⇒ Electro-magnetic wave.

Speed of EMW in vac $= \frac{1}{\sqrt{\mu_0 \epsilon_0}} = 3 \times 10^8$ m/s.

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$$

$\epsilon_0 = 8.85 \times 10^{-12}$, $\mu_0 = 4\pi \times 10^{-7}$

Speed of E.m.w in medium $v = \frac{1}{\sqrt{\mu \epsilon}} = \frac{1}{\sqrt{\mu_0 \mu_r \epsilon_0 \epsilon_r}}$

$$v = \frac{1}{\sqrt{\mu_0 \epsilon_0 \mu_r \epsilon_r}} = \frac{c}{\sqrt{\mu_r \epsilon_r}} = \frac{c}{n}$$

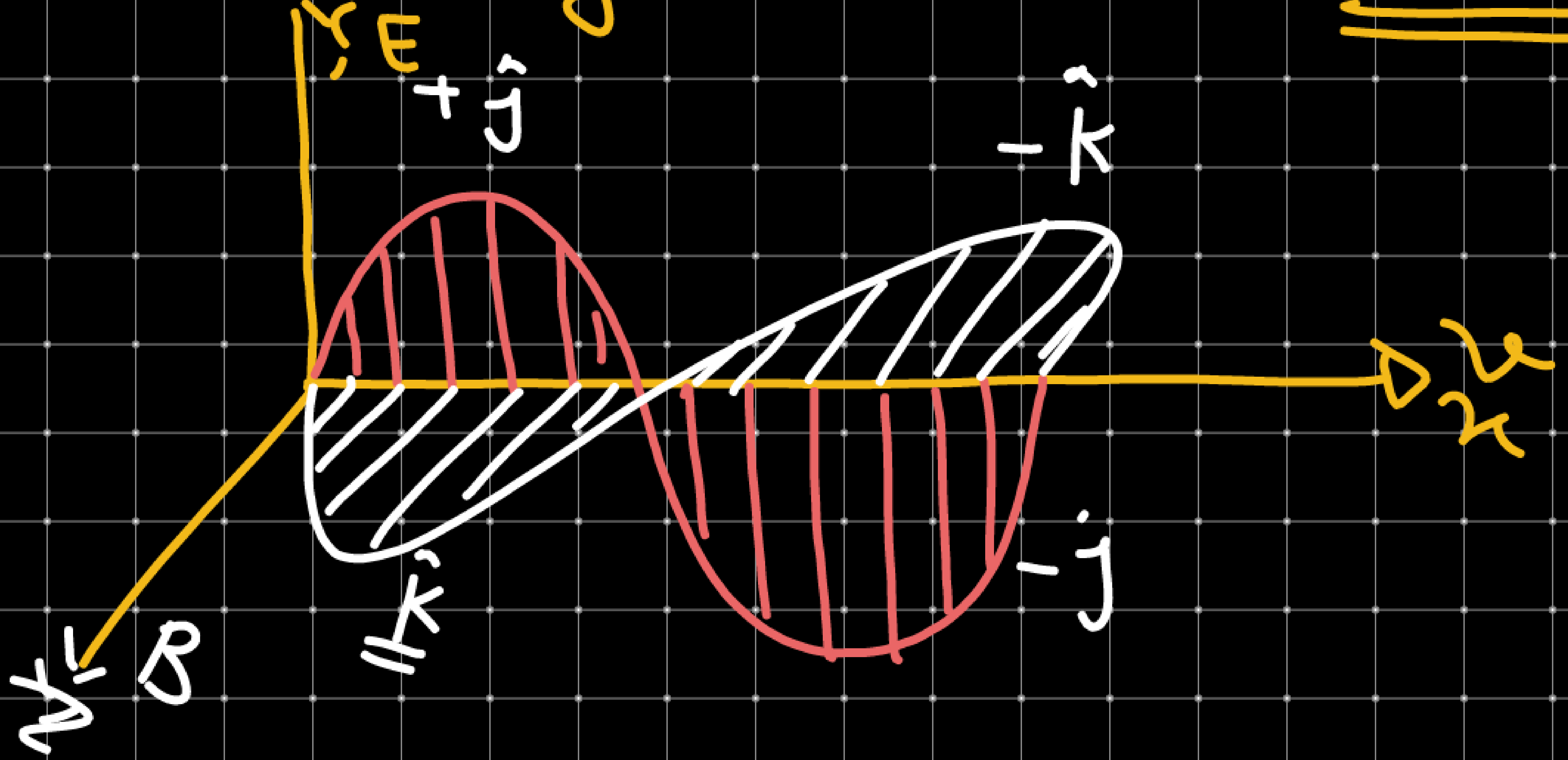
$n = \sqrt{\mu_r \epsilon_r}$ →

└→ refractive index of medium.

