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REVIEWS

Numerical Heat Transfer. By T. M. SHIH. Hemisphere/Springer, 1984, 563 pp. DM114.00.

Physical and Computational Aspects of Convective Heat Transfer. By T. CEBECI and P. BRADSHAW. Springer, 1984, 487 pp. DM142.00.

How should postgraduate and senior undergraduate courses in heat transfer be adapted to recognize the increasingly widespread use of numerical methods in industry and the availability of computers from micros to multi-mega-core devices? These volumes provide two very different responses to that question. It is not, of course, a question that admits a single correct answer. Problems of heat transfer through fluids in relative motion arise in so many branches of thermo-fluids engineering and involve such diverse geometries and phenomena that any attempt at a genuinely comprehensive treatment would sink beneath its own impedimenta. Neither of the present books considers two-phase flows or non-Newtonian fluids. Implicitly, therefore, each is focused on convection in gaseous flows – an emphasis that will lessen their appeal to chemical engineers.

While Cebeci and Bradshaw's book is a recognizable extension of the line of texts from McAdams by way of Eckert & Drake to Kays & Crawford (with many worthies unmentioned in between), the emphasis of Shih's volume is squarely on numerical methods for solving the partial differential equations of heat transport. It is thus a direct descendant of Patankar's highly successful *Numerical Heat Transfer and Fluid Flow* published by Hemisphere in the same series in 1980. It is considerably broader in scope than Patankar's, however. It starts out, under the heading 'Preliminaries', with four chapters – 175 pages – devoted mainly to introducing a large number of methods for solving a linear, second-order ordinary differential equation representative of those appearing in heat-transfer problems. The main emphasis is on different finite-element approaches but finite-difference and finite-volume schemes are also covered. The comparison of different schemes is deliberately based on very coarse meshes to allow results to be worked out by hand. Fluid motion does not appear until page 217 at the start of the first of two chapters on solving the laminar hydrodynamic boundary-layer equations. Again, many approaches are summarized but, for the reviewer's taste, the rationale is insufficiently developed and the selection and emphasis unusual. Thus, the first twenty pages are devoted to solving similarity forms of the equation and then, on acknowledging that not all boundary layers are self-similar, the author switches immediately to the Von Mises form of the equation to develop a condensed version of the Patankar–Spalding two dimensional boundary layer procedure and variants of it. Recirculating flows (or 'streamwise diffusion' flows, as the author terms them) are introduced in Chapter 8. The strength of this section lies in its treatment of both the finite-difference and the Galerkin finite-element methods; its main weakness is that it has nothing to say about the alternatives to central- and conventional upwind-differencing that are at least partially successful in blending the accuracy of the former with the stability of the latter. This is still a rapidly developing area which inevitably poses problems for the textbook writer; some discussion should surely have been attempted, however, since Raithby's skew-upwind and Leonard's quadratic-upwind approximations (which are cited in the references) have been in use for several years.

Energy and species transport is introduced in Chapter 9, first for boundary layers then for recirculating flows. This is followed by a chapter on radiational transport, an unusual and welcome feature even though it considers only briefly combined convective and radiative heat transfer. The third section of the book, 'Important Heat Transfer Phenomena', includes chapters on laminar free and mixed convection, turbulent flows (outlining zero- and two-equation models based on effective turbulent transport coefficients) and combustion phenomena. The final section contains two short chapters on purely numerical aspects.

The conception of the book is on a grand scale and its beginning promises much. The overall impression, however, is rather that of a volume finished off in a rush: the skimpy construction of the upper storeys makes the elaborate ground floor seem out of place. Of course, for an introductory graduate course in numerical methods this uneven emphasis may be exactly what the instructor wants.

