves but this is probably not serious. The argument given for the effect of a blunt nose on wave drag at supersonic speed is unconvincing; a similar argument used at subsonic speed would not give the correct result. The chapter on unsteady flow in pipes includes a discussion of water hammer and surge tanks. In this chapter there is a brief mention of 'sonic bangs' and blast waves but there is no attempt to relate these to the shock waves discussed in the previous chapter.

The final chapter on fluid machines is concerned only with incompressible fluids. The usual basic equations are derived and an account is given of the main types of hydraulic pump and turbine and their characteristics.

Opinion is divided on the type of text-book that is most suitable for use by engineering students. If a book using a general approach is required the one by Plapp is a good example and can be recommended. If the more traditional approach is required the book by Massey should certainly be considered, but it cannot be recommended without reservation because of its rather numerous misleading statements. These could easily be corrected by some deletions and re-arrangement and it is to be hoped that this will be done in a later edition.

W. A. MAIR

Current Ripples. By JOHN R. L. ALLEN. North-Holland, 1968. 433 pp. Hfl. 108 or £12. 12*s*. or $30.00.

Geologists have long been confronted with the challenge of describing the physical factors which over the aeons of geologic time evolved Earth to its present form and structure. Considering the immensity and difficulty of the task it is understandable that they have seized upon every available thread of paleoevidence concerning the ancient environment and its interaction with the land. The intriguingly regular structure of fossilized sediment ripples would seem to contain a storehouse of information about the flows that generated them, if only one could understand how these curious waves of sediment were formed and relate their geometrical characteristics to the properties of the generating flows. Thus for many years geologists, especially sedimentologists, have been at the forefront in the study of sedimentary bed forms.

In *Current Ripples*, Allen, a geologist, undertakes to present a virtually complete description of the geometrical properties and sedimentary structure of ripple marks (geologists' terminology) formed by water-borne sand, and to account for the mechanisms responsible for their occurrence and behaviour. It is impossible, of course, to achieve the second goal without first considering the mechanics of the generating flows, and accordingly chapter 2 is given over to a largely qualitiative discussion of some fundamental aspects of fluid flows, such as the distinction between turbulent and laminar flows, the continuity principle, streamlines, boundary layers, separation, vorticity, critical flow, etc. Fluid mechanicians will encounter several disquieting points in this chapter. For example, on page 7 one finds the sweeping statement, made without any restriction on the nature of the fluid or on the flow system: "The Reynolds number is primarily a criterion of similarity,.... By its use two or more geometrically corresponding fluid systems or parts of systems can be compared dynamically,

regardless of the fluids used and the absolute dimensions involved." And on page 12: "The vorticity of real fluids is usually contained in layers, though the generation of vorticity is not dependent on the action of viscous forces." The suspended load equation is attributed, incorrectly, to H. A. Einstein, rather than to Rouse and Ippen. And so on throughout the chapter. On the whole, however, the treatment of fluid mechanics is adequate for the limited use made of it subsequently in the book, and judged in the arena of geologists' publications on mechanics it is not too bad.

A description of the occurrence and characteristics of ripple marks occupies much of the balance of the book and is handled in admirable fashion. Ten principal types of bed forms are distinguished (parting lineation; small-scale ripples; antidunes; large-scale ripples; sand ribbons; braid bars; transverse bars linguoid bars; scroll, side and point bars; and tidal current ridges) and the occurrence and distinguishing features of each are described in considerable detail. The many excellent photographs and illustrations greatly enhance the descriptions. The volume recounts the results, theoretical as well as experimental, of many investigations on the conditions for occurrence and geometrical properties of bed forms, scour and depositional patterns and the velocity fields over and around them, grain trajectories, avalanching, sediment diffusion, etc. Theoretical studies are generally given scant attention compared to experimental ones. If one were to criticize this aspect of the book it would have to be on the grounds that the author has not been sufficiently selective and critical, but instead has included practically all results available on each topic without providing the reader with adequate evaluation of each. For example, five different empirically based graphs are presented for predicting the occurrence of different types of bed forms, but the relative advantages and strengths (if any) and weaknesses of each are not discussed.

An aspect of ripple marks that has received relatively little attention heretofore is the structure of the flow in the downstream separation zones. Allen seeks to correct this deficiency and devotes four chapters to various aspects of the problem and includes the results of a large number of flow visualization experiments utilizing the plaster of paris technique he developed (*J. Fluid Mech.* **25**, 331–335). The large number of excellent photographs presented shed considerable light on the kinematics of flow in the lees of ripples and on the emergence of short crested bed features from initially two-dimensional ones.

On balance, Allen has produced a first-class work, one that will probably become a standard reference in this subject. Save for the sparse treatment of the mechanics and the mathematical theories of bed instability and sediment motion, one finds little wanting. And if the reader's curiosity about current ripples is not quenched by the 414 pages of detailed description, he can seek further satisfaction in the more than 500 references cited.

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