In EMW

$\bar{E} \perp \bar{B} \perp \vec{v}$

$\Rightarrow$ dirn of E.m.w $\Rightarrow$ $\hat{E} \times \hat{B} = \hat{v}$



$(-\hat{j} \times -\hat{k})$

$+\hat{j} \times \hat{k} = \hat{i}$

#

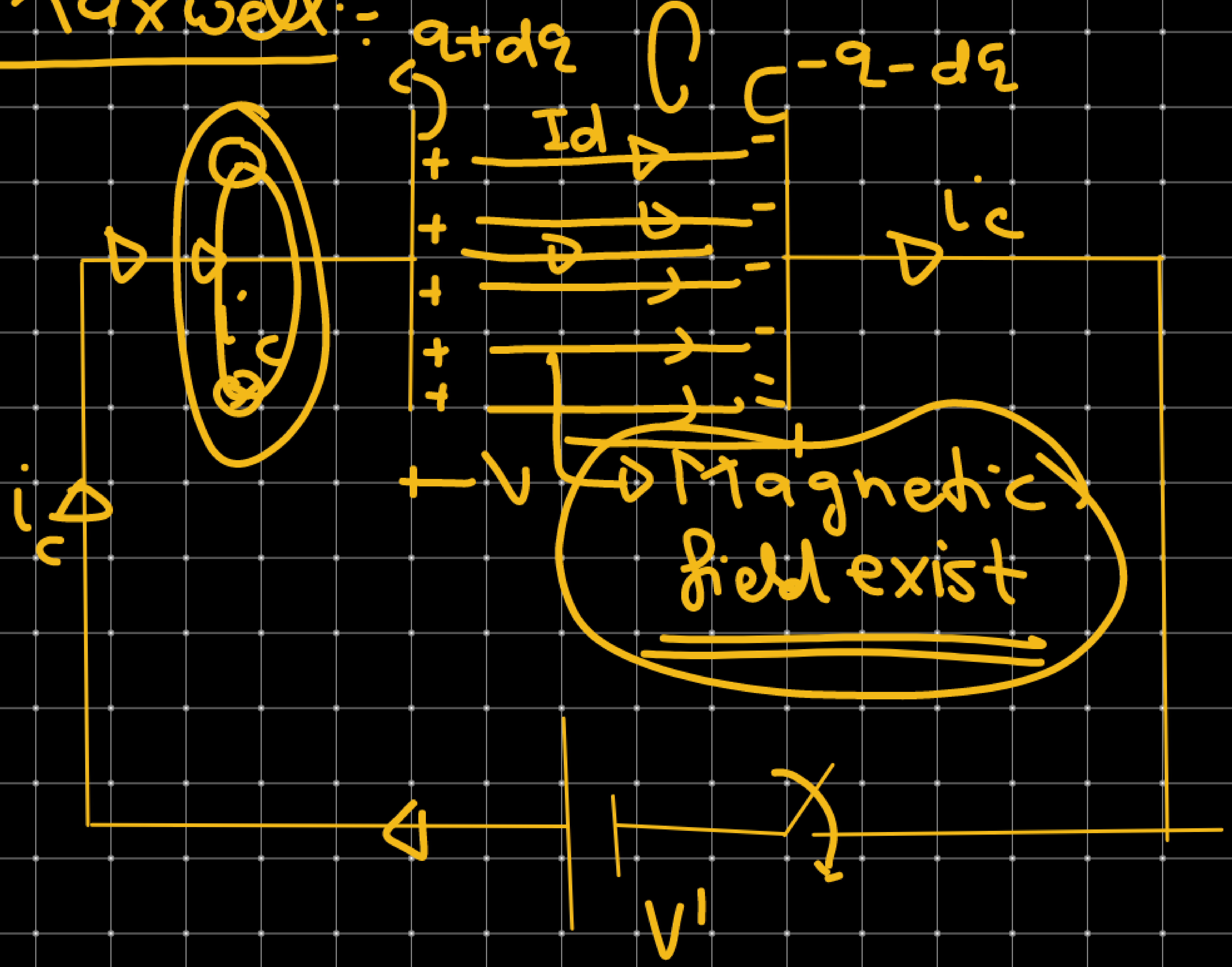
$$\Rightarrow \oint \bar{E}\cdot d\bar{s} = \frac{q_{in}}{\varepsilon_0}$$ [Gauss Law]

$$\oint \bar{B}\cdot d\bar{l} = \mu_0 I_{in}$$ [Ampere circuital Law]

