REVIEWS

Gas Power Dynamics. By A. D. LEWIS. D. Van Nostrand Co., 1962. 535 pp. £3. 16*s*.

The teaching of thermodynamics and fluid mechanics in university engineering courses is a subject of continuous discussion, and substantial changes have been made in these courses during recent years. The 'traditional' thermodynamics course was based on the analysis of heat engine cycles, and contained much descriptive information of a practical nature. In 1940, Prof. J. H. Keenan's book *Thermodynamics*, was published. Keenan provided a rigorous discussion of macroscopic thermodynamics, defining precisely heat, work and internal energy in his development of the first law and emphasizing the difference between a system (a fixed quantity of matter) and a control surface fixed in space, through which a system may move. Keenan's method of teaching engineering thermodynamics spread through American and British universities. Engineering undergraduates find such a thermodynamics course difficult, but there is little doubt that the introduction of Keenan's approach has raised the academic standard of engineering courses.

The development of the gas turbine and other power plants for propulsion has emphasized the importance of fluid mechanics for the mechanical engineer. Most university engineering departments now follow the approach of Hunsaker and Rightmire, or the early chapters of Shapiro's book, in the teaching of elementary fluid mechanics, emphasizing the control surface approach in the development of continuity, momentum, energy and entropy equations for a moving fluid continuum.

Thus we may expect that in most British and American universities the final year undergraduate in mechanical engineering will be well versed in basic macroscopic thermodynamics and elementary fluid mechanics. It is for this man that Prof. Lewis has written his book—for the mechanical engineering student taking 'elective courses in the field of gas power'. Lewis rejects the 'how it works and how it's done' approach, saying that his purpose is to give 'more fundamentals at the sacrifice of material not directly concerned with basic principles'. He first discusses general characteristics of gases, processes, compressible flow and the thermodynamics of combustion and dissociation; he subsequently deals with a number of power plants using gas as a working fluid (the gas turbine, the internal combustion engine, ram-jets, pulse-jets and rockets).

The detail in these later chapters is considerable, and the reviewer submits that here the author has departed from his stated principle of eliminating unnecessary practical material. (Is it necessary to consider in a university engineering course the effects of fuel characteristics on cold starting of I.C. engines?) This is not to imply that the material presented is without value (for example, the chapter on rocket propulsion contains much useful information on fuels and propellants and well explained, detailed calculations of equilibrium flame temperature) but it is towards the practising, specialist engineer rather than the university undergraduate that the content of these later chapters should be directed.

The worked examples in the book are numerous and illustrate a basic difference between British and American methods of teaching engineering. The American lecturer will prescribe reading from a standard text, and, surprisingly, the undergraduate usually completes this required preparation for the next lecture. Within such a teaching method the book forms an essential part of the course and the inclusion of detailed worked examples within a text, as in *Gas Power Dynamics*, is a great asset. The British lecturer does not follow a standard text so closely.

The reviewer's principal criticism of the book, as already implied, is in the balance that has been struck by the author between fundamental work and practical information. The reviewer would prefer to include within an elective 'power' course more advanced fluid mechanics and thermodynamics. Examples of subjects which might be covered are the thermodynamics of availability and unsteady compressible flow (there is no discussion of the comprex machine in the book).

It may be argued that such material should be covered in earlier or parallel courses, but the summaries of basic concepts in the earlier chapters are not entirely satisfactory, partly because of lack of depth. For example, the discussions of the steady flow process and of the quasi-steady emptying and filling processes leave much to be desired, largely because of the lack of any definition of flow work. Also, the reviewer would prefer the unsteady flow energy equation to be presented as a rate equation, since the idea of an infinitesimally small displacement in an infinitesimally small time is involved. The discussion of the momentum equation for flow through a control volume is misleading. In determining the force of reaction, the flux of momentum in and out of the control surface must be considered as well as the time rate of change of momentum within the control surface. And the more books on engineering thermodynamics and fluid mechanics that the reviewer reads, the more he is convinced that the lb.-force, lb.-mass system must be discontinued. Must the engineering student carry this constant g_c through all his analysis?

The major question facing the teacher of engineering thermodynamics at the present time is how far he must introduce microscopic thermodynamics. Increases in operating temperatures of heat engines, the problems of direct conversion emphasize that Keenan's macroscopic approach is no longer sufficient for today's engineering student. A good feature of Prof. Lewis's book is the introduction of some ideas from kinetic theory, although he relies on quoting many of the results.

Gas Power Dynamics is a book which contains information which will be useful to a mechanical engineering student later in his career. The worked examples will be useful to both students and teachers. The British university lecturer cannot hope to cover the whole field of this book in his lectures, even with today's tendency towards greater specialization. The book which provides a completely satisfactory balance between macroscopic and microscopic thermodynamics for engineers has yet to be written.

J. H. Horlock

Methods of Mathematical Physics. Volume II. Partial Differential Equations. By R. COURANT. Interscience Publishers, 1962. 830 pp. £6. 12*s*.

