Chapter 1
Electromagnetism

ABSTRACT

For Direct Current machines, Electromagnetism serves as the core. Therefore, in this chapter, the authors provide the fundamental background to the reader by giving basic information regarding electromagnetism. The chapter starts by discussing system of units, then the authors discuss regarding magnetic field, intensity of magnetic field, flux, flux density, amperes law, and units of flux. After that the authors discuss theory of magnetism, law of electromagnetic induction, Fleming's right and left hand rules, law of magnetic circuit, energy stored in a magnetic field and energy of inductive circuit. Hysteresis loop with core losses and hysteresis loss is then discussed. Finally, we discuss Eddy current loss.

1.1 INTRODUCTION

This chapter includes a few basic concepts which are necessary to understand the material in the proceeding chapters, e.g. system of units, magnetic field, Ampere's law, and laws of electromagnetic induction. The details of systems of units are given in Table 1.

1.2 System of Units

We know from the Coulombs law that electrostatic force "f" between two point charges q1 and q2 placed at a distance "r" given by

$$f = \frac{q^1 q^2}{\varepsilon_a r^2}$$

where $\mathscr{E}$a is a constant of proportionality and is called absolute permittivity of the medium. For air absolute permittivity is represented by Єo and the ratio Єa/Єo = K is called relative permittivity which is also called the dielectric constant of the medium. It was shown by Maxwell that in general

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Table 1. System of units

CGS Units		MKS Units
Quantity	**Units**	**Weber**
Flux	Maxwell's	1 Weber =10^8Maxwells
Flux density	Maxwell/cm^2 Or Gauss	Weber/cm^2 1 Web/m^2 = 10^4 Guass
Field Strength	Orested	MKS field intensity H = 10^3 orested

$$\mu_o \varepsilon_o = \frac{1}{c^2}$$

$$\text{uo } \mathbb{C}\text{o} = \frac{1}{\text{c}^2}$$

where 'C' is the velocity of light (3x 10^{10} Cm/Sec or 3x10^8 m/Sec). The values of these constants depends upon system of units chosen

Assuming these quantities to be unity, we get

$$f = \frac{q^1 q^2}{r^2}$$

With the assumption it is possible to define unit electric charge and unit Magnetic pole.

In CGS system of units, the unit of force is dyne

$$1 dyne = \frac{1 \times 1}{1}$$

So the unit electrical quantity has such magnitude that two such units, concentrated at points 1 cm apart in air will react with a force of 1 dyne and a unit magnetic pole has such magnitude that two such units, concentrated at points 1 cm apart in air, will react with a force of 1 dyne. Later on this unit electrical quantity was given the name stat coulomb, stat ampere, statvolt and stat ohm.

Electromagnetic units were defined and their name was ampere, volt etc. But it was shown latter on that these units are either too large or too small, so practical units were defined e.g. ampere, Henry, volt and ohm.

$$1\text{amp} = 10\text{qmp}$$

Now due to difficulties involved in these system MKS system was defined in which unit of force is 1 Newton = 105 dyne. The basic change was