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

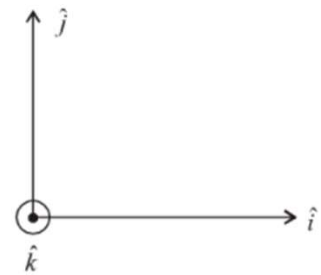
(c) $E_0q(-0.8\hat{i} + \hat{j} + \hat{k})$ (d) $E_0q(0.8\hat{i} + \hat{j} + 0.2\hat{k})$

(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 $\hat{K}$

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



κ

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

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

$\therefore$ 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 $x = y = 0$

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

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

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

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

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

The electric field of a plane electromagnetic wave is given by

$$\vec{E} = E_0 \frac{\hat{i} + \hat{j}}{\sqrt{2}} \cos(kz + \omega t)$$

At $t = 0$, a positively charged particle is at the point $(x, y, z) = \left(0, 0, \frac{\pi}{k}\right)$. If its instantaneous velocity at $(t = 0)$ is $v_0 \hat{k}$, the force acting on it due to the wave is:

[7 Jan 2020, II]

(a) parallel to $\frac{\hat{i} + \hat{j}}{\sqrt{2}}$ (b) zero

(c) antiparallel to $\frac{\hat{i} + \hat{j}}{\sqrt{2}}$ (d) parallel to $\hat{k}$

(c) At $t = 0, z = \frac{\pi}{k}$

$$\therefore \quad \vec{E} = \frac{E_0}{\sqrt{2}}(\hat{i} + \hat{j})\cos[\pi] = -\frac{E_0}{\sqrt{2}}(\hat{i} + \hat{j})$$

$$\vec{F}_E = q\vec{E}$$

Force due to electric field will be in the direction $\frac{-(\hat{i} + \hat{j})}{\sqrt{2}}$

Force due to magnetic field is in direction $q(\vec{v} \times \vec{B})$ and $\vec{v} \parallel \vec{k}$. Therefore, it is parallel to $\vec{E}$.

$\Rightarrow \quad \vec{F}_{\text{net}} = \vec{F}_E + \vec{F}_B$ is antiparallel to $\frac{\hat{i} + \hat{j}}{\sqrt{2}}$

An electromagnetic wave is represented by the electric field $\vec{E} = E_0 \hat{n} \sin[\omega t + (6y - 8z)]$. Taking unit vectors in x, y and z directions to be $\hat{i}, \hat{j}, \hat{k}$, the direction of propogation $\hat{s}$ is : **[12 April 2019, I]**

(a) $\hat{s} = \frac{3\hat{i} - 4\hat{j}}{5}$

(b) $\hat{s} = \frac{-4\hat{k} + 3\hat{j}}{5}$

(c) $\hat{s} = \left(\frac{-3\hat{j} + 4\hat{k}}{5}\right)$

(d) $\hat{s} = \frac{3\hat{j} - 3\hat{k}}{5}$

(c) $\hat{S} = \frac{6\hat{j} + 8\hat{k}}{\sqrt{6^2 + 8^2}} = \frac{-3\hat{j} + 4\hat{k}}{5}$

The magnetic field of a plane electromagnetic wave is given by:

$$\vec{B} = B_0\,\hat{i}\left[\cos(kz - \omega t)\right] + B_1\,\hat{j}\cos(kz + \omega t)$$

Where $B_0 = 3 \times 10^{-5}$ T and $B_1 = 2 \times 10^{-6}$ T.

The rms value of the force experienced by a stationary charge $Q = 10^{-4}$ C at $z = 0$ is closest to: **[9 April 2019 I]**

(a) 0.6 N (b) 0.1 N

(c) 0.9 N (d) 3×10^{-2} N

(a) $B_0 = \sqrt{B_0^2 + B_1^2} = \sqrt{30^2 + 2^2} \times 10^{-6}$

$= 30 \times 10^{-6}$ T

$\therefore E_0 = CB = 3 \times 10^8 \times 30 \times 10^{-6}$

$= 9 \times 10^3$ V/m

$$\frac{E_0}{V_2} = \frac{9}{\sqrt{2}} \times 10^3\, V/m$$

Force on the charge,

$$F = EQ = \frac{9}{\sqrt{2}} \times 10^3 \times 10^{-4} \simeq 0.64N$$

A plane electromagnetic wave of frequency 50 MHz travels in free space along the positive x-direction. At a particular point in space and time, $\vec{E} = 6.3\,\hat{j}\ V/m$. The corresponding magnetic field $\vec{B}$, at that point will be:

[9 April 2019 I]

(a) $18.9 \times 10^{-8}\ \hat{k}T$ (b) $2.1 \times 10^{-8}\ \hat{k}T$

(c) $6.3 \times 10^{-8}\ \hat{k}T$ (d) $18.9 \times 10^{8}\ \hat{k}T$

(b) As we know,

$$|\vec{B}| = \frac{|\vec{E}|}{C} = \frac{6.3}{3 \times 10^8} = 2.1 \times 10^{-8}\,T$$

and $\hat{E} \times \hat{B} = \hat{C}$

$\hat{j} \times \hat{B} = \hat{i}$ [$\because$ EM wave travels along +(ve) x-direction.]

$\therefore\ \hat{B} = \hat{k}$ or $\vec{B} = 2.1 \times 10^{-8}\,\hat{k}T$