Learning
Mantras

LEARNING
MANTRAS

Handwritten Notes
On
Electromagnetic Wave

Electromagnetic Wave

E.M Wave:

Oersted: Current - carrying wire can produce m.f

Faraday: Time varying M.f can produce E.f

Claire Maxwell:

Since time varying M.f can produce electric field hence by sammetrise of nature time varying electric field should also produce magnetic field should also produce magnetic field collectively these are called electromagnetic field.
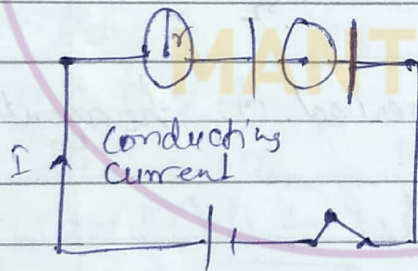
at P

$$\oint \vec{B}.\vec{dl} = \mu_0 I_{in}$$

$$B_1 2\pi r = \mu_0 I$$

$$B_1 = \frac{\mu_0 I}{2\pi r}$$

at P_2 $\quad \oint B_2 \, dl = \mu_0 I_{inc}$

$$B_2 2\pi r = 0$$

$$B_2 = 0$$

By Amperes law of magnetic field inside the plate is zero but actually it is not zero. Hence these must be some current Present b/w the plate known as displacement current

$$\int \vec{B_2} \cdot \vec{dl} = \mu_0 I_0$$

$$B_2 = \frac{\mu_0 I_0}{2\pi r}$$

Let change on plate i·e q at any time

electric field b/w the plate

$$E = \frac{\sigma}{\varepsilon_0} \quad , \quad E = \frac{q}{A\varepsilon}$$

$$EA = \frac{q}{\varepsilon_0}$$

$$\phi_E = EA = \frac{q}{\varepsilon_0}$$

$$\frac{d\phi_E}{dt} = \frac{Ad E}{dt} = \frac{1}{\varepsilon_0} \frac{dq}{dt}$$

$$\frac{dq}{dt} = \varepsilon_0 \frac{d\phi_E}{dt}$$

$$I_D = \frac{\varepsilon_0 \, d\phi_E}{dt}$$

modified Ampean law
$$\oint \vec{B} \cdot \vec{dl} = \mu_0 (I_c + I_D)$$

an Conductor $I_c \neq 0$ $I_D = 0$

Insulator $I_c = 0$ $I_D \neq 0$

Current produce in insulating medium due to time varying electric flux is called displacem current.

Maxwell's eq^n of E.M wave:

(I) $\oint \vec{E} \cdot d\vec{s} = \dfrac{q_{in}}{\varepsilon_0}$ → Gauss Law

(II) $\int \vec{B} \cdot d\vec{s} = 0$ for a closed surface   Gauss law of m.f
   → magnetic monopole never exist

(III) $\int \vec{E} \cdot d\vec{r} = -\dfrac{d\phi_B}{dt}$ → Faraday law of E.M.I

(iv) $\int \vec{B} \cdot d\vec{l} = \mu_0 (I_c + I_D)$
   $= \mu_0 (I_c + \varepsilon_0 \dfrac{d\phi_E}{dt})$

(v) $\vec{F} = q\vec{E} + \varepsilon(\vec{v} \times \vec{B})$ → Lorentz force

✗ Properties of E.M.P

(1) these are produce acclataing charge particle

(2) They travel in space with the speed of light.

③ In a medium there speed depends electric & magnetic Property of medium.

$$Vaccume = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \qquad c = \frac{\varepsilon_0}{B_0} = \frac{E_{max}}{B_{min}}$$

$$C_m = \frac{1}{\sqrt{\mu_0 \mu_r \varepsilon_0 \varepsilon_r}} \qquad c = \frac{E_{rms}}{B_{rms}}$$

④ These are Transvey in nature.

⑤ Electric magnetic field changes sinusodally with Porsion & time and have max & min value at some Place & same time.

