Electromagnetic Waves

SOLUTIONS

Exercise-I (Conceptual Questions)

3. $\Psi(x, t) = 10^3 \sin\pi(3 \times 10^6 x - 9 \times 10^{14} t)$

$\Psi(x, t) = 10^3 \sin(3\pi \times 10^6 x - 9\pi \times 10^{14} t)$

speed $v = \frac{\omega}{k} = \frac{9\pi\times10^{14}}{3\pi\times10^{6}} = 3 \times 10^8$ m/s

4. $\lambda = \frac{2\pi}{k}; \lambda = \frac{2\pi}{3\pi\times10^6} = \frac{2}{3}\times10^{-6} = 666$ nm

Exercise-II (Previous Year Questions)

3. To generate electromagnetic waves we need accelerating charge particle.

4. $(i_d)_{max} = (i_c)_{max} = i_0 = \frac{E_0}{Z} = \frac{220\sqrt{2}}{\sqrt{100^2+100^2}} = 2.2A$

As we are asked amplitude of displacement current. So, need not worry about charge on capacitor.

5. $E_0 = cB_0$

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

$\Rightarrow E_{rms}\sqrt{2} = cB_0$

$\Rightarrow B_0 = \frac{E_{rms}\sqrt{2}}{c} = \frac{6\times\sqrt{2}}{3\times10^8} = 2.83 \times 10^{-8}$ T

6. $\hat{V} = \hat{E}\times\hat{B}, \quad \hat{i} = \hat{j}\times\hat{k}$

$\therefore \hat{B} = \hat{k}$, +z direction

7. $v = \frac{1}{\sqrt{\mu\in}} = \frac{1}{\sqrt{\mu_r \in_r \mu_0 \in_0}} = \frac{c}{\sqrt{\mu_r\in_r}}$

$= \frac{3\times10^8}{\sqrt{1.44}} = \frac{30}{12}\times10^8 = 2.5\times10^8\,ms^{-1}$

8. $I = \frac{E}{At} \Rightarrow E = IAt = \frac{20}{10^{-4}}\times20\times10^{-4}\times60$

$= 24 \times 10^3$ J

9. In EMW, electric field and magnetic field have same energy density and same intensities.

10. Gamma rays have shortest wavelength among all options.

11. $\lambda = \frac{2\pi}{K} = \frac{2\pi}{\pi\times10^3} = 2\times10^{-2}$m

12. $q = CV$

$\frac{dq}{dt} = C\frac{dv}{dt}$

$I_d = C(V_0\,\omega\cos\omega t)$

$= V_0\omega C\cos\omega t$

13. $\vec{v}$ is parallel to $\vec{E}\times\vec{B}, \hat{v} = \hat{i}$ [as $\hat{v} = \hat{i}$]

Option (1) $\vec{E}\times\vec{B} = \vec{0}$ $(\vec{E}\,||\,\vec{B})$

Option (2) $\vec{E}\times\vec{B} = 2\hat{i}$ (parallel to $\vec{v}$)

Option (3) $\vec{E}\times\vec{B} = \vec{0}$ $(\vec{E} \upharpoonleft\!\downharpoonright \vec{B})$

Option (4) $\vec{E}\times\vec{B} = \vec{0}$ $(\vec{E}\,||\,\vec{B})$

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

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

$= \frac{48}{3\times10^8}$

$= 1.6 \times 10^{-7}$ T

19. $\mu = \frac{C}{v} = \frac{\frac{1}{\sqrt{\mu_0\in_0}}}{\frac{1}{\sqrt{1.5\mu_0\times2\in_0}}} = \sqrt{3}$

20. $Q = CV$

$\frac{dQ}{dt} = C.\frac{dV}{dt} \Rightarrow \frac{dV}{dt} = \frac{I}{C} = \frac{2\times10^{-3}}{4\times10^{-6}}$

$= \frac{10^3}{2} = 500\frac{V}{s}$

21. Displacement current is equal to conduction correct and flows in same direction.

22. EMW is emitted from charge performing nonuniform motion

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23. Gamma rays has smallest wavelength.

24. $\frac{E}{H}=\left(\frac{E}{\mu.H}\right)\mu = vu$

$= \frac{1\mu}{\sqrt{\mu\varepsilon}}$

$= \sqrt{\frac{\mu_r\mu_0}{\varepsilon_0\varepsilon_r}} = 120\pi \times \frac{1}{2}$

$= 60\ \pi : 1$

Exercise-III (Analytical Questions)

2. $\vec{E} = 30 \sin(6 \times 10^8 t + kz)\,\hat{i}$

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

Direction of propagation = –z axis

wave length $\lambda = \pi = 3.14$ m

Direction of M. field direction of $\vec{v}$ = direction of $\vec{E}\times\vec{B}$

$-\hat{k} = \hat{i}\times\hat{B}$

$\hat{B} = -\hat{j}$

$a \to s$, $b \to r$, $c \to p$, $d \to q$

3. Energy of x ray is higher than radio waves.