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REVIEWS

Numerical Modelling of Marine Hydrodynamics. By H. G. Ramming and Z. Kowalik. Elsevier, 1980. 368 pp. $63.50.

This book describes an approach to the hydrodynamics of seas and estuaries in which finite-difference methods are used to solve the partial differential equations of motion. Variations of sea-level, currents and transports are thereby evaluated. Important for both research and practical application, the numerical approach facilitates the inclusion of realistic depth topography and nonlinearity. Both have a significant influence in shallow-water regions with which the book is mainly, but not exclusively, concerned.

The work considers tides, wind and density-driven circulations, transport phenomena, and free modes of oscillation in natural basins. Some chapters deal more or less exclusively with numerical methods, others primarily with oceanographical applications. The level and quality of the presentation varies and, as a result, the coherence of the book is strained. However, it just about holds together and interesting facts, based on first-hand research experience, appear regularly from page to page. The bibliography, including a noticeable selection of Russian literature, is quite extensive and therefore the work will certainly be a useful handbook for the researcher as well as providing a starting point for newcomers to the field.

Detailed accounts are given of investigations (carried out originally by the authors themselves) into Baltic Sea circulation, tides in the Arctic Ocean and dynamic processes in the River Elbe. The numerical techniques are shown as one element of a modelling strategy involving observational data and a developing appreciation of the physics. The numerical models discussed by Ramming and Kowalik have been developed during the last twenty years or so and, in one form or another, are being used increasingly to solve problems in coastal engineering. Their worth in marine science is gradually being recognized and, along with other more traditional disciplines, they should contribute much to future endeavours in that subject. The present book is therefore a timely contribution to an expanding area of research, one of the first attempts to bring together methods and results of a comparatively new approach in oceanography.

Going through the chapters, the first sets out the differential equations of motion and continuity for a homogeneous and for a density-stratified shallow sea. The evaluation of frictional forces at the sea surface and at the sea bed is discussed. Better treatments can be found elsewhere, but a beginning of this kind is obviously necessary to set the scene and introduce a notation.

Consideration is then given to steady three-dimensional flow in a shallow sea, driven by wind and prescribed horizontal density gradients. Baroclinic effects are ignored. The stream function for mass transport is shown to satisfy a second-order non-homogeneous elliptical partial differential equation; a whole chapter is devoted to describing methods for the numerical solution of this equation. Once the field of mass transport is thereby determined, surface gradients may be deduced and thence the vertical structure of current from a solution of the Ekman equations. Applications to the Baltic Sea are presented. Of special interest are alternative formulations of

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eddy viscosity on which the computation of currents decisively depends. The role of the equation of turbulent energy in such formulation is discussed at great length. Even so, in the end one is left wondering what to believe and how best to proceed in practice.

Turning next to unsteady motion, the heartland of numerical sea modelling is reached in examining difference schemes for time-stepping solutions of the two-dimensional vertically-integrated dynamical equations. Problems of consistency, stability and convergence are dealt with in easy stages, making up a rather useful and interestingly diverse account. Explicit, implicit and mixed explicit–implicit schemes receive due attention. Application to tidal motion follows, exemplified by a computation of the M_2 tidal distribution in the Arctic Ocean, employing co-ordinates on a stereographic projection. Also described – appendages to such two-dimensional computations – are numerical models for calculating the vertical profile of tidal current, including a treatment of the bottom boundary layer in which eddy viscosity is determined by an equation of turbulent energy. Regrettably, no examples are given to show how well these methods for calculating current structure work out.

Then follows a long, complicated, technically-oriented chapter concerned essentially with tidal models of rivers and shallow coastal areas, referring particularly to the German Bight. A one-dimensional multi-channel model of the River Eider and a two-dimensional model of the River Elbe are shown to reproduce observed tidal curves with remarkable accuracy. Careful allowance is made for the flooding and uncovering of tidal flats; formulae are proposed for bottom friction in extremely shallow waters. A two-dimensional tidal model of the North Sea leading into the River Elbe through four stages of mesh refinement is described and results showing distributions of residual flow are presented. The model, incorporating further mesh refinements, is demonstrated as a tool for predicting effects on the tidal flow of a breakwater and other coastal engineering constructions.

Towards the end, the book gives a short but instructive introduction to the numerical simulation of turbulent diffusion and advection in the sea. A stable finite-difference scheme is evolved for solving the differential equation of horizontal transport. Applications determining the distribution of suspended matter in the River Elbe are included. A final chapter turns to the problem of calculating periods and modes of oscillation of natural basins, describing recent numerical methods due to Platzman, Rao and others. The account, though difficult and seemingly unending, should provide the reader with some initial insights into the theory before consulting the original papers for further details and applications.