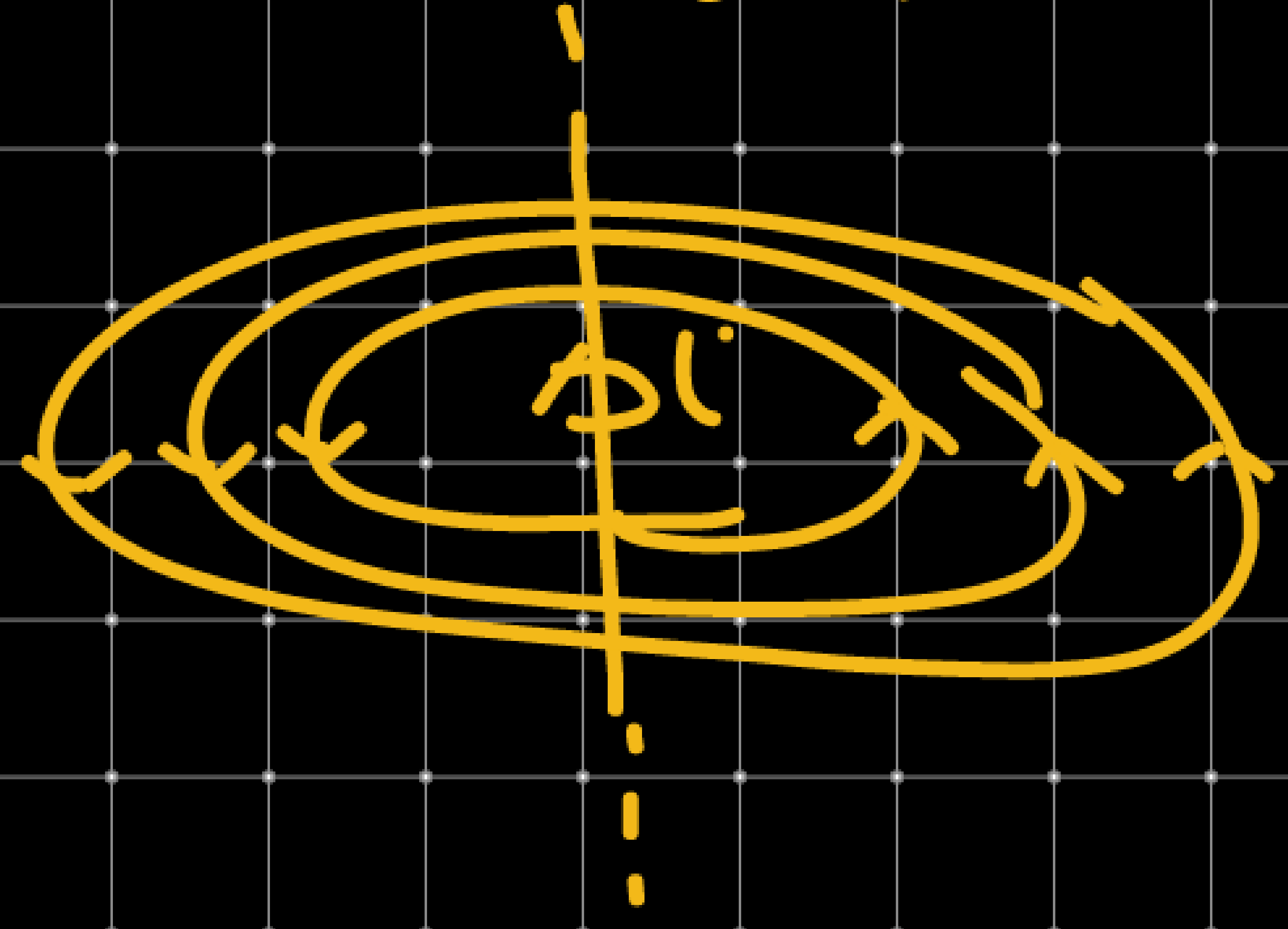
Faraday

$$\oint \bar{E}\cdot d\bar{l} = -\frac{d\phi}{dt} = -A\frac{dB}{dt}$$

⇒ Maxwell :-



i_c = Conduction current.



