Waves for beginners

Waves in Fluids. By James Lighthill. Pp. 504. (Cambridge University Press: Cambridge, New York and London, 1978.) £17.50.

THIS book is designed to provide an introduction to the theory of waves in fluids for students with little previous knowledge of fluid mechanics but with a sound background in elementary mechanics, ordinary differential equations and the theory of integral transforms. Its main thrust is to provide an understanding of their principal theoretical properties and to inculcate the ability to interpret the conclusions in a physical context. Readers of this book can expect to obtain a balanced view of the subject and quite a good basis for appreciating the advances now being made. The emphasis is on the linearised form of the equations but there are significant discussions of non-linear aspects as well.

It opens with an account of the simplest type of waves, namely sound waves, for which the dispersion relationship is linear and isotropic. Consequently, it is possible to explain in readily comprehensible terms such important concepts as sources, dipoles, radiation, scattering and dissipation. Next, the theory of one-dimensional waves is developed with application to a broad spectrum of topics in physics, including acoustics, distensible pipes and open channels. The crucial features common to the waves are that their characteristic length is short compared with that of the geometry of the propagation—for example, the variation in the shape of the channel and their amplitudes are small enough that non-linear effects develop slowly. By a succession of simple, steps, clearly explained, we are brought to an appreciation of the physics of the formation of shocks and hydraulic jumps and of geometric acoustics.

In chapter 3 the theory of water waves is considered as an important example of dispersive systems in which the wave speed, or phase velocity, is a function of the wavelength. The chief message here is that now disturbances originating at some point at time $t=0$ propagate with the group velocity and not with the phase velosity. Many elementary textbooks founder at this point but (not surprisingly) the author sails through the difficulties with majestic ease. The student cannot fail to grasp the essential ideas, and now the way is open to the appreciation of many of the important features observed in wave motion.

Non-isotropic and even inhomogeneous dispersive wave motions are studied in the final and main chapter, with internal waves in stratified fluids as a paradigm and we are led to the heart of the book—the discussion of ray theory, including caustics. This is a concept of great power and importance to scientists and engineers, who will value the lucid mathematical and physical explanations. The book ends with an epilogue; in part listing examples of other types of wave motion and in part explaining Whitham's theory of non-linear waves.

All students of fluid mechanics admire the author as an outstandingly successful contributor and expositor. The present book is an excellent example of his powers and will be especially appreciated by new converts to the field. Not only will they be able to learn the basic ideas of wave motions but also how to marry mathematics and physics in a mutually beneficial way; and they can hone their technique on the large number of sensible and realistic examples included in the text.

From my reading of the book, and bearing in mind the aim of the author in writing it, I have happily found it impossible to formulate a criticism of any significance. The only regret is associated with the use of the word epilogue to describe the final chapter. I hope that this is not the author's farewell to wave motions in fluids and that he intends, or will allow himself to be persuaded, to write another volume giving us the benefit of his view of the modern state of the subject.

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Applications of catastrophe theory

Catastrophe Theory: The Revolutionary New Way of Understanding How Things Change. By A. Woodcock and M. Davis. Pp. 152. (E. P. Dutton: New York, 1978.)

THE aim of this book is to present catastrophe theory and its applications to readers untrained in mathematics or science. This is a difficult enterprise, not only because the mathematics underlying the main catastrophe classification theorem is extremely abstruse but also because the scope of application claimed for the theory is very wide, ranging from the buckling of beams through the development of the sea urchin's gut to the changes in a person's status on marrying out of his or her class. As well as all this, the authors describe the history of the theory's development, and assess the arguments in the current intense controversy about some of its applications.

In a short book, any treatment of these subjects must be superficial. But the public has a right to expect that what is written is at least correct, and I was sorry to find the book ruined by numerous errors of fact, misleading statements and evidence of careless haste in its compilation. It is not true that when a liquid boils its individual molecules undergo a transition, or that an umbilic catastrophe differs from a cuspoid by involving a line jumping across a plane rather than a point jumping along a line, or that the conical shadow near the focus of a perfect lens is an envelope analogous to the caustic surface of an imperfect lens. The discussion of optics is illustrated by photographs with computer simulations that purport to correspond to them and in fact do not. The discussion of buckling is illustrated with two figures, the second of which is incomprehensible without further explanation and is more confused by being carelessly interchanged with the first (the captions remaining where they should be). In the last diagram in the book (half intended as a joke) the behaviour axis is wrongly labelled. It should not be thought that such mistakes are somehow excusable when writing for non-technical readers; in fact, those who know nothing of a subject are more easily confused, and popularisers have a duty to be scrupulous in matters of fact and clarity of presentation.

The higher catastrophes are best illustrated by their projections on to the control space, but in this book such projections never appear. Even the cusp catastrophe projection is presented only once (in that same buckling diagram) and is inexcusibly misdrawn with a corner at its singularity.

Much emphasis is placed on the theory's claim to (eventually) describe Nature's forms, but these are far too varied to be captured by one branch of mathematics. There is little mention of alternative possibilities, such as the numerology of leaf arrangement, the hierarchical 'fractal' structure of trees and blood vessels, the infinitely chaotic bifurcations implicit in population dynamics, and so on.

A colloquial style is used (we are told that Thom has a crew-cut, and Zeeman a bushy beard), implying not only that readers are non-technical but that their interest in the subject is not serious.

There is need for a popular exposition of catastrophe theory but this book does not satisfy it.

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