# ELECTROMAGNETIC WAVES
# CHAPTER - 40

1. $\frac{\epsilon_0 \, d\phi_E}{dt} = \frac{\epsilon_0 \, EA}{dt \, 4\pi \, \varepsilon_0 r^2}$

$= \frac{M^{-1}L^{-3}T^4A^2}{M^{-1}L^{-3}A^2} \times \frac{A^1T^1}{L^2} \times \frac{L^2}{T} = A^1$

= (Current) (proved).

2. $E = \frac{Kq}{x^2}$, [from coulomb's law]

$\phi_E = EA = \frac{KqA}{x^2}$

$I_d = \epsilon_0 \frac{d\phi E}{dt} = \epsilon_0 \frac{d}{dt}\frac{kqA}{x^2} = \epsilon_0 \, KqA = \frac{d}{dt}x^{-2}$

$= \epsilon_0 \times \frac{1}{4\pi \, \epsilon_0} \times q \times A \times -2 \times x^{-3} \times \frac{dx}{dt} = \frac{qAv}{2\pi x^3}$.

3. $E = \frac{Q}{\epsilon_0 \, A}$ (Electric field)

$\phi = E.A. = \frac{Q}{\epsilon_0 \, A}\frac{A}{2} = \frac{Q}{\epsilon_0 \, 2}$

$i_0 = \epsilon_0 \frac{d\phi_E}{dt} = \epsilon_0 \frac{d}{dt}\left(\frac{Q}{\epsilon_0 \, 2}\right) = \frac{1}{2}\left(\frac{dQ}{dt}\right)$

$= \frac{1}{2}\frac{d}{dt}(EC\,e^{-t/RC}) = \frac{1}{2}EC - \frac{1}{RC}e^{-t/RC} = \frac{-E}{2R}e^{\frac{-td}{RE_0\lambda}}$

4. $E = \frac{Q}{\epsilon_0 \, A}$ (Electric field)

$\phi = E.A. = \frac{Q}{\epsilon_0 \, A}\frac{A}{2} = \frac{Q}{\epsilon_0 \, 2}$

$i_0 = \epsilon_0 \frac{d\phi_E}{dt} = \epsilon_0 \frac{d}{dt}\left(\frac{Q}{\epsilon_0 \, 2}\right) = \frac{1}{2}\left(\frac{dQ}{dt}\right)$

5. $B = \mu_0 H$

$\Rightarrow H = \frac{B}{\mu_0}$

$\frac{E_0}{H_0} = \frac{B_0/(\mu_0 \, \epsilon_0 \, C)}{B_0/\mu_0} = \frac{1}{\epsilon_0 \, C}$

$= \frac{1}{8.85 \times 10^{-12} \times 3 \times 10^8} = 376.6 \, \Omega = 377 \, \Omega$.

Dimension $\frac{1}{\epsilon_0 \, C} = \frac{1}{[LT^{-1}][M^{-1}L^{-3}T^4A^2]} = \frac{1}{M^{-1}L^{-2}T^3A^2} = M^1L^2T^{-3}A^{-2} = [R]$.

6. $E_0 = 810$ V/m, $B_0 = ?$

We know, $B_0 = \mu_0 \, \epsilon_0 \, C \, E_0$

Putting the values,

$B_0 = 4\pi \times 10^{-7} \times 8.85 \times 10^{-12} \times 3 \times 10^8 \times 810$

$= 27010.9 \times 10^{-10} = 2.7 \times 10^{-6}$ T = 2.7 $\mu$T.

7. B = (200 $\mu$T) Sin [(4 × $10^{15}$ $5^{-1}$) (t – x/C)]

   a) $B_0$ = 200 $\mu$T

   $E_0 = C \times B_0 = 200 \times 10^{-6} \times 3 \times 10^8 = 6 \times 10^4$

   b) Average energy density = $\frac{1}{2\mu_0}B_0^2 = \frac{(200\times10^{-6})^2}{2\times4\pi\times10^{-7}} = \frac{4\times10^{-8}}{8\pi\times10^{-7}} = \frac{1}{20\pi}$ = 0.0159 = 0.016.

8. $I = 2.5 \times 10^{14}$ W/m$^2$

   We know, $I = \frac{1}{2}\epsilon_0 E_0^2 C$

   $\Rightarrow E_0^2 = \frac{2I}{\epsilon_0 C}$ or $E_0 = \sqrt{\frac{2I}{\epsilon_0 C}}$

   $E_0 = \sqrt{\frac{2\times2.5\times10^{14}}{8.85\times10^{-12}\times3\times10^8}}$ = 0.4339 × $10^9$ = 4.33 × $10^8$ N/c.

   $B_0 = \mu_0 \epsilon_0 C E_0$

   = 4 × 3.14 × $10^{-7}$ × 8.854 × $10^{-12}$ × 3 × $10^8$ × 4.33 × $10^8$ = 1.44 T.

9. Intensity of wave = $\frac{1}{2}\epsilon_0 E_0^2 C$

   $\epsilon_0 = 8.85 \times 10^{-12}$ ; $E_0$ = ? ; C = 3 × $10^8$ , $I$ = 1380 W/m$^2$

   1380 = 1/2 × 8.85 × $10^{-12}$ × $E_0^2$ × 3 × $10^8$

   $\Rightarrow E_0^2 = \frac{2\times1380}{8.85\times3\times10^{-4}}$ = 103.95 × $10^4$

   $\Rightarrow E_0$ = 10.195 × $10^2$ = 1.02 × $10^3$

   $E_0 = B_0C$

   $\Rightarrow B_0 = E_0/C = \frac{1.02\times10^3}{3\times10^8}$ = 3.398 × $10^{-5}$ = 3.4 × $10^{-5}$ T.

♠ ♠ ♠