REVIEWS

Elements of Acoustics. By S. TEMKIN. Wiley, 1981. 515 pp. £15.35.

Acoustics: An Introduction to its Physical Principles and Applications. By ALLAN D. PIERCE. McGraw-Hill, 1981. 642 pp. £20.25.

In the preface to his book, Dr Temkin correctly refers to the lack of modern introductory texts that treat acoustics as a branch of fluid mechanics, and certainly his work is refreshingly free of the notation and jargon prevalent in books treating acoustics as a branch of electrical engineering. In contrast with Dr Pierce's book, Dr Temkin's is also uniform in level, and clearly aimed at the needs of final-year undergraduates and first-year postgraduates in physics, engineering and applied mathematics. It offers an exclusively theoretical treatment of a rather small selection of topics, under the chapter titles (1) Basic fluid mechanics and thermodynamics, (2) Basic properties of acoustic waves, (3) Reflection and transmission phenomena, (4) Spherical and cylindrical waves, (5) Sound emission, and (6) Sound absorption. The last of these accounts for some 110 pages out of the 477 of text, a fraction felt by this writer to be excessive, even granted the author's competence in this area and his opinion that while other topics (aerodynamic sound, diffraction, propagation in nonuniform media) may have been rather fully treated in other recent acoustics texts, that of absorption has not, nor has its importance been recognized.

Dr Temkin's book has been received elsewhere rather favourably, especially as regards its clarity of exposition. I cannot give it an unqualified welcome. The book is unsatisfactory on two levels. First, it has been very carelessly proofread. The slips average one per page, involving text, equations and figures, witn numerous inconsistencies of notation, and frequent misspellings and incomplete references in the Bibliography. At a certain level these things are almost trivial, but not, I think, for the student audience addressed by Dr Temkin.

Secondly, the text itself can often be faulted for loose and even misleading statements and explanations. As an example of the former, we have on p. 80: 'if the pressures (on either side of an interface) were not the same, the interface would move until the pressures would equalize.' An experienced fluid dynamicist may readily see what is meant by this statement; but it may well be mystifying for a student who comes fresh to the subject. The looseness arises from the fact that the statement is made without reference to the underlying mechanical principle, viz that if the pressures on either side of the interface were unequal, then a fluid disk of vanishingly small mass situated on the interface would be subject to an infinite normal acceleration; since this infinite acceleration clearly could not persist over a finite time interval, equality of pressures must in fact be instantaneously established. Temkin's phrase 'would move until the pressures would equalize' suggests a non-instantaneous process, and is to this extent misleading. More generally, his detachment of the statement from the underlying mechanical principle is liable to lead unwary students into uncritical and potentially spurious arguments in related contexts.

A more serious example is provided by the discussion of fields radiated by concentrated oscillatory forces and by small oscillatory bodies. Direct quotation disguises the point because of printing errors, but the argument of pp. 319, 320 runs as follows: the pressure radiated by a compact oscillatory sphere can be written (for $kr \gg 1$, $ka \ll 1$)

$$p \sim -\frac{3ik}{4\pi r} F_0 \cos\theta \exp(ikr - i\omega t),$$

F_0 being the magnitude of the force $\mathbf{F}_0$ exerted by the sphere *on* the fluid, and this can be expressed in dipole terms as

$$p \sim -\mathbf{f}_0 \cdot \nabla\left(\frac{e^{ikr-i\omega t}}{4\pi r}\right),$$

with the remark that 'we have put $\mathbf{f}_0 = 3\mathbf{F}_0$'. Nothing amiss in this, but on pp. 321, 322 the field of a concentrated force $\mathbf{F}_0$ applied to the *fluid* is calculated, correctly, to be

$$p \sim -\mathbf{F}_0 \cdot \nabla\left(\frac{e^{ikr-i\omega t}}{4\pi r}\right),$$

which 'is identical to that obtained from the oscillatory sphere potential, as indeed it should be'. Not a word as to why the $\mathbf{F}_0$ for the sphere is three times the *actual* force, and no explanation of a rather subtle degeneration, of a surface monopole distribution to a concentrated dipole, which occurs in the acoustic field of a rigid oscillating body. In fact, the dipole representing that body is equal to the force exerted on the fluid *minus* the rate of change of the fluid momentum displaced by the body, and for a sphere the displaced mass is twice the virtual mass, which leads at once to a dipole equal to three times the force exerted on the fluid.

There are also cases where an equation and a diagram are easily seen to say different things; for instance, the low-frequency scattered intensity from a massive sphere is predicted by (4.3.89) to vary as $(2-3\cos\theta)^2$, a function whose polar plot is not consistent with figure 4.3.4 showing two lobes aligned along $\theta = 0, \pi$ with a *null* at $\theta = \pm\frac{1}{2}\pi$ separating them. In this reviewer's opinion these, and other similar examples to be found throughout this book, seriously mar what would otherwise have been an acceptably direct and straightforward treatment of basic theoretical acoustics, presented for the most part in reasonably attractive and uncomplicated notation.

