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REVIEWS

Laminar Flow Analysis. By D. ROGERS. Cambridge University Press, 1993. 422 pp. ISBN 0-521-41152-1. £65.

Boundary Layer Analysis. By J. A. SCHETZ. Prentice-Hall, 1993. 586 pp. ISBN 0-130-86885-X.

Rogers describes *Laminar Flow Analysis* as a textbook in viscous flow analysis suitable for fourth-year undergraduates and first-year graduate students. The obvious prerequisites include an introductory course in fluid mechanics, ordinary differential equations, and an elementary understanding of the use of a computer. With notable exceptions this book contains classical subject matter on laminar boundary layers. The exceptions are the inclusion of heat and mass transfer, and the exclusion of integral methods. The former includes free and forced convection heat transfer with and without mass transfer of the same working fluid.

Integral methods are excluded because of Rogers' focus on the use of a computer to generate numerical results. The discussion of difficulties associated with two-point boundary conditions is clear and the examples useful. Rogers' analysis of similarity conditions for compressible laminar boundary layer equations is extensive and the summary table (6-1) is clear.

Rogers says the homework exercises fall into three types: 'numerical, parametric, and directed analysis'. They do, and the level of difficulty seems reasonable to the reviewer.

Schetz has also prepared his text for fourth-year undergraduate students and first-year graduate students. He writes, '...The emphasis is in understanding and analyzing flows of engineering interest'. With this broad scope, the subject content is almost encyclopaedic in breadth. The organization of the book follows the customary order: that is, development of the Navier–Stokes equation, then the boundary layer equations. Schetz departs from the usual pattern by not only including heat and mass transfer, but by giving examples of non-Newtonian fluids.

Schetz's research interest is in turbulent boundary layers and wakes so it is not surprising he devotes 163 out of 570 pages to this topic. The main focus is on computational schemes, starting from elementary examples of flow fields to the more complicated ones, including three-dimensional flow. The examples are clear and well formulated, and the homework problems vary appropriately from simple to fairly demanding. As may be expected, this broad average requires relatively elementary discussion of more advanced topics.

Because of the focus on the computer as a tool, both books contain an extensive collection of figures showing the results of parametric analysis.

Both authors fall into the trap of terming the numerical solutions as 'exact' solutions to the equation in question. Schetz's use of the term 'exact' is particularly odd because it follows his straightforward discussion of truncation and round-off errors.

Both books seem relatively free of typographical errors. Those noted were obvious. In Rogers, for example, it is obvious that equation 6–113 (p. 27) needs a $\sin^2\theta$, not a $\sin\theta$. Similarly on p. 550 of Schetz's book, the fourth line below statement 110 is *not* [4.0 × U(2)–U(3)]. These are petty complaints, in the nature of a 'heads up' to the user.

These two books are significantly different: Rogers treats a narrow range of topics carefully and rigorously; Schetz treats a very broad range of topics, some in detail, some more or less empirically and some casually. The latter is not necessarily a short coming if the teacher is inclined to and prepared to place extra effort where needed.

Both books contain boundary layer codes. Their value to an individual is strongly related to his or her expectations.

E. E. COVERT

Dynamics and Modelling of Ocean Waves. By G. J. KOMEN, L. CAVALERI, M. DONELAN, K. HASSELMANN and P. A. E. M. JANSSEN. Cambridge University Press, 1994. 532 pp. ISBN 0-521-47047-1. £40.00

This is an unusual volume. The first two sentences of the publisher's blurb sum it up:

> This book addresses both fundamental and applied aspects of ocean waves including the use of wave observations from satellite. More specifically it describes the WAM model, its scientific basis, its actual implementation, and its many applications.

The multiplicity of authors is not restricted to the five named on the cover, but extends to a total of 35 people from around the world. One might expect a product from so many people to be just like yet another conference proceedings; but there is a far greater unity of purpose apparent in this book, since all these people have been working together for years, and wish to share their achievements with a wider audience.

WAM, the WAve Modelling group, has been working towards effective prediction of ocean and coastal waves since it emerged, following earlier international co-operations, in 1984; 71 members are listed. The wave-modelling program that is the theme of this book is counted as a third-generation model. It utilizes weather data from the most up-to-date meteorological forecasts and is in operational use. The application of the results from this program can be useful for almost all of man's marine activities. There are so many good reasons to avoid rough seas that wave forecasts are of considerable value. The most sensitive operations in the construction of offshore and coastal structures need minimal wave action. The progress of ships is much diminished in rough seas, and wave forecasts are routinely used for choosing the best routes for ships crossing the oceans.