Displacement Current I_d :-

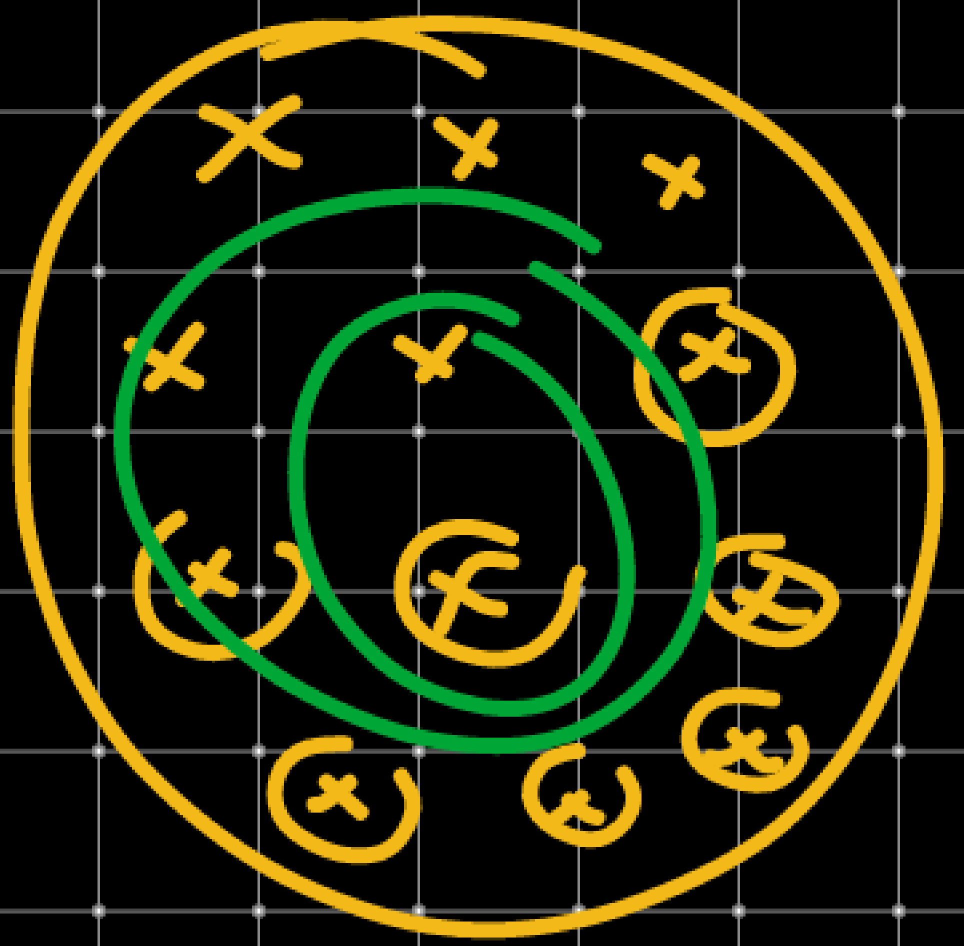
$$i_c = i_d$$

$$q = CV$$

$$i_d = \frac{dq}{dt} = \frac{d}{dt} CV = C \frac{dV}{dt}$$

$$i_d = C \frac{dV}{dt}$$

Faraday :



