BOOK REVIEWS

the student might need more preparation. Nevertheless, because of the consistently interesting and lucid style of the presentation, the book may inspire those students, who feel insufficiently prepared, to realize their need for more advanced study in Hydrodynamics to cope with marine problems.

The second chapter, on Model Testing, is essentially an application of dimensional analysis. Although a student would find the pragmatic treatment useful, he will have to look elsewhere for a careful statement of the Pi theorem.

The third chapter, Motion of a Viscous Fluid, seems to be the weakest part of the book. A statement in the Introduction that "the flow within the boundary layer is relatively insensitive to the form of the boundary" and the justification of the Froude hypothesis on the basis of boundary-layer theory, may lull the student into a disinterest in significant effects of viscosity, turbulence, and piezometric pressure gradients on the generation of secondary flows and vortices on the flow about a ship hull, and the important interactions between waves, and boundary layers and wakes. The vote of confidence in the Froude hypothesis gives aid and comfort to the commercial tanks which are ignoring the now well-verified result that the viscous resistance of a ship model depends on the Froude number.

The treatment of turbulent flow is very brief. Principally considered is the case of a flat plate, for which the two similarity laws, the law-of-the-wall, and the velocity-defect law, are presented. The implication that the former is valid only in the viscous sublayer should be corrected in pages 89 and 90. More serious for marine applications is the omission of treatments of boundary-layer stability, some turbulence theory, including mixing length and eddy viscosity, turbulent boundary layers with pressure gradients, closure equations, and turbulent wakes.

The treatment in Chapter 4 of the Motion of an Ideal Fluid is elegant and appropriate for the course. Reviewer suggests more emphasis on the orthogonality of functions encountered in the method of separation of variables, the presentation of the Lagally theorem (with which all students of ship hydrodynamics should be acquainted), and the generalized form of the Taylor added-mass formula (p. 143), which includes simultaneous translation and rotation.

The great merit of the book stems from the last three chapters, in which the author presents thoughts and procedures based on his own research contributions in these fields. Particularly, the 90-page chapter on Waves and Wave Effects fills a serious gap in the accessibility of ship-wave theory to the new graduate student.


REVIEWED BY P. LIKINS

Professor Wittenburg has provided in this small volume (224 pages) a compact but fairly complete and quite readable account of the dynamics of systems of rigid bodies.

The first third of the book is devoted to the development of background material in the kinematics and dynamics of simple rigid bodies and such special multibody systems as the gyrostat. This foundation is developed with care, and the book has a place in the technical literature on this basis alone (although most of the text deals with multirigid-body systems).

The mathematical language of the book is well suited to its subject, and the author develops his somewhat unusual but quite consistent vocabulary and notation at the outset. He makes extensive use of vectors and dyadics (referring to the latter as tensors), and of matrices whose elements are scalars or vectors. Thus the book must be read from the beginning, unless the reader is familiar with this notational school (to which in modified form this reviewer personally subscribes).

The chapter on kinematics is much better than most treatment of this subject, in that it is correct and consistent. Attention is focused on alternative modes of description of orientation (such as Euler angles, Bryant angles, Euler parameters, and direction cosines), and on the relationships of these variables to angular velocity.

A very brief chapter on the basic principles of rigid-body dynamics is included, with emphasis on Newton-Euler methods.

Solutions of the rather few classically tractable problems of rigid-body dynamics occupy an important chapter in the book, since this material is rarely found in such complete and comprehensible form in one concise treatment. Special solutions for the gyrostat are included with the more conventional problems of tops and freely rotating rigid bodies.

Half of the book is devoted to a chapter on the development of equations of motion for general systems of rigid bodies, and in a final chapter a class of impact problems in such multibody systems is treated. The significance of the book must ultimately be judged by these two chapters. In order to measure this significance, one must answer two distinct questions: (1) How important is the subject? and (2) How successful is the treatment of the subject?

When Fischer produced a system for deriving equations of motion for multirigid-body systems in 1906, the world took little notice, for very good reasons. The equations were extremely complex, and there was no means at hand for their solution. In the middle 1960's, however, the digital computer had made these ordinary differential equations "solvable" and the space program had made these solutions useful and even necessary. The work of Hooker, Margulies, Roberson, Wittenburg, Velman, Russell, Kane, and others in this field was not ignored, and their results were widely used. Although for many (and perhaps most) modern applications the limitations of the multiple-rigid-body model have proven too severe, and newer formulations incorporating member flexibility have become ascendant, the multiple-rigid-body problem retains an important sphere of influence.