Dr Pierce's book is of an altogether different kind, although apparently addressed to the same audience as Dr Temkin's; it is much more wide-ranging, thorough and scholarly – and the publishers are to be congratulated for making such a substantial (and, from the printers' point of view, intricate) volume available in hard-back at such a reasonable price. This book (as Dr Temkin's) stems from courses given over many years; usually this is deemed to be beneficial, but it here has two drawbacks. The first is that the book is uneven in level. To put this in extreme form, the reader is on p. 20 reminded that $(a-b)(a+b) = a^2-b^2$, and on p. 24 that he can verify that $e^{i\alpha} = \cos\alpha + i\sin\alpha$ from a power-series expansion of both sides, while a little later he is briefly introduced to Fourier transforms, filtering and random processes, and well before the end of the book has covered the elements of the geometrical theory of diffraction, creeping waves, etc. Admittedly the author does indicate how selections of *material* may be made for particular groups of students and for reduced-length courses ('Other possibilities should be evident to an astute instructor'), but even within his selections the non-uniformity persists. Secondly, I have the impression that the extravagant notation with which the book abounds has come from one attempt after another to make each and every point clear to successive generations of students; there is hardly a symbol which does not have one or more suffices (parts of words, and even whole words, like 'resist' and 'interfering' are used as suffixes) together with a caret, tilde, prime, asterisk or angle brackets, in what appears to be a desperate attempt to leave no chance of misinterpretation. For me, however, there rapidly comes a point at which this makes things less, rather than more, clear, and reading becomes correspondingly slow.

These disadvantages are, however, outweighed by the many attractive features. The book – almost a treatise, even though introductory – concentrates on 'classical acoustics', comprising eleven chapters, each of about 50 pages, with titles (1) The wave theory of sound, (2) Quantitative measures of sound, (3) Reflection, transmission and excitation of plane waves, (4) Radiation from vibrating bodies, (5) Radiation from sources near and on solid surfaces, (6) Room acoustics, (7) Low-frequency models of sound transmission, (8) Ray acoustics, (9) Scattering and diffraction, (10) Effects of viscosity and other dissipative processes, (11) Nonlinear effects in sound propagation. All these topics are covered in some depth, with the exception of chapter 1, which, for once, I feel is here about right in relation both to the probable background of students and to the needs of the rest of the book. Chapter 2 deals with matters of importance in practical acoustics which are usually ignored in theoretical textbooks – $\frac{1}{3}$ octave and narrow-band spectra, manipulations of sound pressure levels, transfer functions and filtering – and it is appropriate to have this material discussed in a book subtitled 'An introduction to its physical principles and applications'. The titles of Chapters 3, 4, 5 leave little to be said about their content, save that Chapter 4 gives a thorough discussion of multipole fields, uses matched asymptotic expansions in a reasonably self-contained way to analyse the fields of compact vibrating bodies, and examines the Reciprocity Principle (though without the generality one would like for many applications). Chapter 5 gives a very extensive discussion of the field of a vibrating baffled piston, including transient radiation and much detail in the time-harmonic case. The student who works carefully through this section will have a good grasp of the mathematical and physical structure of the phenomenon of diffraction.

The treatment of room acoustics is similarly extensive – covering Sabine's reverberant room theory, modal representations, and statistical aspects of diffuse sound fields – though in my opinion much less happy than that of Chapter 5. Contrary to the author's intention, the Sabine theory does not emerge as a well-defined model, but as an uneasy mix of idealizations reminiscent of statistical mechanics with expedient ad hoc arguments. I could work up no enthusiasm at all for attempting the examples at the end of this chapter.

(The examples are a strong point of this book; a varied set of some thirty follows each chapter, illustrating and developing the text very well. My only complaint is that too many of them call for a numerical answer, when often what should be stressed is the structure of a formula and its physical implications.)

The rest of the book is better, chapter 8 in particular giving a treatment of sound propagation (dealing with inhomogeneous media, at rest and in non-uniform mean motion) which, in its thoroughness and yet compactness is not rivalled in any other acoustics text. Chapter 11 gives a remarkable introduction to nonlinear acoustics in 50 pages, lacking the unique insight of Lighthill's celebrated 1956 article, but covering clearly all the basic material (with the exception of the parametric array), including weak shock theory, the structure of partly and fully dispersed shocks in relaxing media, the analysis of Burgers' equation for harmonic waves (the Fubini and Fay solutions) and sonic booms.

