CHAPTER - 8 ELECTROMAGNETIC WAVES

Electromagnetic Waves

Conduction Current

The current due to flow of charge is often called conduction current

$$i_c = \frac{dq}{dt}$$

Displacement Current

If there exists an electric current as well as a changing electric field, they result into magnetic field & causes displacement current

$$i_d = \varepsilon_0 \frac{-d\phi_E}{dt}$$

Electromagnetic spectrum

- Radio wave $\lambda > 10^8$nm
  Use : radio, TV signal
- Micro wave $10^8 > \lambda > 10^5$nm
  Use : micro wave oven, radar
- Infrared $10^5 > \lambda > 700$ nm
  Use : night vision
- Visible light $700 > \lambda > 400$ nm
  Use : to observe world
- UV rays $400 > \lambda > 10$nm
  Use : destroying bacteria
- X-rays $10 > \lambda > 0.01$ nm
  Use : detect bone break
- γ rays $0.01\text{nm} > \lambda$
  Use : to treat cancer

History

In 1886 Heinrich Hertz became the first person to transmit and received controlled radio waves

Maxwell's Equation

Gauss's Law (electricity)

$$\oint \vec{E}.\vec{ds} = \frac{q_{in}}{\varepsilon_0}$$

Gauss's Law (magnetism)

$$\oint \vec{B}.\vec{ds} = 0$$

Faraday's Law

$$\oint \vec{E}.\vec{dl} = \frac{-d\phi_B}{dt}$$

Ampere's Law

$$\oint \vec{B}.\vec{dl} = \mu_0 i + \mu_0\varepsilon_0 \frac{-d\phi_E}{dt}$$

Combination of mutually perpendicular electric & magnetic fields is referred to as an electromagnetic wave

Characteristics of Electromagnetic waves

- Do not need any material medium for propagation
- Travels with speed of light (c) $= \frac{1}{\sqrt{\mu_0\varepsilon_0}}$
- Produced be accelerated change particle
- Transverse in nature
- Oscillating electric & magnetic fields are in phase and their ratio is contant (C) $= E_0/B_0$

Energy density

- $U = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2}\frac{B^2}{\mu_0}$ = energy per unit volume
- U_{av} over a long time

$$= \frac{1}{4}\varepsilon_0 E_0^2 + \frac{1}{4}\frac{B_0}{\mu_0}$$

$$= \frac{1}{2}\varepsilon_0 E_0^2 \quad [\text{as } c = B/E_0 \ \& \ \mu_0\varepsilon_0 = \frac{1}{c^2}]$$

$$= \frac{1}{2}\frac{B_0^2}{\mu_0}$$