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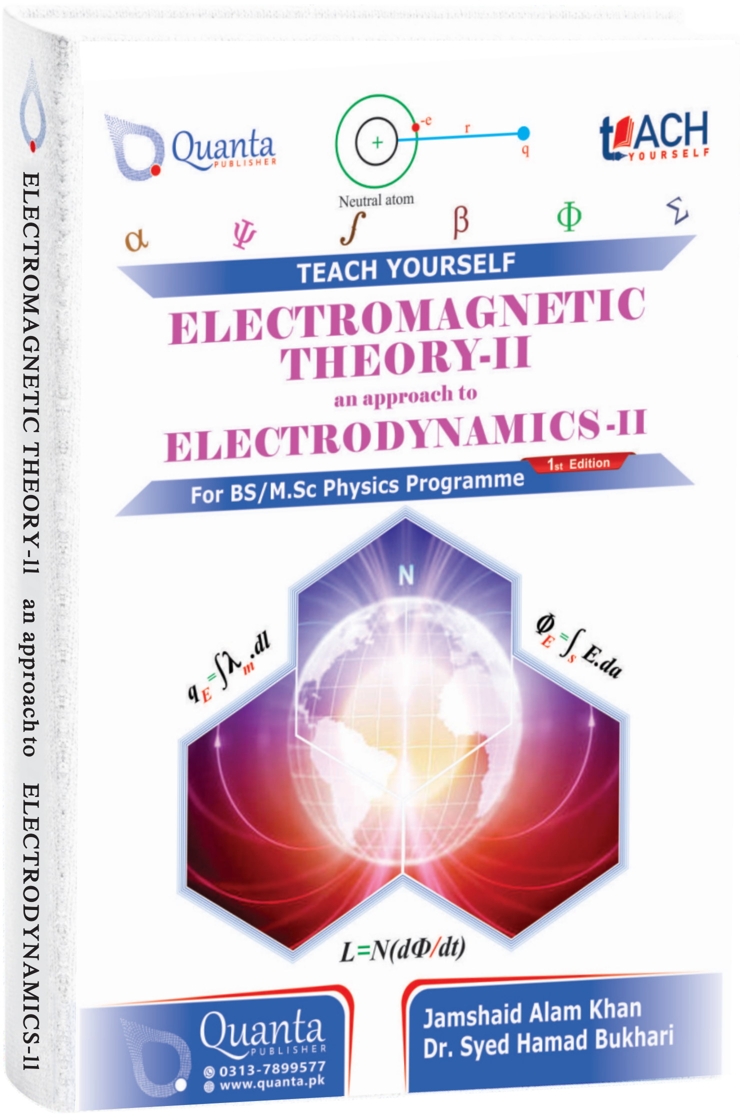

TEACH YOURSELF

ELECTROMAGNETIC THEORY - II

an approach to

ELECTRODYNAMICS - II

1st Edition

For **BS/M.Sc Physics** students of all Pakistani Universities/Colleges

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Chapter 1

Magnetic Field of Steady Currents

THE second kind of field which enters into the study of electricity and magnetism is, of course, the magnetic field. Such fields or, more properly, the effects of such fields have been known since ancient times when the effects of the naturally occurring permanent magnet magnetite (Fe_3O_4) were first observed. The discovery of the north- and south-seeking properties of this material had a profound influence on early navigation and exploration. Except for this application, however, magnetism was a little used and still less understood phenomenon until the early nineteenth century, when Oersted discovered that an electric current produced a magnetic field. This work, together, with the later work of Gauss, Henry, Faraday and others, has brought the magnetic field into prominence as a partner to the electric field.

In this chapter, the basic definitions of magnetism will be given, the production of magnetic fields by steady currents .The detail concept about Biot-Savart law and its applications. The differential and integral form of Ampere's circuital law. The magnetic vector and scalar potential which are used in computing simple fields. The calculation of magnetic field and magnetic flux will be studied, and some important groundwork for future work will be laid.

Chapter 2

Magnetic Properties of Matter

ALL matter exhibits magnetic properties when placed in an external magnetic field. Even substances like copper and aluminum that are not normally thought of as having magnetic properties are affected by the presence of a magnetic field such as that produced by either pole of a bar magnet. Depending on whether there is an attraction or repulsion by the pole of a magnet, matter is classified as being either paramagnetic or diamagnetic, respectively. A few materials, notably iron, show a very large attraction toward the pole of a permanent bar magnet; materials of this kind are called ferromagnetic. Michael Faraday is the first statistician who was discovered classifying substances according to their magnetic properties in the 19th century. The strength of a magnetic field always decreases with distance, though the required mathematical relationship between strength and distance varies.

In this chapter the magnetization process. The calculation of magnetic field which is produce by magnetized materials. The magnetic scalar potential and magnetic poles density. The sources of magnetic field. The magnetic intensity. The calculation of field equation which describe the magnetic effect of currents. The magnetic susceptibility and permeability. The hysteresis loop. The boundary condition on field vector. The differential and integral form of faraday law of electromagnetic induction. The study of emf by using Lenz law. The self induction Phenomenon in various coil like Toroidal coil. The Neumann formula and the mutual induction process between two different coils will be studied.

