Preface

Mechanics is the oldest discipline among the fundamental natural sciences. The name comes from the Greek word "mechanike", which means "mechanism". The subject of mechanics as a science is the investigation of the motion of bodies and their equilibrium under the action of applied forces. Depending on the nature of the bodies, mechanics can be divided into three branches: (a) general mechanics, dealing with the mechanical behaviour of material points and rigid bodies; (b) fluid mechanics (or the mechanics of continuous media), which is concerned with ideal and viscous fluids and (c) mechanics of deformable media, which studies the deformation of solid bodies under applied external forces.

The knowledge of mechanical motion or displacement of bodies can be accomplished by a very general procedure based on a system of basic axioms, called principles. These principles are the core of what is known as Newtonian mechanics, relativistic mechanics, quantum mechanics and so forth. During the eighteenth century, after the huge success achieved by the mechanics of Galileo Galilei (1564–1642) and Isaac Newton (1643–1727), there appeared the tendency of making mechanics more abstract and general. This tendency leads to what nowadays is called analytical mechanics. Among the founders of analytical mechanics are: Pierre-Louis Moreau de Maupertuis (1698–1759), Leonhard Euler (1707–1783), Jean Baptiste le Rond D'Alembert (1717–1783), Joseph-Louis Lagrange (1736–1813), Carl Friedrich Gauss (1777–1855) and William Rowan Hamilton (1805–1865). Analytical mechanics has proved to be a very useful tool of investigation not only in Newtonian mechanics, but also in other disciplines of Physics: electrodynamics, quantum field theory, theory of relativity, magnetofluid dynamics – to mention a few.

Classical mechanics has undergone an important revival during the last few decades, due to the progress in non-linear dynamics, stochastic processes and various applications of Noether's theorem in the study of both discrete and continuous systems. We recall that there are no exactly linear processes in Nature, but only approximately. All linear models studied in any science are only approximations of reality.

This book is dedicated to the principles and applications of classical mechanics, written for undergraduate and graduate students in physics and related subjects. Its main purpose is to make the students familiar with the fundamentals of the theory, to stimulate them in the use of applications and to contribute to the formation of their background as specialists.

The first two chapters are dedicated to the basic notions and principles of both Newtonian and analytical mechanics, as different approaches to the same purpose: the investigation of mechanical behaviour of both discrete and continuous systems. A special emphasis is put on the large applicability of analytical formalism in various branches of physics.

In the third chapter, the Lagrangian formalism is applied to the study of some classic mechanical systems, as the harmonic oscillator and the gravitational pendulum, as well as to the investigation of some non-mechanical systems, like electric circuits.

The fourth chapter is concerned with the mechanics of the rigid body. The derivation of velocity and acceleration distributions in relative motion makes possible to study the motion of a rigid body about a fixed point. The chapter ends with some applications, such as the physical pendulum and the symmetrical top, together with some mechanical–electromagnetic analogies.

The aim of the fifth chapter is to make the reader familiar with the Hamiltonian formalism. The derivation of the canonical equations is followed by several applications and extensions in mechanics and electrodynamics. The canonical transformations, integral invariants and the Hamilton–Jacobi formalism are also described. They are very useful for students for their further studies of thermodynamics, statistics and quantum theory.

The sixth, final, chapter deals with the mechanics of continuous deformable media. Here, both the Lagrangian and Hamiltonian formalisms are applied in order to study some well-known models of continuous media: the elastic medium, the ideal and viscous fluids. Special attention is paid to the extension of Noether's theorem to continuous media and its applications to the fundamental theorems of ideal fluids.

Since classical mechanics has undergone a considerable evolution during the last century, the authors have tried to draw the attention of the reader to three main directions of development of post-classical mechanics: theory of relativity, quantum mechanics and stochastic processes. These three basic orientations in post-classical mechanics are very briefly exposed in three addenda, which conclude the main substance of the book. At the end of the book, for the convenience of readers, two appendices are provided, which contain the most frequently used formulas on vector and tensor algebra, as well as on vector calculus.

The present book is an outcome of the authors' teaching experience over many years in different countries and with different students studying diverse fields of physics and engineering. The authors believe that the presentation and the distribution of the topics, the various applications in several branches of physics and the set of more than 100 proposed problems make this book a comprehensive and useful tool for students, teachers and researchers.

During the preparation of this book the authors have benefited from discussing various questions with many of their colleagues and students. It is a pleasure to express gratitude to all of them and to acknowledge the stimulating discussions and their useful advice. Our special thanks go to Professor Peter Presnajder for valuable suggestions and for his considerable help in improving the manuscript.

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