Class : 12th Physics
Chapter- 8 : Electromagnetic Waves

Electromagnetic 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

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

Displacement Current

If there exists an electric current as well as a changing electric field, results magnetic field & cause 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

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
  $= \frac{1}{4}\varepsilon_0 E_0^2 + \frac{1}{4}\frac{B_0}{\mu_0}$
  $= \frac{1}{2}\varepsilon_0 E_0^2$ [as $c = B/E_0$ & $\mu_0\varepsilon_0 = \frac{1}{c^2}$]
  $= \frac{1}{2}\frac{B_0^2}{\mu_0}$

Conduction current

The current due to flow of charge is often called

$i_c = \frac{d\theta}{dt}$

Contribution

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

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

Characteristics of Electromagnetic waves

1. Do not need any material medium for propagation
2. Travels with speed (v) $= \frac{1}{\sqrt{\mu_0\varepsilon_0}}$
3. Produced by accelerated charge
4. Transverse in nature
5. Oscillating electric & magnetic fields are in phase and their ratio is constant $(C) = E_0/B_0$