Chapter 3

Maxwell's Equations

MAXWELL was the first person to calculate the speed of propagation of electromagnetic waves which was same as the speed of light and came to the conclusion that EM waves and visible light are similar. These are the set of partial differential equations that form the foundation of classical electrodynamics, electric circuits and classical optics along with Lorentz force law. These fields highlight modern communication and electrical technologies. Maxwell's equations integral form explain how the electric charges and electric currents produce magnetic and electric fields. The equations describe how the electric field can create a magnetic field and vice versa.
In this chapter we will study the generalization of Ampere's law. The displacement current. The Maxwell equations. The wave equation with sources. The retarded scalar and vector potentials and Lorentz condition.

3.1 The Generalization of Ampere's Law

The differential form of Gauss's law in electrostatics states:

$$\begin{aligned} \text{div}\vec{E} &= \frac{\rho}{\varepsilon_o} \\ \text{or} \quad \vec{\nabla}\cdot\vec{E} &= \frac{\rho}{\varepsilon_o} \end{aligned} \tag{3.1}$$

where $\vec{E}$ is the electric field and ρ is the volume charge density. The Eq.(3.1) is true for stationary as well as moving charges. Electric charge in motion is equivalent to an

Chapter 4

Applications of Maxwell's Equations

THE uses and applications of Maxwell's equations are just too many to count. By understanding electromagnetism we're able to create images of the body using MRI scanners in hospitals; we've created magnetic tape, generated electricity, and built computers. Any device that uses electricity or magnets is on a fundamental level built upon the original discovery of Maxwell's equations. While using Maxwell's equations often involves calculus, there are simplified versions of the equations we can study. These versions only work in certain circumstances, but can be useful and save a lot of trouble.
This chapter comprises of the plane monochromatic waves in conducting and non conducting media. The polarization process. The Brewster and critical angle. The complex Fresnel's coefficients. The reflection of electromagnetic waves on conducting planes. The reflection and transmission electromagnetic waves by a thin layer. The propagation of electromagnetic waves between parallel conducting plates. The waveguides and the cavity resonators.

4.1 Plane Monochromatic Waves in Non-Conducting Media

Maxwell equations provide us with all information that can be drawn from the classical theory of electric and magnetic fields. It can be shown that the fields produced by moving charges can leave the source and travel through space in the form of waves. This is one of the important features of the Maxwell's equations. i.e.,

Chapter 5

Optical Dispersion in Materials

ELECTROMAGNETIC waves that encounter materials create a a complex of interaction with the charged particles of the medium. Forces are exerted on the charges by the electric field of the wave and because of the motion of the charges, also by the magnetic field of the waves. In responding to these oscillating fields, the charges themselves oscillate and act as a radiator of secondary electromagnetic waves. Thus in determining the net field at some point, the fields of both the source waves and the waves emitted by the charged oscillators must be taken into account. In the case of ordinary fields, smaller than those now attainable with high-energy laser, the net fields are assumed to be a linear superposition of the constituent fields. The complicated effects of all the microscopic contribution to the resultant field by the charges in the material can, for certain purposes, be simply described by macroscopic material parameters, the optical constants of the material. In this chapter, we show in particular how the refractive index and absorption coefficient for isotropic conducting (metals) and non-conducting (insulator or dielectrics) materials can be understood. In order to do this we use Maxwell's equations and the mathematical techniques of vector calculus.

5.1 Drude Lorentz Harmonic Oscillator Model

In 1900, Max Plank presented his purely from assumption that consisting of small packets of energy. In 1905, Albert Einstein showed that electromagnetic waves could be photons with discrete, quantified energy which was dependent on frequency of the wave.

Chapter 6

Electrodynamics and Relativity

UNTIL the end of the 19th Century, classical mechanics was confirmed by all experiments and nobody dared to think that this might not be the case in electromagnetism. However, several experiments have shown some contradictions between classical mechanics and electromagnetic phenomena, especially the propagation of light. In fact, as we shall see in this chapter, Maxwells equations, which are the basic laws of electromagnetism, are not in accordance with the Galilean invariance, which is one of the basic principles of classical mechanics. Several attempts have been made, without success, to modify Maxwells equations in order to make them agree with classical mechanics. Lorentz adopted the opposite strategy and proposed to modify classical mechanics by replacing the Galilean transformation by the now-called Lorentz transformation. In 1905, Einstein analyzed the basic concepts of space and time, and formulated the special theory of relativity. The Lorentz transformation resulted straightforwardly from this analysis. Up to now, all the consequences of this theory have been verified experimentally.

The special theory of relativity and the general theory of relativity, both formulated by Einstein, are new perceptions of physics and the Universe with very important consequences. Special relativity is used to study high-velocity (thus high energy) phenomena. All fundamental physical theories must be formulated in accordance with relativity in order to be covariant (that is, independent of the observation frame). In this chapter we introduce the basic ideas of this theory and analyze some of its consequences in mechanics and in electromagnetism.

Chapter 7

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