B ↑↓

↓

E exist

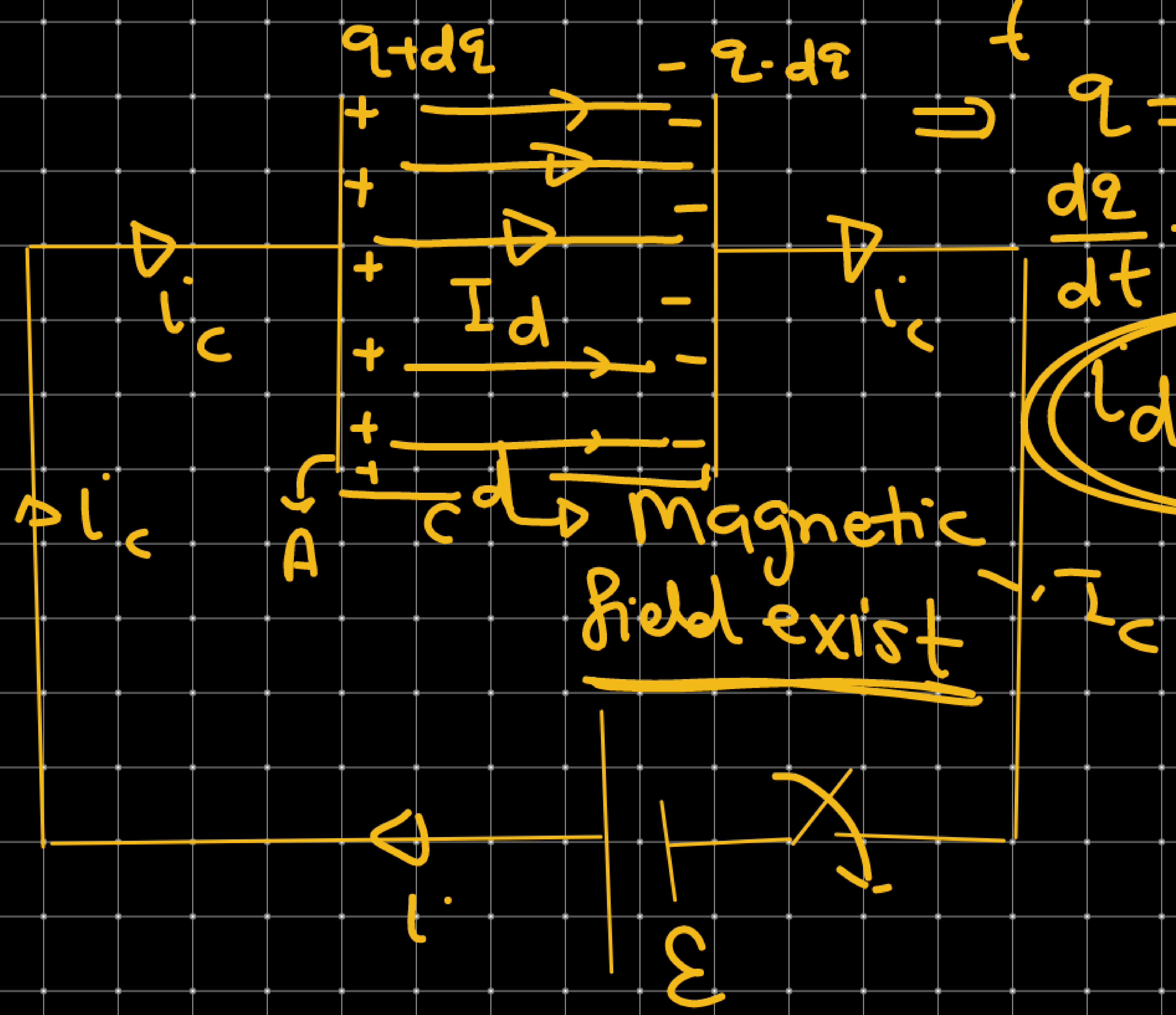
$$\oint \vec{E}\cdot d\vec{l} = -A\frac{dB}{dt}$$

Maxwell :-

↳ E → change hoga
↓
To
↓
Magnetic field
आयेगा

↳ Faraday:

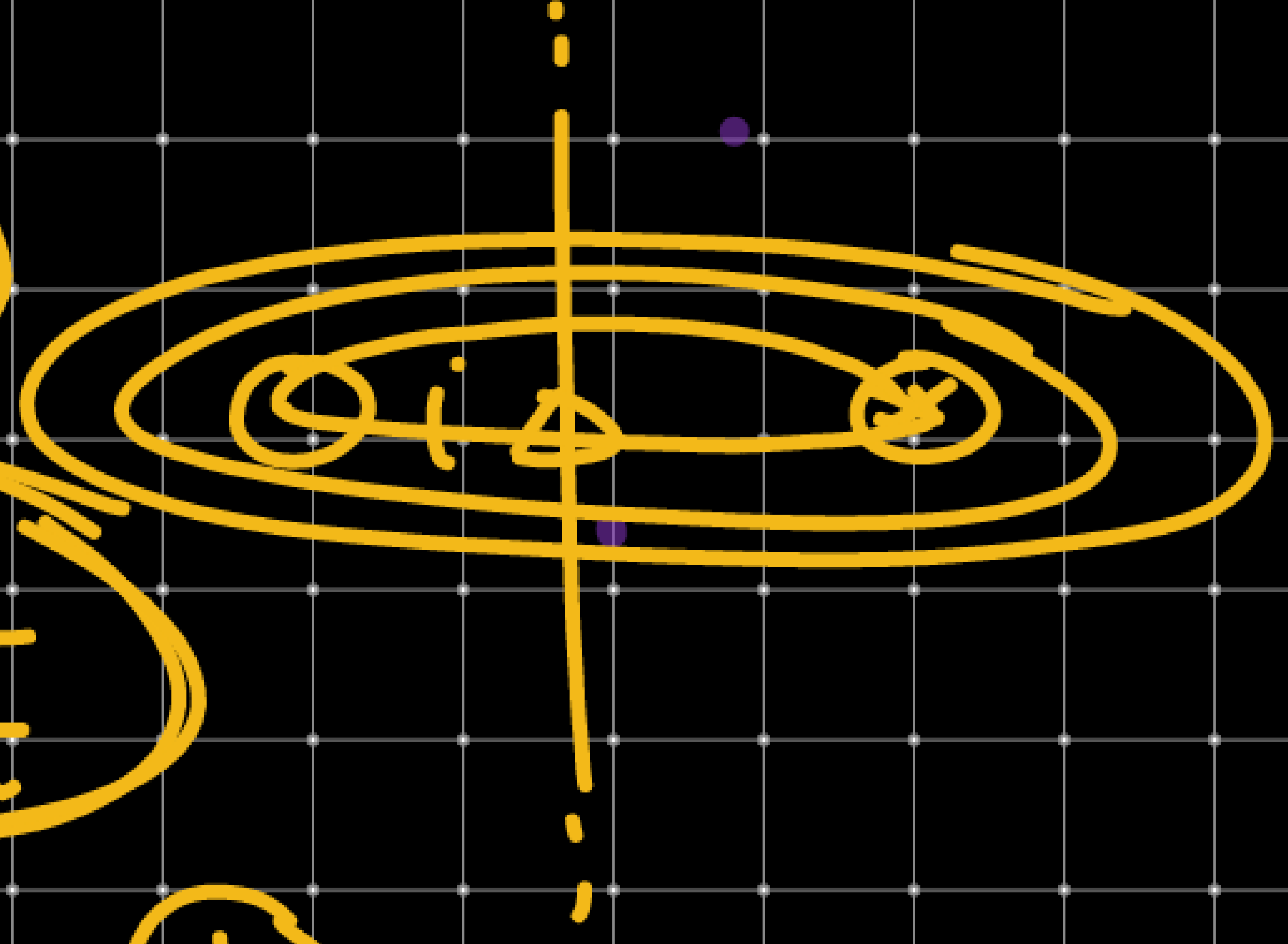
↳ If B changes in a region then Induced Electric field also generate.



$$\Rightarrow q = CV$$

$$\frac{dq}{dt} = \frac{d}{dt}(CV)$$

$$i_d = C\frac{dV}{dt}$$



$\hookrightarrow$ (t)

$$E = \frac{\sigma}{\varepsilon_0}$$

$$E = \frac{q}{A\varepsilon_0}$$

t+dt

$$E' = \frac{q+dq}{A\varepsilon_0}$$

$i_c = i_d$

but when Capacitor is fully charged

$i_c = 0$ $\quad$ $i_d = 0$

Q) If C = 50 μF, Rate of change of voltage = 100 V/sec. find i_d = ?

Sol)

$$i_d = C\frac{dV}{dt}$$

$$= 50\times10^{-6}\times10^{2}$$

$$= 5\times10^{+3}\times10^{-6}$$

$$i_d = 5\times10^{-3}\ \text{Amp}$$

$$i_d = 5\ \text{mA}$$

Q) If EMW enter in a medium of dielectric constant $\varepsilon_r = 4$. find

(a) Reflective index of medium. → 2

(b) Speed of E.M.W

Sol) $n = \sqrt{\mu_r \varepsilon_r}$ If μ_r is not given.

