

Preface

This book, based on courses given to physics and applied mathematics students at Imperial College, deals with the mechanics of particles and rigid bodies. It is designed for students with some previous acquaintance with the elementary concepts of mechanics, but the book starts from first principles, and little detailed knowledge is assumed. An essential prerequisite is a reasonable familiarity with differential and integral calculus, including partial differentiation. However, no prior knowledge of differential equations should be needed. Vectors are used from the start in the text itself; the necessary definitions and mathematical results are collected in an appendix.

Classical mechanics is a very old subject. Its basic principles have been known since the time of Newton, when they were formulated in the *Principia*, and the mathematical structure reached its mature form with the works of Lagrange in the late eighteenth century and Hamilton in the nineteenth. Remarkably enough, within the last few decades the subject has once again become the focus of very active fundamental research. Some of the most modern mathematical tools have been brought to bear on the problem of understanding the qualitative features of dynamics, in particular the transition between regular and turbulent or chaotic behaviour. The fourth edition of the book was extended to include new chapters providing a brief introduction to this exciting work. In this fifth edition, the material is somewhat expanded, in particular to contrast continuous and discrete behaviours. We have also taken the opportunity to revise the earlier chapters, giving more emphasis to specific examples worked out in more detail.

Many of the most fascinating recent discoveries about the nature of the Earth and its surroundings — particularly since the launching of artificial satellites — are direct applications of classical mechanics. Several of these are discussed in the following chapters, or in problems.

For physicists, however, the real importance of classical mechanics lies not so much in the vast range of its applications as in its role as the base on which the whole pyramid of modern physics has been erected. This book, therefore, emphasizes those aspects of the subject which are of importance in quantum mechanics and relativity — particularly the conservation laws, which in one form or another play a central role in all physical theories.

For applied mathematicians, the methods of classical mechanics have evolved into a much broader theory of dynamical systems with many applications well outside of physics, for example to biological systems.

The first five chapters are primarily concerned with the mechanics of a single particle, and Chapter 6, which could be omitted without substantially affecting the remaining chapters, deals with potential theory. Systems of particles are discussed in Chapters 7 and 8, and rigid bodies in Chapter 9. The powerful methods of Lagrange are introduced at an early stage, and in simple contexts, and developed more fully in Chapters 10 and 11. Chapter 12 contains a discussion of Hamiltonian mechanics, emphasizing the relationship between symmetries and conservation laws — a subject directly relevant to the most modern developments in physics. It also provides the basis for the later treatment of order and chaos in Hamiltonian systems in Chapter 14. This follows the introduction to the geometrical description of continuous dynamical systems in Chapter 13, which includes a discussion of various non-mechanics applications. Appendices from the fourth edition on (A) Vectors, (B) Conics, (C) Phase-plane analysis near critical points are supplemented here by a new appendix (D) Discrete dynamical systems — maps.

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