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REVIEWS

Theoretical Hydrodynamics. 5th Edition. By L. M. MILNE-THOMSON. MACMILLAN, 1968. 743 pp. £5. 5*s*.

It is not easy to review this book. Almost every reader of the *Journal of Fluid Mechanics* is likely to be familiar with one of the earlier editions, so that a reviewer can hardly adopt the traditional method of devoting much of his space to a summary of the material; rather, he must pass at once to the merits and faults of the book. A more serious difficulty is that, while I cherish my copy of the second edition, and feel nothing but gratitude to its author, I am also conscious of the more critical attitude of a number of distinguished scientists, the force of whose arguments I am bound to concede. Perhaps the core of the difficulty lies in the strong degree of simplification that Prof. Milne-Thomson adopts; this makes the book completely successful as an introductory text, but also makes it unbalanced, and possibly even dangerous, for students beyond their first graduate year and for young research workers.

Let us begin with that main part of the book (chapters III, IV, VI–XIII, XV–XIX) devoted to the irrotational flow of an inviscid fluid of uniform density and already known from the second edition. This is a detailed, graceful and wholly readable account of almost all that can be achieved by more or less simple applications of the methods of complex variable, conformal mapping, point singularities, images and separation of variables in the Laplace equation. It is always the mathematics that is put to the fore; the author's sympathy for his material and for his students, and his mastery of expository prose, are such that this wealth of classical material can be understood by those with only a primitive knowledge of calculus, and yet causes no offence to those with more refined mathematical knowledge and taste. There are not many texts of which this can be said.

On the other hand, fluid dynamicists interested primarily in the description of real flows in the world about us tend not to approve of this main part of the book, on the grounds that it largely ignores the advances in the understanding of real fluids that have been made in the twentieth century. There is some justice in this criticism. The second edition (1949) contains the astonishing remark that the applications of boundary-layer theory 'have so far been of a tentative and empirical character'. In the new edition this phrase is replaced by a chapter on Prandtl's great discovery, but only the positive implication of boundary-layer theory is emphasized, and the negative one is virtually ignored throughout the book. That is, we are told that for sufficiently well streamlined bodies Prandtl 'at one blow rehabilitated the classical theory of hydrodynamics' by showing it to be applicable outside the boundary layer; but we are *not* told that whenever potential theory predicts even moderately adverse pressure gradients along the surface of a body, the classical solution has very little relevance to the observed flow field as a whole (except at the initial instants of motions started from rest). It is true that some remarks in this direction are made on pp. 25–6, but they are extremely vague, as are the accompanying diagrams, and pressure gradients are not mentioned. There is no serious attempt to distinguish between solutions that model reality and solutions that have no counterpart in the laboratory.

Three early chapters are absent from the list above. The introductory chapter I sets the scene with simplicity and economy. Chapter II is an admirable treatment of vector algebra and calculus to which many of us have turned time and again. It includes a brief discussion of tensors which is a minor disaster for the beginner. Evidently Prof. Milne-Thomson resolved at an early stage that all general statements must be written only in bold-type notation (as opposed to general, or Cartesian, suffix notation). Now to develop the theory of (second-order) tensors without resort to suffices and transformation laws makes a splendid puzzle for the initiated, but is contrary to the whole spirit of general tensor analysis; and in the present instance our attention is diverted from the basic meaning of equations to a losing battle with the dyadic notation. This also obscures the derivation of the Navier–Stokes equations later on. Chapter V, on the complex variable, assumes no prior knowledge and in 28 lucid pages equips the reader with a remarkably complete apparatus. Students of mathematics, accustomed to current standards of rigour in their courses on analysis, might conceivably raise their eyebrows at the proofs, here and elsewhere in the book, but they would be mistaking the author's purpose.

