Preface

When faced with a new textbook on dynamics, a natural question confronts the reader: What is the textbook contribution, if any, relative to the many others already available in the field? With regard to fundamental theory, there is clearly no possible difference, for since Newton, Euler, Lagrange, and D'Alembert there have been no significant developments in the realm of classical mechanics. Nonetheless there has been a generalized and growing dissatisfaction with available textbooks on dynamics. The difficulty encountered by engineering students, or even recent graduates in this area, in correctly analyzing a somewhat more complex mechanical system can be seen as evidence of this dissatisfaction. In an era when engineers face challenges such as modeling a system with several degrees of freedom, designing a mechanical arm, analyzing the stability of an underwater robot, actively controlling the chassis movement of a motor car, or accurately predicting the trajectory of a satellite, as examples, a thorough understanding of dynamics is indispensable.

When confronted with the challenge of a nonconventional problem on classical mechanics, the engineer must not and may not lose himself in a multitude of formulae and methods. In order to safely obtain a solution it is necessary to recognize with accuracy the forces and torques which act upon the system, to identify the number of degrees of freedom with absolute certainty, and to choose appropriate reference coordinates, bases, and axes, describing the motion of the system as a

function of the chosen coordinates. To correctly describe the system he or she must master the use of intermediary reference frames. One must also be able to set up the inertia matrices of the system, write a coherent set of equations of motion and kinematics constraints equations, and, finally, solve them or extract relevant information from them. To master all these techniques and consequently be capable of obtaining a reliable result, it is of the utmost importance to have a thorough knowledge of the fundamental concepts of dynamics and, at the same time, to have a solid training in problem-solving methodology.

This book gradually began to take shape as the result of the experience gained over 30 years of teaching — and learning — dynamics and related subjects. It originated from the need for a textbook more in accordance with the methodological unity dictated by the subject and which could simultaneously fulfill the tasks of teaching and training. The reader will find that the text almost always introduces general concepts before introducing specific ones. The author's deliberate choice to do so only appears to present more difficulties at the very beginning. Didactic experience, however, demonstrates the exact opposite: The student, exposed to a concept in its most general form, will rapidly become accustomed to it and will easily master the simplifications which occur in special cases and, most important of all, will not hesitate when faced with more complex situations. In this book, each new concept is introduced along with an illustrative example. Since theory and practice accompany each other, the student is able to implicitly learn useful problem-solving techniques.

It is precisely the methodological approach used in this book, the author believes, that characterizes its contribution, modest though it may be. Although the presentation of concepts is somewhat rigorous, the purpose of this approach is to avoid ambiguities and to develop in the reader the habit of thinking a little more abstractly. Aside from this, several concepts, such as the definition of vector systems, the notion of the angular velocity of a rigid body, or the introduction of the concept of a particle inertia tensor, among others, are presented in a manner considered unusual in basic textbooks of mechanics. The textbook presents a unity within the discipline that is evident to any minimally attentive reader and that is supported by the consistent notation

and the methodology used throughout the book. In this manner particle dynamics, system dynamics, and rigid body dynamics, notwithstanding their specificities, are treated uniformly, so that a beginner in the subject will always recognize the principles which permeate the discipline.

The text presents the so-called Newtonian mechanics. Hamilton's, Lagrange's, or Kane's formulations are therefore not discussed here. Experience has shown that a solid basis in Newton-Euler mechanics is a prerequisite for readily mastering the methods of analytic mechanics, thus strengthening the intuition of the future engineer. This is a deliberate choice of the author. This texbook can be seen as a support for an undergraduate first course in dynamics. However, it is intended to prepare engineers to solve simple problems in dynamics and, on the other hand, to create a solid base for a graduate course on analytical mechanics. In this way, graduate students in physics, engineering, and correlate areas will find the text useful.

Instructors will find the text to be reasonably complete, including theory, examples, and problems, covering the essential material to be taught in a two-semester dynamics course, each semester consisting of around 60 hours. Usually the first four chapters can be covered during the first semester and the last four during the second. The natural prerequisites are at least one year of undergraduate-level calculus, one linear algebra course, and a physics course covering the principles of classical mechanics. It it also desirable, but not essential, for the reader to have taken a basic mechanics course, usually offered in all engineering departments, so as to have acquired notions of statics and link analysis.

No textbook, regardless of its excellence, can substitute for the instructor's work in the classroom. It is, naturally, the instructor who must determine the best method to be followed, excluding some topics or adding others according to his or her personal convenience. For example, Section 5.8, which deals with fluids, can be omitted without hindering in any way the understanding of the material that follows. Aside from this, the ideal sequence in a textbook is not always the most adequate one in a classroom. For instance, consider Section 5.7, which covers the conservation principles for mechanical systems. In the text each principle is followed by its respective example, while in the classroom it is more efficient to present a theoretical discussion about all the principles,

followed by the set of examples. In this way the student is allowed to decide which principle should be applied in each case. When the student returns to the textbook, however, the direct association between theory and application will always be present. This consideration is also valid for several other topics.

The work of preparing such a textbook would not have been possible without the invaluable help, support, and friendship of many colleagues to whom I am immensely grateful. I would like to thank especially Professor Arthur Palmeira Ripper Neto for reading and commenting on the text, to Professor Antonio Carlos Marques Alvim for helping me to prepare Appendix A, and to Professor Luiz Bevilacqua for his encouragement and optimism. I would like to thank Mrs. Elvyn Marshall, my translator, now a close friend, for her professionalism and sense of humor.

To complete this work, the aid of several students, who gave hours and hours of their time taking care of many details, was essential. Engineer Roberto Seabra dedicated himself with extraordinary competence and determination to the task of transforming my sketches and rough diagrams into final figures stored in computer files. Most of the book's illustrations are his. A tragic accident deprived me of my main collaborator and great friend. Many other students helped me and I am very thankful to all of them.

It would not be possible to conclude without thanking the hundreds of students who, over the last years, dealt with the preliminary versions of the text and helped me improve the book by pointing out an endless number of errors. The remaining ones are my sole responsibility.

Comments, suggestions, and corrections will always be welcome.

Rio de Janeiro *Roberto A. Tenenbaum*
Spring 2003

http://www.springer.com/978-0-387-00887-5

Fundamentals of Applied Dynamics
Tenenbaum, R.A.
2004, XV, 713 p. 48 illus., Hardcover
ISBN: 978-0-387-00887-5