$n = \sqrt{\mu_r \varepsilon_r} \simeq \sqrt{\varepsilon_r}$

$n = \sqrt{4} = 2$

$v = \frac{c}{n} = \frac{3 \times 10^8}{2} = 1.5 \times 10^8 \; m/s$

⇒ Speed of E.M.W in vac ⇒ $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$$v_{med} = \frac{c}{\sqrt{\mu_r \varepsilon_r}} = \frac{c}{n}$$

#

$$v = \frac{E_0}{B_0}$$

→ E_0 → maximum value of Electric field

B_0 – maximum value of Magnetic field

NEET 2017) In EMW the amplitude of magnetic field 20 nT. then find amplitude of Electric field.

Sol

$$C = \frac{E_0}{B_0}$$

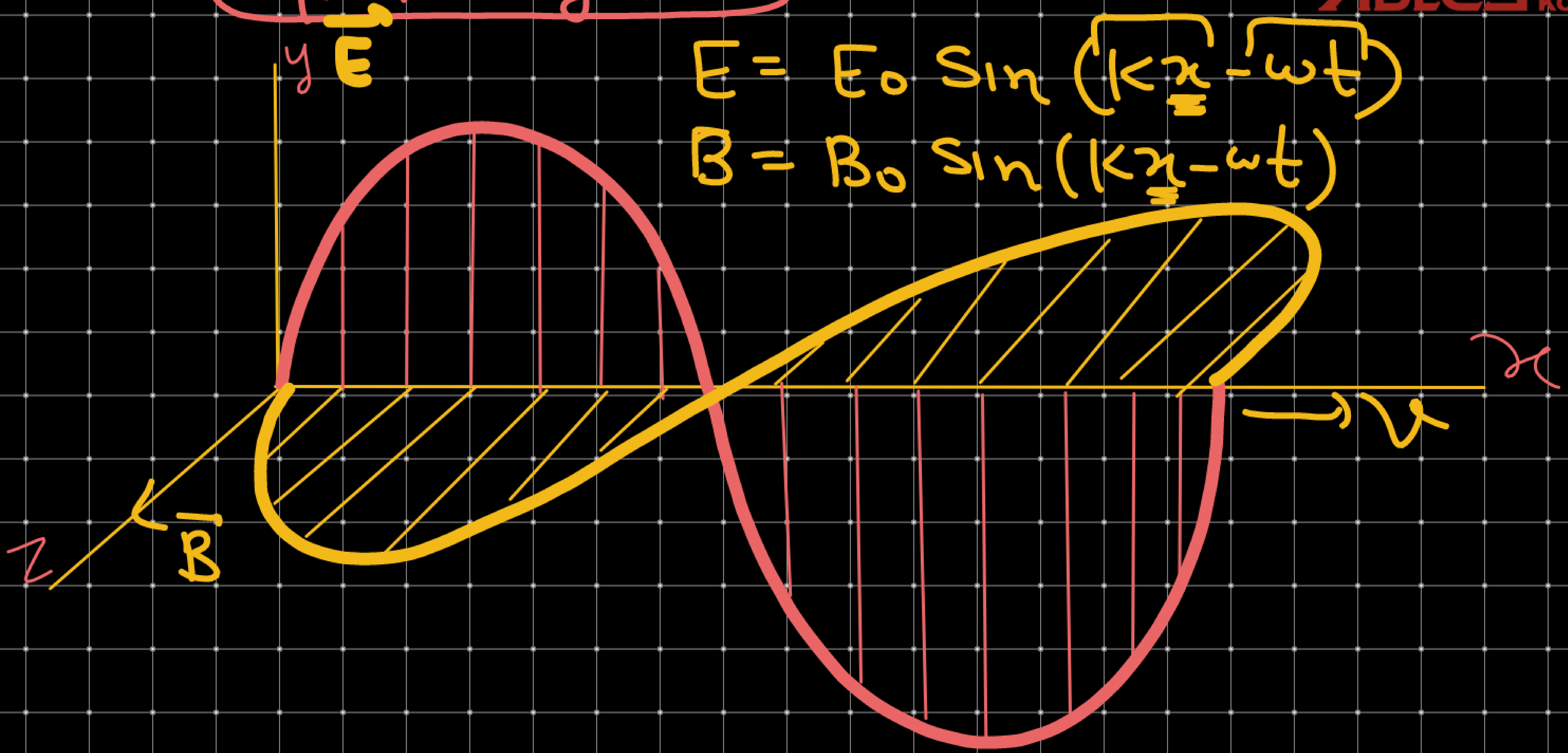
$$3 \times 10^8 = \frac{E_0}{20 \times 10^{-9}\ T}$$