A word must also be said about the references cited; Dr Pierce very properly draws constant attention to the historical development of all these topics with assiduously complete references and footnotes. Some may find this overdone; the assiduousness is almost absurd, to the point of giving the full Christian names of nearly all authors quoted (though here the author is curiously inconsistent), but on balance I found the references and index excellent, the footnotes more often illuminating than irritating.

In sum, this is a valuable addition to the acoustics literature; not a book to be read continuously, to be sure, nor a book to be used as a quick formula reference (the notation militates against that), but a serious and scholarly text, immaculately printed, which should serve advanced students well.

D. G. CRIGHTON

Asymptotic Methods in Nonlinear Wave Theory. By A. JEFFREY and T. KAWAHARA. Pitman 1982. 256 pp. £18.50.

The central theme of this book is the use of asymptotic techniques to describe the far field of nonlinear dispersive wave problems. The approach is heuristic with a deliberate lack of rigour, and the techniques are described by their detailed application to the Boussinesq equation

$$\frac{\partial^2 u}{\partial t^2} - c^2\frac{\partial^2 u}{\partial x^2} - \mu\frac{\partial^4 u}{\partial x^2\,\partial t^2} = \frac{1}{2}\frac{\partial^2}{\partial x^2}u^2,$$

which is a model for the propagation of moderate-size disturbances on the surface of a sea of liquid of sufficiently small depth.

Part I gives an introduction to wave propagation and to singular perturbation methods applied to ordinary differential equations. Chapter 3 describes in detail the application to the Boussinesq equation of the reductive perturbation method, the derivative expansion method, and an extension of the Krylov–Bogliubov–Mitroupolsky method to obtain either the nonlinear Schrödinger equation (NLS) for the slowly varying amplitude of a nearly harmonic wavetrain in a frame moving with the group velocity or the Korteweg–de Vries (KdV) equation for long waves of arbitrary profile in a frame moving with the phase velocity. The authors show that all these methods are related to, and in some sense contained within, the method of multiple scales, which is then formally applied to a more general system. In chapter 4 the Whitham approach using a Lagrangian formalism, or an averaged Lagrangian, is described and is also related to the method of multiple scales. Finally in Chapter 5 the ray method, or generalized WKB method, is developed for long waves to obtain (for the fifth time) the KdV equation.

This completes Part II, and in Chapter 6 the authors appear to conclude that the method of multiple scales in its most general form, which includes expansion of both dependent and independent variables and the introduction of new independent variables as in the two-timing method, is the 'best buy' for almost all problems. The book is then completed with some interesting but disconnected topics including wave propagation in random media and exact solutions of the KdV equation obtained by inverse scattering and other methods.

The general presentation is clear and the detailed algebra, although hard work to read, appears to be relatively free from error. There is no discussion of the physical basis for any of these model equations, and consequently results cannot be interpreted in physical terms. This seems a pity, despite the obvious difficulty of describing appropriate physical situations in a few pages, because many readers may well obtain a qualitative feel for the equations from physical analogy more easily than from complicated asymptotic expressions. To many this is a subject where the application being modelled helps the analysis almost as much as the analysis sheds light on the physics, and agreement with physical observation substitutes for rigorous proof.

A second more serious criticism is that it is difficult to see for which kind of reader this book is written. Part I contains a very simple introduction to singular perturbation methods at the level of a first course for third-year undergraduates, with most of the difficulties and exceptions avoided or dismissed with a reference. It also contains an introduction to wave propagation which appears to take a great number of things for granted. Thus the concepts of group velocity and of hyperbolicity are relegated to references, and terms such as characteristic, conservation laws and systems, quasilinear, cnoidal, all appear in the first ten pages without definition or explanation. It would seem unlikely that a beginning graduate student could read this without considerable cross reference and the content and style of Part I as an introduction form a rather unsatisfactory compromise. Part II (and Chapter 6) will however appeal strongly to research workers deeply involved in nonlinear dispersive systems, and gives valuable information about appropriate strategies for attacking new problems. Also, for those who would like to prove rigorous results about asymptotic methods this part could be the basis of a lifetime's work and provides many valuable conjectures. Chapter 8 and the latter part of Chapter 7 will be of considerable interest to applied analysts interested in solutions of nonlinear partial differential equations. On the other hand, the first part of Chapter 7 may be of considerable value to modellers concerned with difficult scientific problems such as seismic detection.

Professors Jeffrey and Kawahara are both experts in this many-faceted area of nonlinear dispersive wave motion, and the book does contain much detailed material not available elsewhere. However, for the general reader wishing to understand the complex mechanics of wave motion there is too much detail and repetition, and I doubt if this will replace the existing texts on wave motion for graduates learning the topic.

A. B. TAYLER