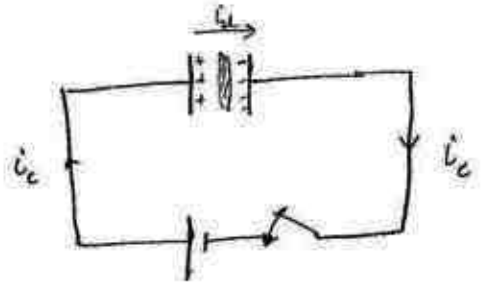
Electro magnetic Waves

Maxwell gives the idea of EMW on the basis of displacement current

displacement current (i_d)

It is the current due to change in electric flux with time



$$\phi_E = ES = \frac{I}{\epsilon_0} S = \frac{q}{S\epsilon_0} S \quad \therefore q = \epsilon_0 \phi_E$$

$$\frac{dq}{dt} = \epsilon_0 \frac{d\phi_E}{dt} \quad \therefore \quad \boxed{i_d = \frac{\epsilon_0 \, d\phi_E}{dt}}$$

On the basis of displacement current, Maxwell gives correction in Ampere-circuital law and introduced a new equation called Ampere-Maxwell e

$$\boxed{\oint \vec{B} \cdot \vec{dl} = \mu_0 (i_c + i_d)} \quad (i_c = i_d)$$

maxwell's equation

i) $\oint \vec{E} \cdot \vec{ds} = \frac{q_{en}}{\epsilon_0}$ (gauss law ⌀ in electrostatics)

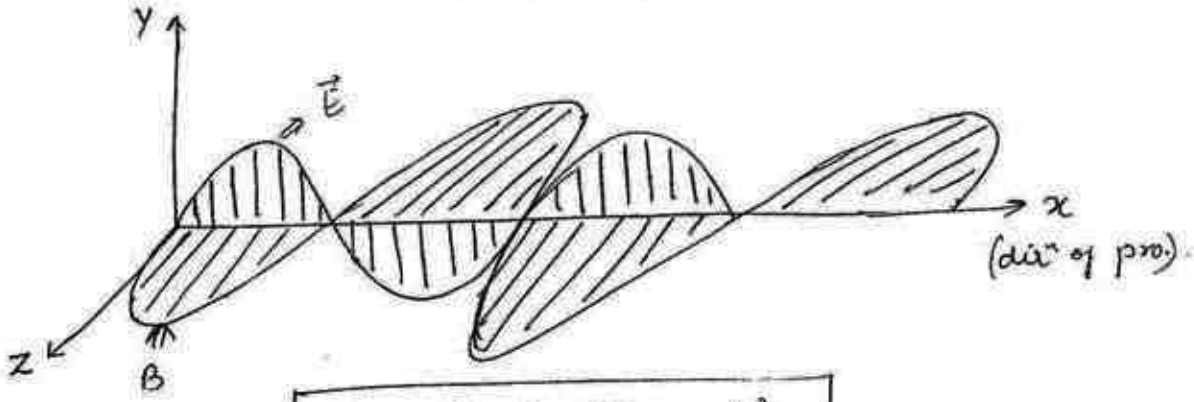
ii) $\oint \vec{B} \cdot \vec{ds} = 0$ (—"— magnetics)

iii) $\oint \vec{E} \cdot \vec{dl} = S\frac{dB}{dt}$ (faraday law in EMI)

iv) $\oint \vec{B} \cdot \vec{dl} = \mu_0(i_c + i_d) = \mu_0\left(i_c + \epsilon_0 \frac{d\phi_E}{dt}\right)$ {Amp. maxwell eq}.

Properties of EM waves

- In EMV changing electric field produces magnetic field and changing magnetic field produces electric field.
- These waves are transverse in nature dt is electric and magnetic components Oscillates in the dir^n $\perp$ to the dir^n of propagation of waves.



$$E_y = E_0 \sin(Kx - \omega t)$$
$$B_z = B_0 \sin(kx - \omega t)$$

- These waves are produced by accelerating / retarding the charge
  - vibrating atoms / molecules
  - Transition of e^- from outer Energy level to another lower energy level.

> These are non-mechanical wave ∴ do not require any medium

> Speed of these waves are different medium

$$C = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = 3 \times 10^8 \text{ m/s} \qquad \therefore V = \frac{1}{\sqrt{\mu \epsilon}}$$

> These waves transport, energy, momentum & information but doesn't transport the charge.

Momentum of electronic waves $= \boxed{P = \frac{U}{C}}$

> Energy of these waves per unit per unit time is given by poynting vector $(\vec{S})$

$$\boxed{\vec{S} = \frac{\vec{E} \times \vec{B}}{\mu_0}}$$

> Energy of these waves per unit vol^m is equally distributed in electric and magnetic field.

$$\boxed{\mu = \mu_E + \mu_M}$$

$$\boxed{\mu_E = \frac{1}{2} \epsilon_0 E_{rms}^2}$$

$$\boxed{\mu_m = \frac{B_{rms}^2}{2\mu_0}}$$

$$\boxed{\mu_E = \mu_M}$$

$$\mu = 2\mu_E = 2\mu_M \qquad \therefore \boxed{\mu = \epsilon_0 E_0^2 = \frac{B_{rms}^2}{\mu_0}}$$

$$\mu = \epsilon_0 \left(\frac{E_0}{\sqrt{2}}\right)^2 \qquad \therefore \boxed{\mu = \frac{1}{2} \epsilon_0 E_0^2 = \frac{B_{0\,rms}^2}{2\mu_0}}$$