Imp Formula

EM Waves

(i) $\oint \vec{B} \cdot d\vec{l} = \mu_0 i + \mu_0 \varepsilon_0 \frac{d\phi_E}{dt}$

$\oint \vec{B} \cdot d\vec{l} = \mu_0 i_c + \mu_0 i_d$, where i_d is the displacement current.

Numerically, $\boxed{i_d = i_c}$

$i_d = \frac{\varepsilon_0 \, d\phi_E}{dt}$.

$$\boxed{i_d = v \frac{dc}{dt} \quad \text{or} \quad i_d = c \frac{dv}{dt}}$$

(ii) Maxwell Equation (4 laws)

(a) $\oint E \cdot dA = \frac{Q}{\varepsilon_0}$

(b) $\oint \vec{B} \cdot d\vec{s} = 0$

(c) $\oint \vec{E} \cdot d\vec{l} = \frac{d\phi_B}{dt}$

(d) $\oint \vec{B} \cdot d\vec{l} = \mu_0 (I_c + I_d)$

Waves

Longitudnal
E.g → Sound waves

Transverse
E.g → Guitar string, Light wave

$$y = \underbrace{A}_{\text{Amplitude}} \sin(kx - \omega t)$$

$k = \frac{2\pi}{\lambda}$

$\omega = 2\pi f$

$$\boxed{v = f\lambda}$$

or, $$\boxed{v = \frac{\omega}{k}}$$

Results :→

(i) $\hat{E} \times \hat{B} = \hat{c}$

(ii) $\frac{E_0}{B_0} = c$; $\frac{E_{RMS}}{B_{RMS}} = c$; $\frac{E}{B} = c$

(iii) $E = E_0 \sin(kx - \omega t)$ → wave is travelling in $+x$ direc^n

(iv) $\frac{E_0}{B_0} = c = \frac{\omega}{k}$

(v) $\frac{\partial E}{\partial z} = -\frac{\partial B}{\partial t}$

⊛ More Results

(i) $U_E = \frac{1}{2}\varepsilon_0 E_{RMS}^2 = \frac{1}{4}\varepsilon_0 E_0^2$

(ii) $U_B = \frac{B_{RMS}^2}{2\mu_0} = \frac{1}{4}\frac{B_0^2}{\mu_0}$

(iii) $C_v = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ (speed of wave in vaccum)

(iv) $C_m = \frac{C_v}{\sqrt{\mu_r \varepsilon_r}}$

(v) $U_E = U_B$

(vi) $U_T = U_E + U_B$

$\Rightarrow U_T = 2U_E$ or $U_T = 2U_B$

(vii) $U_T = \frac{1}{2}\varepsilon_0 E^2 = \varepsilon_0 E_{RMS}^2$

$U_T = \frac{B_0^2}{2\mu_0} = \frac{B_{RMS}^2}{\mu_0}$

(viii) Intensity (Poynting vector)

$$S = \frac{1}{\mu_0}(\vec{E}\times\vec{B})$$

(ix) $I_{avg} = \frac{E_0 B_0}{2\mu_0} = \frac{E_{RMS} B_{RMS}}{\mu_0}$

(x) $I = \frac{\text{Power}}{\text{Area}}$, $I = \frac{1}{2}\varepsilon_0 E^2 \times c$

Electromagnetic Spectrum