Chapter XIV, 'Flows under gravity with a free surface', brings together various exact solutions (for an ideal fluid) that were mainly introduced into other chapters of the fourth edition. This material is not elementary and includes useful discussions of (*a*) the inverse methods, both old and new, that generate exact solutions by ingenious treatment of the free-surface condition (at a price: the exact form of the rigid boundaries cannot be specified *a priori*), and (*b*) Nekrasov's non-linear integral equation and associated forms. Such integral equations have been solved numerically by the author's students in Arizona, and are also important in the growing existence theory of these flows. Their derivation here, by means of various Fourier series that are not simply related to each other, seems a little awkward; it is a pity that the integral operator which solves the Neumann problem for the unit disk was not introduced earlier, in its own right.

The final four chapters, totalling some 150 pages, deal with compressible flow, with viscous flow in general, with Stokes and Oseen flows, and with boundary layers; most of the material on the last two topics is new to the book. There are some good things here, such as the complex-variable treatment of plane Stokes flow, but there are also some bad mistakes (in exercise XXI, 31; before equation 22.24 (1); equations 23.23 (9) and (10); exercise XXIII, 1), and the derivation on p. 718 of the all-important matching condition at the 'outer edge' of the boundary layer is appalling. I am not convinced that these four chapters enhance the book. One has the impression that they result from pressure to make the book in some sense up to the minute and comprehensive, whereas I feel that Prof. Milne-Thomson might have been better advised to take a firm stand on the theory of an ideal fluid, put into a different perspective. For it is impossible now to do justice to compressible flow and to viscous flow in the form of supplements of this kind, and at the level adopted in most of the book.

In making these remarks, I have been looking at *Theoretical Hydrodynamics* with the jaundiced eye of the middle-aged don. But it is not for such readers that Prof. Milne-Thomson wrote his book; it is intended to give an *introductory* exposition. Therefore it may be not too unseemly to recall my reaction when I first encountered the book in 1949. That response was one of pure delight: a subject that had seemed impossibly difficult in Lamb's book became comprehensible and significant; the many exercises provided a definite goal at every stage, and the few that I solved were a source of infinite satisfaction; there were (and are still) sufficient diagrams to satisfy my need to have abstractions shown in concrete terms; and, above all, the text gave me the impression of a wise and kindly teacher, anxious that I share his knowledge and enjoyment of theoretical hydrodynamics. Many others must have such feelings about the book, and that may well be more important than the carping of any critic.

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Strömungsmechanik. By E. TRUCKENBRODT. Springer-Verlag, 1968. 532 pp. DM 69 or $17.25.

This book deals primarily with fields of fluid mechanics which are traditionally taught at engineering schools. The scope is indicated by the subtitle: 'Fundamentals and technical applications'. Beginning with a very thorough presentation of the fundamentals, the book actually proceeds to what may be called an 'intermediate' level of coverage in each field, that is, more than what is usually presented in general lectures on fluid mechanics to non-specialized students. Finally, technical applications, e.g. turbines and pumps, profiles and wings, etc., are included. Thus the book has an ambitious scope, and the author has succeeded remarkably well in fulfilling it. The beginner will appreciate the detailed presentation of the fundamental derivations, complete with helpful drawings and numerous illustrative examples and applications. The more advanced topics are presented in a polished and up-to-date manner. Most attractive is the way in which basic fluid mechanics is connected with technical applications.

The author's choice of topics is non-controversial in general, with the possible exception of the chapter on integral methods in boundary-layer theory: here, the author presents his preferred treatment of the problem by the energy integral, instead of the widespread momentum method. More controversial and unusual is the general arrangement of the subject matter, which will probably please only a small group of educators. For instance, the vorticity theorems are introduced towards the end of the book, after a detailed chapter on potential flow; they are followed by examples of potential vortex motion. Boundary-layer theory comes at the end, after a long interuption in viscous flow theory. However, these matters of arrangement do not affect significantly the usefulness of the book as an educational tool; it could be used as a reference book together with widely different structures of the presentation. An interested and ambitious student will find this book very helpful if he wants to support and to complement his education in fluid mechanics. In case his interest goes beyond the coverage of the book, there is an extensive bibliography to help him.

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