Preface

Mechanics is a mature engineering subject. Why do we need another mechanics book?

This book presents rigid-body mechanics in a compact form for a multidisciplinary engineering program. Typically, such programs include *mechatronics*, which covers mechanical engineering, electrical and electronic engineering, and computer engineering, and *biomechanics*, which is related to human physiology, sports, and engineering mechanics. In terms of course structure, they have the following features:

- A wide range of subjects in various areas is taught.
- Limited teaching time is allocated to each subject.
- There is a sharp transition from fundamental to specialized subjects.

Mechanics is one of the most important subjects in traditional mechanical engineering programs. It usually takes two semesters to cover all the relevant topics, arranged in the following order: mechanics of particle motion (one dimension), planar motion (two dimensions), and rigid body motion in space. In comparison, the time allotted to the teaching of mechanics is much shorter in a multidisciplinary engineering program. It is hard to find a concise presentation of the material that covers the essential principles of mechanics and that can be taught in a limited time.

Many existing textbooks focus almost exclusively on the mechanics of particle and planar motions, which are easily visualized and can be readily analyzed with geometrical and graphical methods. On the other hand, multibody dynamics in three-dimensional space is the cornerstone of many specialized courses in multidisciplinary engineering programs (e.g., robotics). There is a huge gap between what is covered in traditional textbooks on mechanics and the requirements for specialized courses (e.g. [7] and [8]) on the motions of rigid bodies and complex systems in three-dimensional space. Thus a book is needed that narrows the gap by focusing on the mechanics of rigid bodies, with particle motion and planar motion as special cases.

The main motivation for writing this book was to produce a work that is compact but comprehensive in its coverage of the essential principles of rigid-body dynamics. To achieve this, the following approaches were adopted in the book:

- The three-dimensional dynamics of a rigid body is dealt with from the beginning of the book to the end. Mechanics in relation to particle motion and planar motion are treated as special cases. This is in contrast to the traditional, sequential coverage of topics: particle motion → motion in a line → planar motion → three-dimensional motion.
- Matrix and vector manipulations are used extensively to make the presentation concise and clear. This is in contrast to the traditional approach, which is dominated by scalar and vector manipulations. This is fine for low-dimensional motion but too clumsy for describing motions and mass properties with respect to different reference frames. Matrix and vector notations can greatly simplify mathematical expressions and reveal the essential principles governing motions in high dimensions; this is also in line with the general approach taken in advanced specialized courses like robotics and mechanisms. In this regard, the reader is expected to be familiar with concepts and manipulations of vectors and matrices, which are covered in undergraduate courses like linear algebra or engineering mathematics. Chapter 1 of this book is designed for readers who might need to review the basics in the relevant areas.
- The concepts of *observation frame* and *description frame* are introduced and are reflected by a set of new vector notations to define kinematic variables more clearly.

The main parts of the book concern the description and analysis of position, velocity and acceleration, inertial properties, and the establishment of equations of motion through three main methods: Newton–Euler formulation, D'Alembert's principle, and Lagrange equations. Some examples are taken from existing books on engineering mechanics and biomechanics. They are addressed with the methodologies and approaches presented in the book, and each step to reach the solution is painstakingly and rigorously explained. There are no question sets for practice after each chapter since rich sources of questions can be found in many existing books on mechanics (e.g. [3] and [5]).

Though some important topics like the impulse-momentum method, collisions, vibrations, and forward dynamics (derivation of a rigid body's motion from forces or torques) are not covered due to space constraints, what is presented in the book should provide a sufficient foundation for dealing with those topics. Statics is not covered here either since it can be treated as a special case of dynamics.

As a note of clarification, dynamics in this book means the study of the relation between changes in motion and the causes of those changes (forces and torques). In some books, this is called kinetics, and dynamics includes both kinematics and kinetics.

The book comprises the following chapters. Chapter 1 covers preliminary mathematical knowledge needed to study the book. It focuses on vector and matrix operations which has been discussed in [1] and [2]. Chapter 2 is on kinematics, Chap. 3 is on dynamics, and Chap. 4 presents case studies.

The book is suitable for undergraduates and postgraduate students in multidisciplinary engineering programs like mechatronics and biomechanics. It is also suitable for students in mechanical engineering and engineers and researchers interested in rigid-body dynamics.

Springer
http://www.springer.com/978-1-4614-0471-2

A Concise Introduction to Mechanics of Rigid Bodies
Multidisciplinary Engineering
Huang, L.
2012, XII, 156 p., Hardcover
ISBN: 978-1-4614-0471-2