PREFACE

The field of biomechanics continues to change rapidly. At the time the first edition was published videographic analysis was displacing 16-mm cinefilm motion analysis. Now the biomechanist has a variety of systems for quantifying human motion from analog video (such as VHS, Beta, SVHS) to digital video (DV) to direct capture by DV cameras, charge-coupled devices (CCD) and infrared (IR) cameras. Not only have the means of capturing human motion improved but the software to digitize (locate coordinates of markers attached to the body) and analyze human motion has proliferated. These software simplify and automate the tasks of calculating kinematic information and of computing the kinetic characteristics, such as, the joint forces, the work done or the power produced by the muscles, of complex human motions.

In response to these changes, an additional chapter was added that illustrates how biomechanists analyze the motion of walking and the control of balance during gait. Distinguished Professor Emeritus Dr. David A. Winter, an expert in the fields of locomotor biomechanics and balance control during gait and posture provided the second half of this extra chapter on balance control. This chapter permits students to apply the knowledge gained in the first chapters to the analysis of real human movements.

Other enhancements to the previous edition include the addition of references and supplementary readings to most chapters as well as additional problems. Some of these problems, identified as optional, require a more theoretical analysis to further test knowledge of the principles of biomechanics. Added to chapter six is a section that discusses what physicists call pseudo-forces, including centrifugal, Coriolis and *g*-forces. Chapter seven has additional equations that define a method of determining internal mechanical work. In chapter nine, an alternate explanation for lift forces that considers Newton's third law is outlined.

Finally a number of new photographs and stick-figure diagrams have been added to illustrate various biomechanical technologies and analyzed human motions. Overall the form and structure of the pervious edition has been maintained guided by the philosophy that the best way to learn physical and biomechanical principles is by applying them mathematically to solve realistic research questions. All examples were performed assuming two-dimensional motion to keep the mathematics relatively simple. The bibliography at the end of the text lists other texts that extend biomechanical analysis to three-dimensional motion.

I hope you find the second edition useful in teaching and learning about biomechanics. Be sure to visit the course website that I use with this textbook (http://www.health.uottawa.ca/biomech/courses/apa2313).

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PREFACE TO FIRST EDITION

This book was written to bridge the gap between the way mechanics is taught to engineering or physics students and to those students in kinesiology or physical education. In the past, students who wanted to study, in depth, the mechanics of human motion had to either study the mechanics of gears, pulleys and levers with the engineers or deal with the complexities of optics, wave motion and quantum electrodynamics with the physicists. In this text human motion is analyzed primarily in two dimensions with mathematical tools easily modified to handle three-dimensional motions in an advanced course. This book is intended to form the foundation upon which advanced analysis of mechanical human or animal motion can be undertaken.

Chapters are arranged in a progression and should not be taught in a different order. The first two chapters are concerned with fundamental concepts that are required for all subsequent chapters. In particular, the metric system (System International) is defined and used almost exclusively throughout the text, although methods for converting between former measurement systems and the metric system are provided.

Chapter three defines the laws of statics but is primarily concerned with developing understanding of vectors and the mathematical concepts associated with vectors. Vector algebra was selected as the optimal mathematical tool for handling the concept of forces acting on human bodies. Since this is an introductory text, however, analysis is centred around linear or planar motions on rigid bodies. The human body is therefore considered to be either a point mass or a single rigid body or parts of the body are considered in isolation to simplify their analysis. More complex analysis, such as, linked segment analysis or the elastic deformation of bodies is reserved for an advanced textbook.

Chapter four analyzes the forces created by dry friction when two or more bodies are forced against each other. No analysis of the fluid friction or how uneven surfaces interact is provided.

Chapter five introduces the concept of kinematics, that is, motion description, which is essential for quantifying the differences between one athletic technique and another or the differences among several individuals performing the same skill. Kinematic analysis is also the first step to performing inverse dynamical analysis which define the underlying causes of human movements.

In chapters six, seven and eight, three different forms of kinetic analysis are presented. First, the force/mass/acceleration and its angular counterpart are defined, followed second by the impulse-momentum theorem and its angular counterpart and the third by the work-energy theorem and the concept of mechanical power are presented. Each chapter introduces these concepts with the laws from which they were derived. Sample problems are provided with the answers to odd numbered problems collected at the end of the text. Numerous example problems are given with each section.

Chapter nine concludes the textual material with an introduction to the principles and concepts associated with fluid mechanics—both statics and dynamics—to enable understanding of the complex motions produced in a world that includes a thick atmosphere and is plentiful with large and small bodies of water. I am indebted to Dr. Peter Stothart for writing this chapter. Peter has many years of teaching experience in biomechanics and structural anatomy and can put quite a curve on a volleyball.

One of the most important features of this text is the use of example problems and sample questions within each chapter. Students have available many solved problems plus the answers to all the odd-numbered questions at the end of the book. Instructors may use the even-numbered problems for homework assignments or examination questions. Furthermore, there is a list of all the essential equations included at the back of the book for quick reference.

Included in appendices are brief descriptions of some of the fundamental laws, rules and concepts associated with, trigonometry, algebra, planar geometry, vector algebra and calculus. In addition, tables on the System International, conversion factors and physical constants are provide as reference material. Finally, there is a glossary, bibliography and extensive index to assistant readers in their pursuit of biomechanical information in this text and others.

Thanks are extended to many friends and colleagues who reviewed portions of this book, including Dr. Ton van den Bogert, Dr. Graham Caldwell, Dr. Joe Hamill, Ms. Sheila Purkiss, Dr. Li Li, Ms. Patti Turnbull and particularly Dr. Peter Stothart. I am also indebted to Dr. David Winter my mentor, friend and now publisher, for supporting my work over the years.

Special thanks are reserved for my wonderful wife, Dr. Lorna McLean, who offered advice and encouragement throughout the process of writing and editing. I would also like to thank my children for coping with my extended periods in front of the computer at all hours of the day and night.

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Author, Dr. Gordon Robertson, and a former graduate student, Dr. Edward Lemaire, align a high-speed cine-camera in preparation for filming Canadian sprinters indoors. Two world records were set by Canadians during the competition.