Professor Wittenburg is perhaps the most dedicated scholar of this subject in the world today. He has largely resisted the temptations that have drawn others into the consideration of flexible bodies, preferring to refine his treatment of multirigid-body systems. The material in the final chapter on collisions of such systems is uniquely his domain. His presentation of the subject, while not unique in its proper claim to elegance and completeness, is as worthy of textbook publication as any competing formulation.


REVIEWED BY FREDERICK F. LING

The author set out to fill a hitherto neglected area of wear and has done an excellent job of exposition of the area of impact wear, methods of analysis and computation, and experimental verification. It is a welcome addition to the literature. After a review of friction and wear in Chapter 1, the author introduces in Chapter 2 the methods of percussive impact analysis including such items as numerical methods of impact stress analysis of what is called non-Hertzian problems and combined stress wave and Hertz-impact analysis. Chapter 3 deals with impact response of engineering surfaces including impact on elastic layers and thermal effects of impact. Chapters 4 and 5 discussed specific and general questions of erosion by solid particles. Experimental background of percussive impact wear is discussed in Chapter 6. Several methods are discussed in detail, including a ballistic impact-wear and pivotal hammering impact-wear experiments. Next, in Chapter 7, the zero impact wear model is discussed. A surface damage contribution factor, β, is proposed. Chapter 8 deals with...
measurable impact wear theory. Chapters 9 and 10 treat impact wear in plastic stress range and impact wear through flexible media such as paper and metal surface protected by the polymer film. The last chapter, Chapter 11, deals with liquid erosion including failure mechanisms under liquid impact. Four appendices conclude the book—Appendix 1 contains computer programs in APL programming language; Appendix 2 deals with elastic contact solutions including those for spherical contact. Appendix 3 discusses hardness tests and Appendix 4 deals with surface texture. The book is complete with author and subject indexes. The exposition is well done and very readable. It is recommended as a text in Tribology or a "must" reference for research in the impact wear field.


On page 584, the first of equations (8) should be as follows:

\[ C_1 = \left[ r^4 (b - 4a - 2a - 4b + 4a - 4) + r^2 \right] \]

The second of equations (8) should be as follows:

\[ C_2 = 2t/R \left[ r \cosh \frac{b}{2} - 2b \right] + r^2 z^2 \left( 2b^2 + 8a - 2b^2 \right) + z^4 (4b - 2a - 2a - 2a) + \frac{Us}{R} \left[ 3r^4/2 - 12r^2 z^2 + 4z^4 \right] \]


In the second line from the bottom of the first column on page 510, there should be a + sign immediately after the closing bracket. After the correction, the line will read as follows:

\[ n_4 (S_4 - P_4) + n_4 \]
1. INTRODUCTION. Tribology is a science, which is concentrated on interacting surfaces in relative motion. Interactions like friction, wear and lubrication take place and are the main factors of a complete tribosystem. Mechanical properties of materials are one of the main factors that influence the wear resistance. This study concentrated on impact toughness and hardness of the materials and their relation to wear. Impact toughness was measured by unnotched Charpy impact test, and hardness with the HV2 method. Results are shown in Table 2. Microstructure and wear surface characterization. Microstructural studies of a material can give valuable information on its wear behaviour. Impact wear is found to be strongly dependent on impact dynamics, in particular it is observed to be proportional to energy loss during impacts and dependent on incidence angle with a maximum near 20° to the tangential axis. Microscope observation of the wear scars shows the existence of numerous abrasive scratches whose length corresponds to the sliding distance during impact. In AWJM of ductile materials, material is mainly removed by low angle impact by abrasive particles leading to ploughing and micro cutting. Such process has been studied in detail initially by Finnie [102] as available in the edited volume by Engels [102]. Removal of material in wear is caused if material hardness exceeds that of an abrasive, erodent particle by impact and cyclic loading and high contact pressure as a ticle can hardly cause a plastic flow in the hard target. The result of direct fracture or fatigue processes. Thus, toughness and degree of elastic penetration and therefore the energy transmitted fatigue properties of materials are as important as their hardness lead to a surface depends on the elastic modulus and, if the latter parameters, is high, less elastic penetration occurs.