All in all, the material in the book forms something of a heterogeneous mixture. Some relevant topics, such as storm surges and time-dependent layered models, receive little or no attention. There are a number of errors in the production which might give concern to the uninitiated. Nevertheless it is an interesting and perceptive presentation of the numerical modelling of marine hydrodynamics as developed in recent years particularly in Germany and Eastern Europe. The book will be of value to students, research workers and practitioners in oceanography and coastal engineering.

N. S. Heaps

Mechanics of Non-Newtonian Fluids. By W. R. SCHOWALTER. Pergamon Press, 1978. 300 pp. $35.00 or £17.50.

This volume is the subject of a previous, brief review by J. Astin, in *Rheology Abstracts*, vol. **22**, 1979, p. 140, who rather aptly characterizes it as 'an excellent theoretical book, with just sufficient application to prove that rheology is a unique blend of abstractions, experience and experiment.' This evaluation is in keeping with the stated aims of the author's preface, which are to prepare graduate students for the reading of current literature and to provide research engineers with an exposition of fundamental principles which govern the flow of polymer melts, polymer solutions, and suspensions. For this task the author is well qualified, for he has been a major contributor to the modern literature on non-Newtonian fluid mechanics and suspension microrheology and one of a relatively small group of scientific workers who have, over the past ten to twenty years, labored to bring about a marriage between modern continuum-mechanical theories of nonlinear materials with memory and rigorous microrheological or statistical mechanical theories. In this domain, the present book reflects the author's accumulated insights and broad familiarity with the literature, as well as his solid appreciation for the theoretical subtleties and practical limitations associated with various problems and results. These attributes are joined together with a certain felicity and urbanity of expression to make for a pleasant, and sometimes even amusing, exposition (how else to describe, for example, the footnote interpretation of the so-called principle of determinism on p. 61, or the assessment of molecular models on pp. 199–202?).

Of the total of 13 chapters, the first nine are devoted almost entirely to continuum mechanics, ranging from the customary treatment of vectors and tensors, conservation laws, analysis of stress, and kinematics, to the mathematical theory of simple fluids and their material functions for viscometric and other restricted classes of flow. In these initial chapters, there are few surprises, since most of the ideas are now to be found in several other textbooks and standard references on the subject, and only four or so of the references have dates later than 1969. For that matter, it appears that none of the author's references dates beyond about 1975, but these comments should not detract from a work which is primarily intended to serve as a self-contained, introductory textbook.

What is perhaps more crucial is what this reviewer perceives as a missed opportunity in the initial chapters to go beyond many of the *idées réçues* of the standard continuum-mechanics literature and to expose certain abstract, and sometimes overreaching continuum-mechanical 'principles' for what they are, namely, *assumptions*, which are amenable to concrete micro-structural interpretation and parametrization. Thus, it is particularly disconcerting to find the high ground ceded to the so-called 'principle of material objectivity or frame indifference' by an author who himself has already called our attention so well to the possible importance of microscopic inertial effects in suspension rheology (in *J. Fluid Mech.*, vol. 44, 1970, p. 1). On this and related questions, dimensional considerations, of the type which emerge only much later in chapter 12, could have been most instructive early on in an exposition which otherwise serves so well to relate microstructural to continuum models.

In the latter respect, the reviewer finds that the most original contributions and

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greatest strengths of the book are to be found in chapters 10 through 13, where the author's own stamp of authority is clearly in evidence. Here, the survey of fluid mechanics and microrheology conveys a wealth of ideas with great mathematical economy and an engaging literary style. Much of this material is so vital to an advanced course in rheology that the reviewer considers it worthwhile to record here a few minor criticisms or points of disagreement:

the (Chandrasekhar) derivation of the Smoluchowski equation which is reduced to a few brief formalistic strokes in § 10A2 (most disconcerting to those who have pored over the original for long hours!);

the conclusion on p. 218 that creeping-flow solutions offer only limited insights into non-Newtonian flow;

an incomplete treatment of Cerf declared on p. 276 to be 'clarified' (rather than corrected) by subsequent workers;

an approximate suspension theory of Batchelor for interacting rod-like particles implied to be exact on p. 285.

Minor questions of content aside, the book appears to be, on the whole, correct and highly polished in form. The reviewer discovered only four typographical equation errors in a reasonably close reading of the entire text, which is quite mathematical. (It might be noted that Astin, in the review cited above, has criticized some of the photographic plates.) As a prospective graduate text some may find the book a bit short on problems and exercises, which average about five per chapter.

Because of the advanced nature of the material covered, one suspects that the book is destined for use as an advanced text or reference rather than an introductory graduate textbook, especially for engineering students. That does not dampen the enthusiasm of this reviewer for the book, for although I could not recommend it as nourishment for the novice, I could readily insist on it to instill good taste in the acolyte.

J. D. GODDARD