The first edition of 'Courant–Hilbert' was published by Springer in 1924. Its objective was summarized in the preface to that edition in the following words: 'Since the seventeenth century, physical intuition has served as a vital source for mathematical problems and methods. Recent trends and fashions have, however, weakened the connexion between mathematics and physics; mathematicians, turning away from the roots of mathematics in intuition, have concentrated on refinement and emphasized the postulational side of mathematics, and at times have overlooked the unity of their science with physics and other fields. In many cases, physicists have ceased to appreciate the attitudes of mathematicians....It seems therefore important to direct our efforts toward reuniting the divergent trends by clarifying the common features and diverse scientific facts.' A second, revised and improved, edition of volume I followed in 1930, and an English version of this has been available since 1953. The second volume, devoted entirely to the theory of partial differential equations, did not appear until 1937, and is probably much less well known than the celebrated first volume. Now this is a subject that is particularly in need of treatment from the unifying point of view set out above. Its problems arise in the main from applications, and its results are of direct interest to mathematical physicists and applied mathematicians. Yet it has always attracted the attention of pure mathematicians of the highest calibre. In the last thirty years there has been renewed activity in this field, and extensive developments have followed chiefly as a result of the application of functional analysis to partial differential equations. But the language of pure mathematics is becoming increasingly difficult to understand, and there can be little doubt that the average applied mathematician must find that the bulk of the new results is virtually inaccessible. It is therefore greatly to be welcomed that this English edition of volume II of Courant–Hilbert is not simply a translation of the original, but an entirely new version that contains much recent work.

For many applied mathematicians, parts of this book may prove difficult reading, but any effort that has to be made will undoubtedly be repaid by a better understanding of an important field of mathematics. Such a reader will be aided by the spirit in which the book is written. In the words of the preface, it is 'to make an important branch of mathematical analysis more accessible by emphasizing concepts and methods rather than presenting a collection of theorems and facts, and by leading from an elementary level to key points on the frontiers of knowledge'. He may find it best to begin by studying the introductory chapter I and, particularly, chapter III, which is an introduction to the study of partial differential equation of order higher than the first. (First-order equations, a self-contained subject culminating in the theory of the Hamilton–Jacobi equation, are dealt with in chapter II.) The basic ideas and methods are developed here with the aid of examples drawn from mathematical physics; § 6, on typical problems in differential equations of mathematical physics, should be prescribed reading for all applied mathematicians.

The systematic theory of higher-order equations is contained in the last three chapters, which form the bulk of the book. Chapter IV deals with potential theory and elliptic equations. Classical potential theory and the solution of the basic boundary value problems for Laplace's equation occupy the first four sections; this is followed by a section on scattering problems for the reduced wave equation. The general elliptic equation is treated, rather more briefly, in the rest of the chapter. Here there are accounts of many important modern developments, such as Schauder's fixed point theorem, methods based on '*a priori* estimates', and an exposition of the theory of 'pseudo-analytic functions' that has an important bearing on the basic mathematical theory of gas dynamics.

It is perhaps worth pointing out that the last two chapters, which deal with hyperbolic equations, occupy almost exactly half the length of the book. It is well known that hyperbolic equations with two independent variables present less difficulty than those with more than two independent variables; their theory forms a well-defined subject which is treated in detail in chapter v. This includes such basic topics as characteristics, domains of dependence, and Riemann's method of integration, with applications to the dynamics of compressible fluids. Further sections deal with the extension of iterative methods to linear and semi-linear systems of the first order, and with hyperbolic equations of higher order. The last section treats the mathematical theory of discontinuous solutions and shocks, introducing the concept of a weak solution, that has played such an important part in much of the new work.

The last chapter, on hyperbolic equations in more than two independent variables, has been completely re-written for this edition. It is a model of lucid exposition. The theory of such equations is so extensive that a complete treatment as a chapter in a book, probably even as a single book, is impossible. The author and his collaborators have adopted the selective viewpoint of wave propagation as a unifying principle. The chapter is divided into two parts, the first dealing with uniqueness, construction and geometry of solutions, and the second with the representation of solutions. Both single equations and symmetric hyperbolic systems (a type to which nearly all the hyperbolic systems arising in applications belong) are discussed. Throughout the chapter, L. Schwartz's theory of distributions, which has given a 'new look' to this subject, is employed, and there is a useful appendix in which an outline of this theory is given. (It is perhaps to be regretted that this theory has not also been used in the appendix 2 to chapter v on transient problems and Heaviside operational calculus).

In conclusion, it should be observed that this is neither an encyclopaedia nor a straightforward text-book, but a book with a distinct point of view that should prove a stimulus to anyone who takes the connexion between pure and applied mathematics seriously. But it would be idle to expect to find in it the answers to all questions on partial differential equations (such as they are). Fluid dynamicists should perhaps be warned that equations of parabolic type are only treated in passing; a work on this subject in the manner of Courant–Hilbert would be a very valuable addition to the literature.

A shorter third volume which is to be published will be concerned with existence proofs and with the contruction of solutions by finite difference methods and other procedures.

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