AIAA JOURNAL
Vol. 37, No. 5, May 1999

Book Reviews

Dynamics of Multibody Systems, Second Edition

Ahmed A. Shabana, Cambridge University Press, New York, 1998, 372 pp., $85.00

During the past two decades, the field of multibody dynamics has been quite active, due to both the development of new techniques and the tremendous advances in computer technology. Therefore, the second edition of this book, initially published in 1989, is a welcome and timely addition to the literature in this field. The primary intent of this book is to provide an introduction to and working knowledge of the field of multibody systems, which are dynamical systems consisting of interconnected rigid and deformable bodies, each of which may undergo large translational and rotational motion. In the early days of this field (late 1960s and early 1970s), such systems were also called hybrid dynamical systems. Currently such systems are playing an important role, with modern applications to aerospace and mechanical engineering. The technique of multibody dynamics is particularly relevant for helicopters, aircraft and space structures, mechanisms, ground vehicles, and robotic manipulators. Furthermore, in many of these applications one encounters highly nonlinear systems. As stated by the author, the book is intended as an introductory text for seniors and first-year graduate students, and it meets its stated goal well.

The book has a total of seven chapters that cover considerable material in a comprehensive and lucid manner. Its general texture is that of a textbook and not a research monograph. The material in these chapters is not covered in a uniformly detailed manner. Some sections are very detailed and informative, whereas other portions of the book are occasionally superficial. However, the book contains an excellent and complete list of references that help the reader in finding additional material when the coverage in the book is too concise. For the sake of completeness, a brief description of the various chapters is provided next. Chapter 1 is devoted to basic material on reference frames, particle kinematics and dynamics, and rigid-body dynamics. The chapter concludes with a description of deformable body dynamics and constrained motion. The material is well explained, and there are good representative examples. Chapter 2 deals with reference kinematics. Starting with the basic rotation matrix, successive rotations and infinitesimal rotations are treated, followed by Rodriquez parameters, Euler angles, and transformation matrices, including rotation and translation in a homogeneous manner. Chapter 3 contains a review of analytical techniques after introducing the concept of a generalized coordinate. The analytical techniques covered are the principle of virtual work, Lagrangian dynamics, calculus of variations, and Hamilton's principle. These analytical techniques receive a fairly concise and superficial coverage. Chapter 4 is an attempt to present a brief review of solid mechanics, consisting of the definition of strain and stress, the equations of equilibrium, constitutive equations, and virtual work of elastic forces. It is rather ambitious to condense so much material into such a short chapter, and this chapter could have used an expansion. Chapter 5 is devoted to floating reference frames, which have a central role in multibody dynamics, since the motion of the body is defined as the motion of its reference frame plus the motion of the material points in the body with respect to its reference. This chapter also includes a treatment of the inertia properties of deformable bodies (or the mass matrix), derivation of overall equations of motion, and coupling between the reference and elastic displacements, as represented by inertia shape integrals. The chapter concludes with such useful topics as generalized coordinate partitioning and organization of multibody computer programs. Chapter 6 is essentially the author's version of finite elements. It is divided into several sections, such as Characterization of Planar Elastic Systems, followed by Characterization of Spatial Elastic Systems. Methods of coordinate reduction or a reduction in the number of degrees of freedom associated with the deformable components of the multibody system such as substructuring and components mode synthesis are also treated. The presentation of the material is somewhat dated, and this chapter could be enhanced in this otherwise excellent book. Chapter 7 is devoted to the treatment of the large deformation problem, using absolute coordinates. The method is illustrated by applying it, in a comprehensive manner, to a beam problem. There is also excessive preoccupation in this chapter with discussion of the merits of the consistent vs lumped mass matrices, which probably belongs in the preceding chapter.

Each chapter of the book is followed by a set of problems. These problems are rather routine exercises requiring small derivations based on the material presented in the appropriate chapter. These problems do not present the challenge of forcing the student to synthesize the material in a complete multibody system or to connect it to practical applications. These problems do not require the use of a computer in the solution, nor is there an attempt to use existing software for formulating and solving this class of problems.