⑥ electric & magnetic field au $\perp$ to each other and also $\perp$ to the direction of propagation of E·M waves

$$\vec{E} = E_0 \sin(kn - \omega t) \hat{j};$$

$$\vec{B} = B_0 \sin(kn - \omega t) \hat{k}$$

⑦ opticle properties of Emv au due to electric field vector hence it is also called light vector

⑧ They carry energy and momentum au applied force & pressur an a surfac called radiation pressure

* Intensity of E.m.v

Energy density

electric energy density $= \frac{1}{2}\varepsilon_0 E^2$

may —————— $= \frac{B^2}{2M_0}$

E.M wave

$U_E = \frac{1}{2}\varepsilon_0 E_{rms}^2$
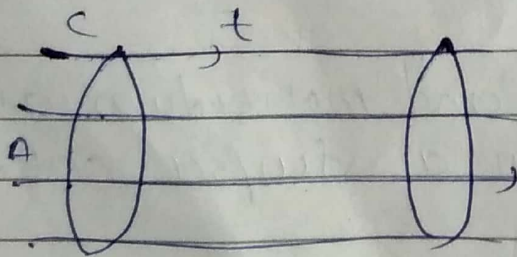
$U_B = \frac{1}{2}\frac{B_{rms}^2}{M_0}$

$U_E = U_B$

$U = \frac{1}{2}\varepsilon_0 E_{rms}^2 + \frac{B_{rms}^2}{2M_0}$

$U = \varepsilon_0 E_{rms}^2 = \frac{B_{rms}^2}{M_0}$

Total Energy density of E.M.

$= \varepsilon_0 E_{rms}^2 = \frac{1}{2}\varepsilon_0 E_0^2$

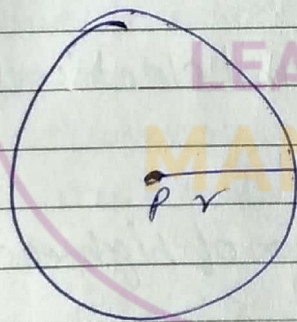$E_{rms} = \frac{E_0}{\sqrt{2}}$

Vol. of cylinder $= Act$

Total Energy $= \frac{1}{2} \varepsilon_0 \varepsilon_0^2 \, Act$

$\underline{Intensity} = \dfrac{Energy}{tA}$

$\underline{Intensity} = \frac{1}{2} \varepsilon_0 \varepsilon_0^2 \, c$

$\underline{Intensity} = \dfrac{B_0^2 \, c}{2 \mu_0}$

Q. A small bulb of power emits E.M.W find intensity and maximum value of electric & magnetic field at distance from the source.

$I = \dfrac{P}{4\pi r^2} = \frac{1}{2} \varepsilon_0 \varepsilon_0^2 c$

$c = \dfrac{\varepsilon_0}{B_0}$

Q. A sinusoidal EM w travell through empty space along x-axis electric field is along y-axis and its maximum value is 63 volt/m. frequency of wave = 1.5 Hz. find it wave length maximum value of magnetic field and E and H.F as a function of position and time.

frequency $= 1.5$ Hz $= 1.5 \times 10^9$ Hz.   max value $= 63$ v/m.

$c = f\lambda$ $c = \dfrac{E_0}{B_0}$

$K = \dfrac{2\pi}{\lambda}$ $\dfrac{3 \times 10^8}{1.5 \times 10^9} = \lambda$

$W = 2\pi f$ $\dfrac{3}{15} = \lambda$ $\lambda = \frac{1}{5}$

$\vec{E} = E_0 \sin(kx - \omega t)\, \hat{j}$

$\vec{B} = B_0 \sin(kx - \omega t)\, \hat{k}$

wave

$*$ Electromagnetic $\uparrow$ spectrum :

① Radiowave : $\lambda \simeq (10^3 - 1 \, m.)$

Generated by L-c oscillations

② Microwave : $\lambda \simeq (10 \, 1 - 10^{-4} \, m)$.
Generated by electronic devices.

③ Infra red : $\lambda \simeq (10^{-3} \, to \, 10^{-6})$
Produce by molecules at room-temp.

④ Visible Part : (Light wave) $\lambda \simeq (4000 \, A° - 7000 \, A°)$
Produce by de exitation of Atoms and molecules)

⑤ Ultraviolet : $\lambda \simeq (10^{-6} - 10^{-9})$
Produced by excited atoms and electric discharge.

⑥ x - Rays : $\lambda \simeq (10^{-8} \, to \, 10^{-11})$
Produced by de acceleration of high energetic e's by
a metal target.

⑦ ɣ-Rays : $\lambda \simeq (10^{-10} \, to \, 10^{-11})$ Produce in Radioactive
nuclei and nuclear Reaction's

RMP
↓ ↓
XY coy