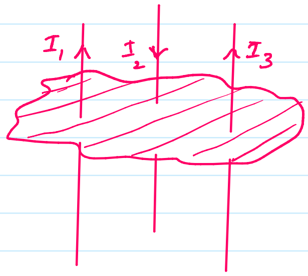
EM WAVES

Thursday, October 31, 2019 4:33 PM

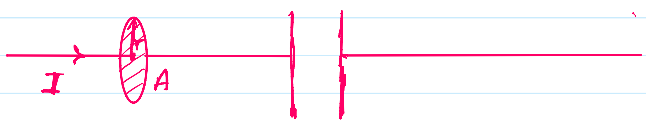
Ampere circuital law.

$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{net}$



$$\boxed{\oint \vec{B}\cdot d\vec{l} = \mu_0 (I_1 + I_3 - I_2)}$$

Ampere circuital applied to a capacitor being charged.



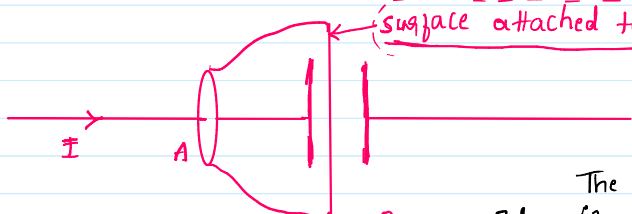
Applying ACL at point A.

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I$$

$$\oint B\,dl = \mu_0 I$$

$$B\,2\pi r = \mu_0 I$$

$$\boxed{B_A = \frac{\mu_0 I}{2\pi r}}$$



$$\oint \vec{B}\cdot d\vec{l} = \mu_0 \cancel{I_{net}}^{\,0}$$

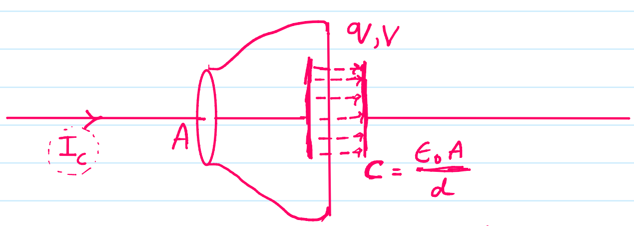
$$\Rightarrow \underline{B_A = 0}$$

The inconsistancy is at point A the MF turns out be zero if the surface attached to the Ampere loop is considered as shown in fig.

But At point A, MF $\neq 0$

Maxwells Ampere circuital law

To overcome inconsistancy in ACL maxwell introduces a current called displacement current which arises due varying Electrical field.



$$\boxed{I_d = \epsilon_0 \frac{d\phi_E}{dt}}$$

WKT $C = \frac{q}{V}$

$B = \frac{\mu_0 I_c}{2\pi r}$ } MF when the surface is in the same plane of the loop

WKT $c = \frac{q}{V}$

$\therefore q = CV$

differentiating wrt time

$$\frac{dq}{dt} = \frac{\epsilon_0 A}{d}\frac{dV}{dt}$$

But $V = Ed$

$$I_d = \frac{\epsilon_0 A}{\cancel{d}} \times \frac{d(E\cancel{d})}{dt}$$

$$= \epsilon_0 A \frac{dE}{dt}$$

$$= \epsilon_0 \frac{d}{dt}(EA)$$

$$\boxed{I_d = \epsilon_0 \frac{d\phi_E}{dt}}$$

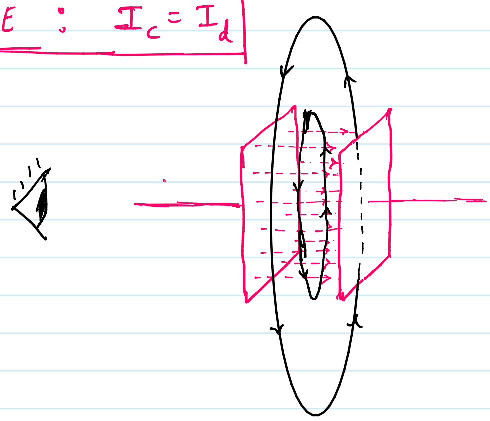
$B = \frac{\mu_0 I_c}{2\pi r}$ } MF when the surface is in the same plane of the loop

