A plane electromagnetic wave is propagating along the direction $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$, with its polarization along the direction $\hat{k}$. The correct form of the magnetic field of the wave would be (here B_0 is an appropriate constant):

[9 Jan 2020, II]

(a) $B_0 \frac{\hat{i}-\hat{j}}{\sqrt{2}} \cos\left(\omega t - k\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(b) $B_0 \frac{\hat{j}-\hat{i}}{\sqrt{2}} \cos\left(\omega t + k\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(c) $B_0 \hat{k} \cos\left(\omega t - k\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(d) $B_0 \frac{\hat{i}+\hat{j}}{\sqrt{2}} \cos\left(\omega t - k\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(a) Direction of polarisation = $\hat{E} = \hat{k}$

Direction of propagation = $\hat{E} \times \hat{B} = \frac{\hat{i}+\hat{j}}{\sqrt{2}}$

But $\vec{E}.\vec{B} = 0 \therefore \hat{B} = \frac{\hat{i}-j}{\sqrt{2}}$

A plane electromagnetic wave of frequency 25 GHz is propagating in vacuum along the z-direction. At a particular point in space and time, the magnetic field is given by $\vec{B} = 5\times10^{-8}\,\hat{j}\,T$. The corresponding electric field $\vec{E}$ is (speed of light $c = 3\times10^{8}\ \text{ms}^{-1}$)

[8 Jan 2020, II]

(a) $1.66\times10^{-16}\,\hat{i}$ V/m (b) $-1.66\times10^{-16}\,\hat{i}$ V/m

(c) $-15\,\hat{i}$ V/m (d) $15\,\hat{i}$ V/m

(d) Amplitude of electric field (E) and Magnetic field (B) of an electromagnetic wave are related by the relation

$$\frac{E}{B} = c$$

$$\Rightarrow E = Bc$$

$$\Rightarrow E = 5\times10^{-8}\times3\times10^{8} = 15\ N/C$$

$$\Rightarrow \vec{E} = 15\hat{i}\ V/m$$

A plane electromagnetic wave having a frequency $\nu = 23.9$ GHz propagates along the positive z-direction in free space. The peak value of the Electric Field is 60 V/m. Which among the following is the acceptable magnetic field component in the electromagnetic wave ?

[12 April 2019, II]

(a) $\vec{B} = 2 \times 10^{7} \sin(0.5 \times 10^{3} z + 1.5 \times 10^{11} t)\hat{i}$

(b) $\vec{B} = 2 \times 10^{-7} \sin(0.5 \times 10^{3} z - 1.5 \times 10^{11} t)\hat{i}$

(c) $\vec{B} = 60 \sin(0.5 \times 10^{3} x + 1.5 \times 10^{11} t)\hat{k}$

(d) $\vec{B} = 2 \times 10^{-7} \sin(1.5 \times 10^{2} x + 0.5 \times 10^{11} t)\hat{j}$

(b) $B_0 = \dfrac{E_0}{C} = \dfrac{60}{3 \times 10^8}$

$= 20 \times 10^{-8}\,\text{T} = 2 \times 10^{-7}\,\text{T}$

$$K = \frac{\omega}{v} = \frac{2\pi f}{v} = \frac{2\pi \times 23.9 \times 10^9}{3 \times 10^8} = 500$$

Therefore, $\vec{B} = B_0 \sin(kz - \omega t)$

$= 2 \times 10^{-7} \sin(0.5 \times 10^{3} z - 1.5 \times 10^{11} t) i$

The electric fields of two plane electromagnetic plane waves in vacuum are given by

$\vec{E}_1 = E_0\hat{j}\cos(\omega t - kx)$ and $\vec{E}_2 = E_0\hat{k}\cos(\omega t - ky)$.

At $t = 0$, a particle of charge q is at origin with a velocity $\vec{v} = 0.8c\hat{j}$ (c is the speed of light in vacuum). The instantaneous force experienced by the particle is:

[9 Jan 2020, I]

(a) $E_0q(0.8\hat{i} - \hat{j} + 0.4\hat{k})$ (b) $E_0q(0.4\hat{i} - 3\hat{j} + 0.8\hat{k})$

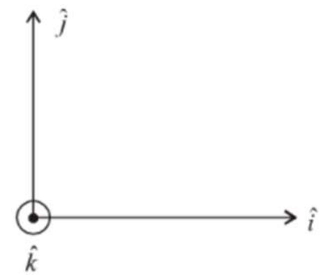
(c) $E_0q(-0.8\hat{i} + \hat{j} + \hat{k})$ (d) $E_0q(0.8\hat{i} + \hat{j} + 0.2\hat{k})$

(d) Given: $\vec{E}_1 = E_0\hat{j}\cos(\omega t - kx)$

i.e., Travelling in $+ve$ x-direction $\vec{E} \times \vec{B}$ should be in x-direction

$\therefore$ $\vec{B}$ is in $\hat{K}$

$\therefore$ $\vec{B}_1 = \frac{E_0}{C}\cos(\omega t - kx)\hat{k}$ $\left(\because B_0 = \frac{E_0}{C}\right)$



κ

$\vec{E}_2 = E_0\hat{k}\cos(\omega t - ky)$

$\vec{B}_2 = \frac{E_0}{C}\hat{i}\cos(\omega t - ky)$

$\therefore$ Travelling in $+ve$ y-axis

$\vec{E} \times \vec{B}$ should be in y-axis

$\therefore$ Net force $\vec{F} = q\vec{E} + q(\vec{v} \times \vec{B})$

$q(\vec{E}_1 + \vec{E}_2) + q(0.8c\hat{j} \times (\vec{B}_1 + \vec{B}_2))$

If $t = 0$ and $x = y = 0$

$\vec{E}_1 = E_0\hat{j}$ $\vec{E}_2 = E_0\hat{k}$

$\vec{B}_1 = \frac{E_0}{c}\hat{k}$ $\vec{B}_2 = \frac{E_0}{c}\hat{i}$

$\therefore \vec{F}_{net} = qE_0(\hat{j} + \hat{k}) + q \times 0.8c \times \frac{E_0}{C}\hat{j} \times (\hat{k} + \hat{i})$

$= qE_0(\hat{j} + \hat{k}) + 0.8qE_0(\hat{i} - \hat{k})$

$= qE_0(0.8\hat{i} + \hat{j} + 0.2\hat{k})$