Wave-9

***Option in bold letters is the answer**

Q1. Light is an electromagnetic wave. Its speed in vacuum is given by the expression

(a) $\sqrt{\mu_0\varepsilon_0}$ (b) $\sqrt{\frac{\mu_0}{\varepsilon_0}}$ (c) $\sqrt{\frac{\varepsilon_0}{\mu_0}}$ **(d)** $\boldsymbol{\frac{1}{\sqrt{\mu_0\varepsilon_0}}}$

Q2. If $\vec{E}$ and $\vec{B}$ are the electric and magnetic field vectors of E.M. waves then the direction of propagation of E.M. wave is along the direction of

(a) $\vec{E}$ (b) $\vec{B}$ **(c)** $\boldsymbol{\vec{E}\times\vec{B}}$ (d) None of these

Q3. In an apparatus, the electric field was found to oscillate with an amplitude of 18 V/m. The magnitude of the oscillating magnetic field will be

(a) $4\times10^{-6}\,T$ **(b)** $\boldsymbol{6\times10^{-8}\,T}$ (c) $9\times10^{-9}\,T$ (d) $11\times10^{-11}\,T$

Sol. (b)

$$c=\frac{E}{B}\ \Rightarrow\ B=\frac{E}{c}=\frac{18}{3\times10^{8}}=6\times10^{-8}\,T$$

Q4. In an electromagnetic wave, the electric and magnetising field are $\boldsymbol{100\,Vm^{-1}}$ and $\boldsymbol{0.265\,Am^{-1}}$. The maximum energy flow is

(a) $\boldsymbol{26.5\ W/m^2}$ (b) 36.5 W/m^2 (c) 46.7 W/m^2 (d) None of these

Sol. (a) Here

$$E_0=100\ V/m\,,H_0=\frac{B_0}{\mu_0}=0.265\,A/m.$$

∴ Maximum rate of energy flow

$$S=\frac{E_0\times B_0}{\mu_0}\Rightarrow S=\frac{E_0B_0 sin90°}{\mu_0}=E_0\times\frac{B_0}{\mu_0}\times sin90°$$

$$=100\times0.265\times1=\boldsymbol{26.5\ W/m^2}$$

Q5. The oscillating electric and magnetic vectors of an electromagnetic wave are oriented along

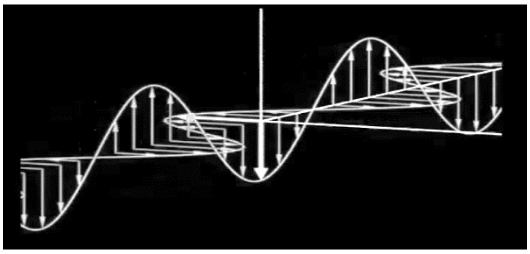
(a) The same direction but differ in phase by 90°

(b) The same direction and are in phase

(c) **Mutually perpendicular directions and are in phase**

(d) Mutually perpendicular directions and differ in phase by 90°

Sol. **(c)** $\vec{E}$ and $\vec{B}$ are mutually perpendicular to each other and are in phase i.e. they become zero and minimum at the same place and at the same time.

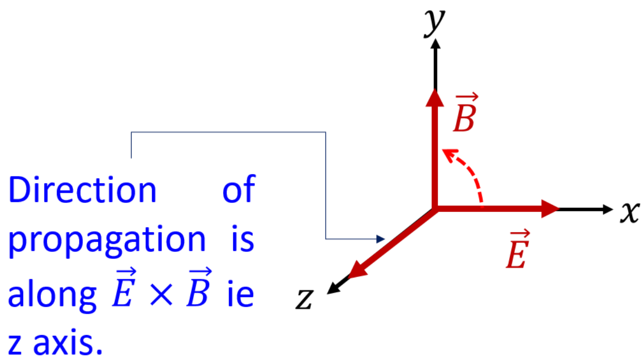


Q6. An electromagnetic wave travels along z-axis. Which of the following pairs of space and time varying fields would generate such a wave

(a) $\boldsymbol{E_x, B_y}$ (b) E_y, B_x (c) E_z, B_x (d) E_y, B_z

Sol. **(a)**. As $\hat{\boldsymbol{\imath}} \times \hat{\boldsymbol{\jmath}} = \hat{\boldsymbol{k}}$

$\Rightarrow \; E_x\,\hat{\imath} \times B_y\,\hat{\jmath} = C\,\vec{k}$ i.e. E is along x-axis and B is along y-axis. $\boldsymbol{E_x}$ and $\boldsymbol{B_y}$ would generate a plane EM wave travelling in z-direction



Q7. A plane electromagnetic wave is incident on a material surface. If the wave delivers momentum p and energy E, then

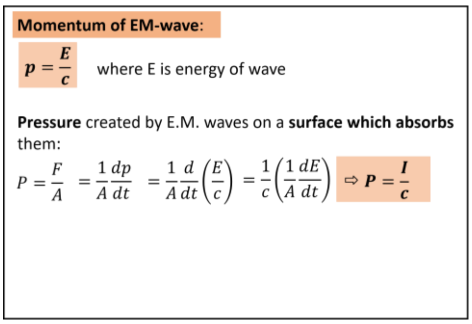
(a) p = 0, E = 0 **(b) p # 0, E # 0** (c) p # 0, E = 0 (d) p = 0, E # 0

Sol. **(b)** EM wave carry momentum and hence can exert pressure on surfaces. They also transfer energy to the surface so p # 0 and E # 0.

Q8. The pressure exerted by an electromagnetic wave of intensity I(watt/m^2) on a nonreflecting surface is [c is the velocity of light]

(a) Ic (b) Ic^2 **(c) I/c** (d) I/c^2

Sol.



Momentum of EM-wave:

$\boldsymbol{p = \frac{E}{c}}$ where E is energy of wave

Pressure created by E.M. waves on a **surface which absorbs** them:

$P = \frac{F}{A} = \frac{1}{A}\frac{dp}{dt} = \frac{1}{A}\frac{d}{dt}\left(\frac{E}{c}\right) = \frac{1}{c}\left(\frac{1}{A}\frac{dE}{dt}\right) \Rightarrow \boldsymbol{P = \frac{I}{c}}$

Q9. Radiations of intensity $0.5\ W/m^2$ are striking a metal plate. The pressure on the plate is

(a) $\mathbf{0.166 \times 10^{-8}\ N/m^2}$ (b) $0.332 \times 10^{-8}\ N/m^2$

(c) $0.111 \times 10^{-8}\ N/m^2$ (d) $0.083 \times 10^{-8}\ N/m^2$

Sol.

$$P = \frac{I}{c} \Rightarrow P = \frac{0.5\ W/m^2}{3 \times 10^8 m/s} = \mathbf{0.166 \times 10^{-8}\ N/m^2}$$

Q10. Maxwell's equations describe the fundamental laws of

(a) Electricity only (b) Magnetism only (c) Mechanics only **(d) Both (a) and (b)**