The Cebeci–Bradshaw volume, as its title suggests, gives substantial attention to discussing the physical processes at work. As might be expected, the authors bring to their book a distinctly aeronautical flavour but not so strong as to make it wholly unpalatable to other engineering disciplines. The emphasis is very much on calculation methods rather than analytical solutions – but often relatively *simple*, approximate schemes, readily applied on a small micro-computer or even with just pencil and paper. The sequencing of the chapters follows the conventional pattern of textbooks on convection: a brief introduction, general forms of the describing equations, boundary-layer forms of the equations, solution of laminar boundary layers, laminar duct flows, etc. Yet within this orthodox framework, some surprises are to be found – for example, estimates of the importance of density fluctuations in high-Mach-number turbulent flow appear as early as page 49. Indeed, the Reynolds equations are well to the fore in Chapter 2, a clear hint that despite the chapters on laminar flow noted above, turbulent shear flows command a good deal of attention. An admirable feature of the book is its large number of interesting and varied problems. In many cases, brief computer-program listings are given to help; in Chapter 4, for example, a 25-statement coding of Thwaites' method is provided.

After Chapter 5 on laminar duct flows, there follow analogous chapters on turbulent flow in boundary layers and ducts. The only model considered is the old Cebeci–Smith eddy viscosity scheme, a frankly disappointing parochialism. These chapters, however, like the ones that follow on free shear flows and buoyant flows are generally well handled. The final two chapters in the book present in detail the finite-difference boundary-layer solvers used to generate many of the results shown in earlier chapters. The authors consider first convective heat transfer with a known velocity field. This is a thoughtful step that cushions the reader with no prior background in finite-difference analysis for the more taxing problems of solving the fully coupled boundary-layer equations.

Overall this may be judged a successful contribution and one that will be particularly popular in aeronautical engineering curricula. Writing as a *mechanical* engineer, the reviewer regrets: that the only brief reference to recirculating flow is made in connection with *shock-wave* induced separation; that no consideration is given to turbulent flow in ducts other than straight, circular-sectioned tubes (are the authors not aware of the importance of Prandtl's secondary flow of both the first and second kind in heat exchanger design ?); and that no mention is made of laminarization and related low-Reynolds-number phenomena that can so strongly modify local heat transfer coefficients.

However, books must be judged by what is in them, not what is not, and the intent of the above remarks is really to suggest that, despite the thousand-odd pages provided by these two works, there remains scope for yet further distinctive volumes in convective heat transfer.

B. E. LAUNDER

Introduction to Wave Phenomena. By A. HIROSE and K. E. LONNGREN. Wiley, 1985. 355 pp. £53.

Waves exist in profusion in the physical world and one of the dilemmas facing university teachers, confronting the constraints imposed by timetables, is whether to explore one type thoroughly in depth or to give an overview of waves in a number of different contexts. Each approach has its penalties, one limiting the horizon of the student and the other the degree of penetration into the properties. Probably, it would be ideal if the student could encounter both attitudes but nowadays so many degrees are modular in structure that it may be difficult to avoid the student looking at only one side of the picture.

The authors of this book are firmly of the view that it is the unity of wave motion which should be stressed, so they start with a discussion of acoustic and electromagnetic waves as well as mechanical waves on strings and springs. Thereafter, numerous topics are touched upon, e.g. travelling and standing waves, phase and group velocity, reflection, dispersion, Doppler effect, plasmas, interference, diffraction, geometrical optics, photons, nonlinear effects. The price to be paid for this multiplicity is that, with very few exceptions, the waves under consideration are one-dimensional in character. This means that water waves are, effectively, not mentioned and that the modal structure of propagation in pipes and fibres is omitted.

The treatment is pictorial in nature, formulae being derived from how things behave in the illustration by plausible arguments rather than by analysis of the basic equations. Indeed, the mathematics deployed is generally elementary though there is some discussion of the Laplace transform, self-similar solutions, characteristics and solitons. Yet even here the description is sketchy in that awkward questions like the convergence of series and integrals are not addressed. Against that must be set the fact that there is ample provision of well-drawn diagrams and that the conclusions which can be extracted from them are very clearly presented. The explanation is supplemented by a number of exercises for the reader to try at the end of each chapter; some of these exercises contain extensions of the theory in the preceding chapter.

It is doubtful if this book could form the principal text for a course in a British university. Nevertheless it could be a useful adjunct when teaching a course on waves. It brings out vividly how various phenomena occur and shows how much valuable information can be obtained from thinking about a visual representation of a problem. Lecturers are likely to find it helpful to be able to refer their students to this book, partly for the modelling aspect and partly for the clarity which students will find there.

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