$$E_0 = 6\ N/C$$

Equation of EMW

$E = E_0 \sin(kx - \omega t)$

$B = B_0 \sin(kx - \omega t)$



$$B = B_0 \sin(kx - \omega t)$$

$$E = E_0 \sin(kx - \omega t)$$

$$v = \frac{E_0}{B_0}$$

$\omega \rightarrow$ angular frequency.

$K \rightarrow$ Propagation constant

$\Rightarrow$ $B = B_0 \sin(Kx + \omega t)$

$E = E_0 \sin(Kx + \omega t)$

$-x \rightarrow$ Emw

$B = B_0 \sin(Kx - \omega t)$

$E = E_0 \sin(Kx - \omega t)$ $\longrightarrow$ $+x$ dir - dirⁿ of Emw

$E = E_0 \sin(Kz - \omega t)$

$B = B_0 \sin(Kz - \omega t)$ $\Rightarrow$ dirⁿ of Emw is $+z$ dirⁿ

⇒ <u>Equn of EMW</u>

$$\Rightarrow v = \frac{E_0}{B_0}$$

$$E = E_0 \sin(kx - \omega t)$$

$$B = B_0 \sin(kx - \omega t)$$

$\omega \rightarrow$ angular frequency → rad/sec

$K \rightarrow$ Propagation constant $= \frac{2\pi}{\lambda}$

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

$$v = \frac{\omega}{K} = \frac{\omega}{2\pi/\lambda} = \frac{2\pi}{T \times 2\pi/\lambda} = \frac{\lambda}{T}$$

$$v = \frac{\omega}{K}$$

$$v = \frac{c}{n} = \frac{c}{\sqrt{\mu_r \epsilon_r}}$$

$$v = \frac{\omega}{K} = \frac{E_0}{B_0}$$

$n = \frac{c}{v}$ $v = \frac{c}{n}$

Q1) In E.M.W. $E = 10\sin(2\pi \times 10^{+6} t - \pi \times 10^{-2} z)$ $n = \frac{3\times 10^{8}}{2\times 10^{8}} = 1.5$

find

(I) Dirⁿ of propagation of wave ↓ (+z dirⁿ)

(II) Time period.

(III) Speed of wave

$E = 10\sin(2\pi\times 10^{+6} t - \pi \times 10^{-2} z)$

$E = E_0 \sin(\omega t - kz)$

$\omega = 2\pi \times 10^{+6}$ rad/sec.

$K = \pi \times 10^{-2}$

$v = \frac{\omega}{K} = \frac{2\pi \times 10^{+6}}{\pi \times 10^{-2}}$

$T = \frac{2\pi}{\omega} = \frac{2\pi}{2\pi \times 10^{+6}} = 10^{-6}$ sec

$v = 2 \times 10^{8}$ m/s

$\Rightarrow n$? OR $\sqrt{\mu_r \epsilon_r} = n = 1.5$

⇒ Find value of $\mu_0 \varepsilon_0$. If speed of EMW in medium is 0.5×10^8 m/s. X

Sol)

$$C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

$$\sqrt{\mu_0 \varepsilon_0} = \frac{1}{C} \qquad \mu_0 \varepsilon_0 = \frac{1}{(3 \times 10^8)^2} = \frac{1}{9 \times 10^{16}}$$

$$\mu_0 \varepsilon_0 = \frac{1}{C^2} \qquad \mu_0 \varepsilon_0 = \frac{1}{9} \times 10^{-16} \; m^{-2} s^2$$

Equ^n of E.M.W.

$$E = E_0 \sin(\omega t - kx)$$

$$B = B_0 \sin(\omega t - kx)$$

$$E_{rms} = \frac{E_0}{\sqrt{2}}$$

$$B_{rms} = \frac{B_0}{\sqrt{2}}$$

$$v = \frac{\omega}{K}$$

$$T = \frac{2\pi}{\omega}$$

$$v = \frac{E_0}{B_0}$$

$$v = \frac{E_{rms}}{B_{rms}}$$