The book is divided into six chapters of varying length plus a summary. The first two chapters, totalling 200 pages, are on 'Basics' and 'The physical description of wave evolution' and provide the core of the information on which the wave modelling is based. The remaining chapters are on numerical modelling, applications, satellite measurements and wave-data assimilation, and hence are more specific to the WAM model and its operation. However, the involvement of the authors in WAM dominates the earlier chapters, as well as those sections specifically related to the model. While this has its good side in that the enthusiasm of the authors often shows through, it does mean that some readers who are attracted by the book's title may feel disappointed at such a single-minded view of the subject.

Although there is this common direction within the book it is not by any means narrow in the choice of subjects covered. This effort is aimed at understanding an important aspect of the real world, so many topics are featured at least briefly, some unexpectedly. Clearly the wind and its input of energy and momentum to the waves dominates. But this input depends also on the density stratification of the atmosphere, the changing direction of the wind, the 'age' of the wave field and its directions too. Description of the wave field itself is no trivial matter. Wave propagation is also important, damaging waves can, and do, arrive from the other side of an ocean. As waves travel they evolve, meet currents, and pass over varying bed topography. Few of these topics can be treated thoroughly in the space available, so a newcomer to these subjects will find the book tough reading; even an expert can find sections which are too concise. However, there are many references to the primary literature, making this book a valuable guide. For many of the basic topics I have the impression that someone with a theoretical physics background would find the presentation easier to read than would a fluid mechanician. It is a good feature of this book that the many fixes that are necessary where we have insufficient understanding of the basic phenomena are not hidden and the need for more study is clearly pointed out.

Nowhere is this need for more study more evident than in the dominant feature of rough seas: wave breaking. I marvel at the relative success of this wave modelling when this difficult feature, which is so important in wave dissipation, has to be taken into account. The major omission from this account of ocean waves is also in the area of wave breaking. From experiments by Banner and his collaborators it is clear that especially high momentum transfer to waves from wind can occur when they are breaking. Strangely enough it is in the same breaking events that there is substantial momentum transfer from waves to currents. Yet there is no discussion of this wave generation process, which could be overwhelmingly dominant in storms. Perhaps with the authors' viewpoint this is understandable, since we are only at the beginning of quantified measurements of wave breaking in the laboratory, let alone in the ocean, and the essence of this book is how to produce quantified wave forecasts.

The difficulties in making such forecasts do not end once the physics is reduced to equations and parameters. Two-thirds of the book is about other, sometimes troublesome, aspects. Even if you believe the best meteorological models, and this book indicates where you shouldn't, the numerical, and computational aspects are not plain sailing. Some difficulties are related to the finite capacity of computers, where the continual progress in the hardware can be expected to be of value. Numerical difficulties have their counterpart in other fluids problems. More specific to this type of geophysical forecasting is the problem of a lack of data for initial conditions. The main thrust in using data is how to assimilate the limited measurements into the computational structure. This involves using it with the computed data and is described as wave analysis. It gives the starting point for forecasts and the criteria for assessing their accuracy. It is intriguing to read that 'often the 12–24 hour forecasts are of the same quality, or even better, than the analysis'. However, the dependence on good meteorological forecasts appears to be a most important feature.

This volume is best thought of as being a product of the WAM group for those who are interested in WAM. In its published form it appears to be aimed at a wider audience. That wider audience is a specialist one, which must already have an awareness of water-wave problems, and I have some difficulty identifying it. The majority of customers for wave forecasts have neither the necessary background, nor the inclination, to read this book. Around the world there are groups, at present mostly in contact with the WAM group, who produce local wave forecasts. The number of such groups is sure to increase and as they use and adapt WAM this book will be valuable.

D. H. Peregrine

Selected papers of J. M. Burgers. Edited by F. T. M. Nieuwstadt and J. A. Steketee. Kluwer, 1995. 650pp. ISBN 0-7923-3265-2. HF1.495 or $317.

Fluid mechanics in the Netherlands undoubtedly starts with the work and the person of Johannes Martinus (Jan) Burgers, who was appointed Professor of Aero- and

Hydrodynamics at the Technical University of Delft in 1918 when he was 23 years old. He was to stay there, in spite of many invitations from elsewhere, until 1955 when he moved to the University of Maryland to serve as Professor and, after his retirement in 1965, as Research Professor in the Institute of Fluid Dynamics and Applied Mechanics.

He died in 1981 and left to posterity an enormous amount of papers, books and letters, testifying to an almost unlimited capacity for work. The great majority of his scientific papers appeared in the *Proceedings of the KNAW*, the 'Koninklijke Nederlandse Akademie van Wetenschappen' (Royal Netherlands Academy of Arts and Sciences), to which he was elected a Member in 1931 when he was 36 years old. These *Proceedings* are hard to come by in many parts of the world.