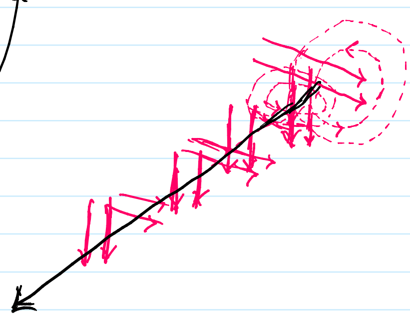
equal

$B = \frac{\mu_0 I_d}{2\pi r}$ } MF when the surface is not in the plane of the loop.

$\therefore$ The modified Ampere circuital law is given by $\boxed{\oint \vec{B}\cdot\vec{dl} = \mu_0 (I_c + I_d)}$

NOTE : $I_c = I_d$





Properties of EM waves

* Non mechanical
* Transverse in nature
* They travel at speed $= 3\times10^8$ m/s in vaccum.
* EF & MF are mutual $\perp^{r}$ to each other and also $\perp^{re}$ to direction of propagation.
* The speed in any medium is $\boxed{c = \frac{1}{\sqrt{\mu\epsilon}}}$
* The Electric Energy density of EF in Em wave is $\frac{1}{2}\epsilon_0 E^2$

$\sqrt{\mu\epsilon}$

* The Electric Energy density of EF in Em wave is $\frac{1}{2}\epsilon_0 E^2$
* The magnetic Energy density of MF in Em wave is $\frac{1}{2}\frac{B^2}{\mu_0}$

* The total Energy of EM wave is equally distributed b/w EF & MF

ie $\boxed{\frac{1}{2}\epsilon_0 E^2 = \frac{1}{2}\frac{B^2}{\mu_0}}$ $\Rightarrow \epsilon_0 E^2 = \frac{B^2}{\mu_0}$

$$\boxed{\frac{E}{B} = \frac{1}{\sqrt{\mu_0\epsilon_0}} = c}$$

* $$\boxed{\vec{c} = \frac{\vec{E}\times\vec{B}}{B^2}}$$

Source of EM wave

The source of EM wave is L-C oscillator which Produces fluctuating MF which inturn produces fluctuating EF at a frequency $\omega = \frac{1}{\sqrt{LC}}$.

NOTE : As the wave length decreases, the particle nature becomes predominant
As the —"— increases, the wave nature —"— —"—

Chang in momentum of light

① Non reflecting surface [perfectly absorbing surface]

$E = mc^2$

$\frac{E}{c} = mc = p$

$$\boxed{\Delta p = \frac{E}{c}}$$

② Reflecting surface

$$\boxed{\Delta p = \frac{2E}{c}}$$

Radiation pressure

$F = \frac{\Delta p}{\Delta t}$

* For non reflecting surface

$F = \frac{E/c}{\Delta t}$ ← Total energy of EM wave.

$= \frac{E}{\Delta t\, c} \times \frac{A}{A}$ Energy/Area × time = Intensity

$F = \frac{I}{c}A$

$\frac{F}{A} = \frac{I}{c}$

$$\frac{F}{A} = \frac{I}{c}$$

$$\boxed{\text{Pressure} = \frac{I}{c}}$$ → is the expression for Radiation pressure for non reflecting surface.

* For reflecting surface

$$\boxed{\text{Pressure} = \frac{2I}{c}}$$

Intensity of Electrical Energy & Magnetic Energy

WKT

$$\frac{\text{Electrical Energy}}{\text{Volume}} = \frac{1}{2}\epsilon_0 E^2$$

$$\frac{\text{Electrical Energy}}{\text{Volume}} \times \frac{l}{t} = \frac{1}{2}\epsilon_0 E^2 \frac{l}{t}$$

$$\frac{EE}{A \times \cancel{l}} \times \frac{\cancel{l}}{t} = \frac{1}{2}\epsilon_0 E^2 c$$

$$\boxed{I_E = \tfrac{1}{2}\epsilon_0 E^2 c}$$

IIIly

$$\boxed{I_B = \frac{1}{2}\frac{B^2}{\mu_0} c}$$