The author conducts his 688-page book, through “a modern perspective of classical electrodynamics”, by considering a theory based on Einstein’s principle of relativity, and the Maxwell and Lorentz equations. It is paid appropriate attention to the mathematical framework where the theory (and the equations) are being considered.

The book contains three parts. In Chapters 1 to 4 (Part I), it starts by introducing the physical and mathematical foundations of the classical electrodynamics of a system of charged point-like particles. The Maxwell and Lorentz equations are also here introduced and analysed in a basic way. The variational method is described as an alternative approach for the formulation of a generic relativistic field theory, and its relation with Noether’s theorem is exploited.

In Chapters 5 to 14 (Part II), starting from a series of exact solutions of Maxwell’s equations, the main concern is to describe the basic phenomenological predictions of classical electrodynamics. That is why the properties of the electromagnetic waves are looked as a basis of solutions of Maxwell’s equations in vacuum, so that every solution can be expressed as a linear superposition of these waves. The angular and spectral distributions of the radiation emitted by a series of important physical systems, such as the high-energy accelerators, the collisions between charged particles, the linear antennas, the classical hydrogen atom, and the Thomson scattering are considered in detail.

Chapters 15 to 21 (Part III) are especially devoted to more recent developments of theoretical high-energy physics. This includes the analysis of ultraviolet divergent self-force arising in the Lorentz equation, which takes part in the radiation reaction phenomenon, as well as the infinite energy of the electromagnetic field of a charged point-particle. Solutions are proposed, taking profit of the theory of distributions, and the interactions between the Lorentz-Dirac equation and the local conservation of energy and momentum. The case of classical electrodynamics of massless charged particles is also discussed, leading, in this framework, to the analysis of the well-posedness of Maxwell’s equations, as well as the analysis of the existence of exact analytical solutions of these equations. Then, massive vector fields are described (also thinking that they describe massive spin-one particles), and an introduction is presented to the classical electrodynamics of extended charged objects occupying a p-dimensional volume. Moreover, the author analyses the possibility of introducing in classical electrodynamics elementary particles endowed with magnetic charge and, more generally, elementary particles carrying both electric and magnetic charges (i.e., dyons). Finally, he examines the dynamics of a two-dyon system in the framework of non-relativistic quantum mechanics.

The book intends to be self-contained but a basic knowledge of classical electromagnetism and relativistic kinematics is recommended to the reader. The author includes a significant number of concrete examples, illustrating the theory, and several problems are proposed in each chapter.

Reviewer: Luis Filipe Pinheiro de Castro (Aveiro)

MSC:

78-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to optics and electromagnetic theory
78A25 Electromagnetic theory (general)
78A40 Waves and radiation in optics and electromagnetic theory
78A35 Motion of charged particles
78A45 Diffraction, scattering
78M30 Variational methods applied to problems in optics and electromagnetic theory
83A05 Special relativity
81V45 Atomic physics
35Q60 PDEs in connection with optics and electromagnetic theory
35Q41 Time-dependent Schrödinger equations and Dirac equations
00A79 Physics
Keywords:
electrodynamics; electromagnetic fields; wave equation; scattering; Einstein’s principle of relativity; Maxwell equations; Lorentz equations; variational method; Noether’s theorem; quantum mechanics; Green function

Full Text: DOI