There are a number of missing topics in this otherwise comprehensive and excellent book that are mentioned here in a constructive spirit, to suggest that future editions of the book might benefit from the addition of such material. Multibody systems not only imply formulation

of the dynamic equations of motion but also require a solution. This class of problems is usually solved by numerical integration schemes. The discussion of suitable numerical integration schemes and their implementations is an important issue that is not treated in the book. A related problem is associated with the treatment of highly nonlinear problems, which are often emphasized in the book. It is well known that numerical integration of nonlinear equations, under certain conditions, can lead to chaotic solutions. The uninitiated reader should be warned about such a possibility. Another deficiency in the book is the disregard of existing commercially available packages that can solve multibody problems. Mentioning such packages would provide the interested reader with an opportunity to solve representative multibody problems instead of being limited to the simple examples considered in the book.

To conclude, this book is recommended to students and teachers as an introductory textbook in multibody dynamics. Researchers in the field and practitioners will also find the book very useful, and they will be able to augment the material in the book with additional material taken from the comprehensive reference list. This book deserves to be on the shelf of every dynamicist; it represents a substantial improvement on the first edition, and judging from this progress, the third edition should be perfect.

Peretz P. Friedmann
University of Michigan

Vortices and Heat Transfer

Edited by M. Fiebig and N. K. Mitra, Verlag Vieweg, Wiesbaden, Germany, 1998, 378 pp., DM 298

This book is the "Final Report" of a research group at Ruhr–Universitat Bochum, which operated from 1991 to 1996 under the sponsorship of the Deutsche Forschungsgemeinshaft (German Research Association, a rough equivalent of the National Science Foundation). It is not clear whether the eight project reports and three lectures it contains were subject to peer review. (The corresponding reports of the first three years of operation were published as part of an issue of *Experimental Thermal and Fluid Science* devoted to the proceedings of a conference held in Bochum in 1993.) However, the research papers certainly seem to be of archive journal quality. The lectures were among six delivered by invited external speakers at the 1996 Bochum conference marking the end of the project: J.T.C. Liu provides a review of "Longitudinal Vortices in Boundary Layer Heat-Transfer Augmentation," whereas the other two lectures are essentially presentations of the authors' own research.

The theme of the volume is the enhancement of heat transfer by generation of transverse vortices or (much more effective) longitudinal vortices. Vortex generators include transverse ribs, ranging from rectangular blocks to thin fences, and various arrangements of winglets at angle of attack. There is one project (direct and large-eddy simulation) on impinging jets. Laminar, transitional, and turbulent cases are considered. There is a slight preponderance of computational over experimental projects—if one ignores the fact that simulations like those described here are starting to acquire the status of experiments!

The cases measured or analysed are mainly fully developed flows in channels, which are not of much direct relevance to heat transfer in aeronautics or aero engines, except perhaps for ventilation systems and coolers. However, the work is of considerable fundamental interest, providing insight into heat-transfer processes in general—and also providing some relevant and difficult test cases for prediction methods intended for, e.g., gas turbine combustion chambers.

The price of about $180 is not too extreme by modern standards, and the production is excellent. The papers differ slightly in format, e.g., in the numbering of sections and equations, but this does not obtrude. A few gray-scale photographs or graphics have printed with too much contrast.

The book sets what may be an unfortunate precedent for "vanity publishing" of original research without peer review; book publishers' standards of review vary widely from one house to another and, in science, are set up mainly to deal with more-or-less unoriginal textbooks. If book publication of the results of a large research project became common, one would look in the Preface for a phrase like "thoroughly revised and meticulously reviewed," the phrase Profs. Fiebig and Mitra use in the journal versions of their midterm reports.

Having uttered this caution, I am happy to say that the present book is a carefully edited and well-produced record of useful work at a university with a high reputation in fluid dynamics, and its quality is not in doubt. Heat-transfer specialists in all areas will benefit from reading about basic research in which really complex flows were tackled successfully.

Peter Bradshaw
Stanford University