Since 1992 all Dutch University groups working in fluid mechanics have been united in a Research School named after Burgers: 'the J. M. Burgers Centre for Fluid Mechanics'. This commemorated in January 1995 the centenary of his birth. In the context of this event, and because many papers are hard to obtain for the above-mentioned reason, it was decided to bring out a selection of his papers. The result is the book under review, edited by F. T. M. Nieuwstadt and J. A. Steketee who can be congratulated for their skilful work. Out of a total of 182 papers (there is a list of the complete works) 25 are reproduced in this book in the original print. The selection by the editors of these 25 has been partly based on the difficult availability otherwise, and partly on the scientific significance.

These papers are preceded by a 'Biography' written by A. J. Q. Alkemade, a former student of Nieuwstadt, who shows a remarkable gift for this type of work. This biography, 152 pages long and illustrated with some nice photographs, not only gives an account of the life and work of Burgers but also of the academic life in the Netherlands in Burgers' time and, as far as fluid mechanics is concerned, abroad.

Jan Burgers came to Delft as a (very) young Professor thoroughly trained in theoretical physics by Lorentz and Ehrenfest at Leyden University, but with almost zero knowledge of fluid mechanics. In the beginning he learned a lot from the work of the great founders of the subject, G. I. Taylor (born 1886), L. Prandtl (born 1875), Th. von Kármán (born 1881), with all of whom he was to develop friendly relations in the course of time. Soon however he started his own line of research.

Together with C. B. Biezeno, Professor of Applied Mechanics at Delft, and the main agent in achieving Burgers' appointment, the latter organized the first International Congress of Theoretical and Applied Mechanics which took place in Delft in 1924 (the 19th ICTAM will be in 1996 in Kyoto). There he reported on his first major contribution to fluid mechanics in a paper entitled 'The motion of a fluid in the boundary layer along a plane smooth surface'. In this paper, one of the few experimental ones, Burgers gives an account of his measurements, together with B. G. van der Hegge Zijnen, of the velocity distribution in the boundary layer. For the first time measurements of the laminar and turbulent part of the same boundary layer were published. This paper is not included in the collection under review, presumably because copies of the Proceedings of the first ICTAM are available in many libraries, but rather an earlier paper, by Burgers and Van der Hegge Zijnen, on the same subject entitled 'Preliminary measurements of the distribution of the velocity of a fluid in the immediate neighbourhood of a plane smooth surface', and published in the Proceedings of the KNAW. The measurements were made with hot wires, at that time representing a new technique.

The papers reproduced in the book are interesting in various ways. The first is the opportunity to read about Burgers' work in the original version. For example, most fluid mechaniciens know about the 'Burgers Equation' from the reference to his 1948 review paper in *Advances in Applied Mechanics*. In fact the first formulation had already occurred, as shown by papers reproduced in the book, in papers in 1939 and 1940, albeit in the form

$$\partial v/\partial t + 2v\partial v/\partial y - \nu\partial^2 v/\partial y^2 = 0.$$

Even more interesting than to see the birth of the 'nonlinear diffusion equation', as Burgers himself modestly used to call it, is to watch his struggle to understand turbulence by using ideas and methods from statistical mechanics, in a series of seven papers starting in 1930 and ending around 1940.

Browsing through the book one is struck by the diversity of Burgers' interests. There are papers on turbulence, on gasdynamics, on kinetic theory, on slow viscous flow, on astrophysics, on geophysics, to mention a few subjects. Sometimes they arise from his own studies, but often from discussions with colleagues from other fields. There is, for example, a series of papers on interstellar gasdynamics, originating from discussions with the famous dutch astrophysicist J. H. Oort. Another example is the work on the low Reynolds number motion of particles dispersed in a fluid, which resulted from a request to write a 'Report on Viscosity and Plasticity' for the KNAW.

This reviewer has realized, not without sadness, that before embarking on work in a project which is new to you, you should nowadays first estimate your chances of obtaining funds to do it.

The work of Burgers is best known through the 'Burgers Equation' the 'Burgers Vector', and the 'Burgers Vortex'. Some of these give rise even today to new investigations. For example, there appeared in a recent issue of *Phys. Fluids* (Vol. 7, 1995, p. 7) a paper on the stability of the Burgers Vortex. Incidentally, reference is also made there to the review paper by Burgers in *Advances in Applied Mechanics* (1948). However, the vortex appears for the first time as a footnote(!) in the 1940 paper 'Application of a model system to illustrate some points of the statistical theory of free turbulence'.

Apart from reading the papers on these specific topics with which the name of Jan Burgers is forever connected, there are many other things to enjoy. The clear style and careful formulation are always stimulating. Reading some papers, for example 'On the distinction between irregular and systematic motion in diffusion problems' (1941), and 'On the transmission of sound through a shock wave' (1946) improved my general understanding considerably. Naturally, there are also papers which have lost their interest in the course of time, but in conclusion I can say that the collected papers together with the excellent biography by Alkemade makes this book a valuable one for all those interested in fluid mechanics in the widest sense.

L. van Wijngaarden