Q-1 - 13156889

A parallel plate capacitor with plate area A and separation between the plates d, is charged by a constant current i. Consider a plane surface of area $A/4$ parallel to the plates and drawn symmetrically between the plates. Find the displacement current through this area.

SOLUTION:

Let at some instant change on capacitor be Q. Electric field between plates of capacitor

$$E = \frac{Q}{A \in_0}$$

Flux passing through area $A/4$

$$\phi_E = E.\frac{A}{4} = \frac{Q}{A \in_0}$$

$$.\frac{A}{4} = \frac{Q}{4 \in_0}$$

The displacement current

$$i_d = \in_0 \frac{d\phi_E}{dt} =$$

$$\in_0 \frac{1}{4}\frac{dQ}{dt} = \frac{1}{4}i$$

Q-2 - 14160386

if $E = E_0 \sin(kz - \omega t)$ and $B = B_0(kz - \omega t)$ are electric and magnetic field produced by an electromagnetic wave travelling in +z direction in a medium. Then if $\eta = \frac{E_0}{B_0}$, then the value of η is $[\mu$ =permeability of a medium $\varepsilon =$ permittivity of medium]

(A) $\sqrt{\in / H}$

(B) $\sqrt{\mu / en}$

(C) $\sqrt{\mu \in}$

(D) $\frac{1}{\sqrt{\mu \in}}$

CORRECT ANSWER: B

SOLUTION:

Dimensional analysis.

Q-3 - 16267357

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

(A) E_x, B_y

(B) E_y, B_x

(C) E_z, B_x

(D) E_y, B_z

CORRECT ANSWER: A

Q-4 - 11971440

The electric field part of an electromagnetic wave in a medium is represented by

$E_x = 0,$

E_y

$= 2.5 \frac{N}{C} \cos\left[\left(2\pi \times 10^6 \frac{rad}{m}\right)t - \left(\pi \times 10^{-2} \frac{rad}{s}\right)x\right]$

$E_z = 0$.

The wave is

(A) moving along y-direction with frequency $2\pi \times 10^6 Hz$ and wavelength $200m$.

(B) moving along x-direction with frequency $10^6 Hz$ and wavelength $100m$

(C) moving along x-direction with frequency $10^6 Hz$ and wavelength $100m$

(D) moving along x-direction with frequency $10^6 Hz$ and wavelength $200m$

CORRECT ANSWER: C

SOLUTION:

The standard equation of electromagnetic wave

$$E_y = E_0 \cos(\omega t - kx)$$

The given equation

$$E_y = 2.5\frac{N}{C}\cos\left[\left(2\pi \times 10^6\frac{rad}{m}\right)t - \left(\pi \times 10^{-2}\frac{rad}{\sec}\right)x\right]$$

Comparing with standard equation

we get

$$\omega = 2\pi f = 2\pi \times 10^6$$

$$\Rightarrow \lambda f = 10^6 Hz$$

Moreover, we know that

$$\frac{2\pi}{\lambda} = k = \pi \times 10^{-2}m^{-1} \Rightarrow f = \lambda = 200m$$

Hence, the wave is moving along positive x-direction with ftequency $10^6 Hz$ and wavelength $200m$.

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Q-5 - 11971276

Electromagnetic waves travel in a medium which has relative permeability 1.3 and relative permittivity 2.14. Then the speed of the electromagnetic wave in the medium will be

(A) $1.36 \times 10^6 m / s$

(B) $1.8 \times 10^2 m / s$

(C) $3.6 \times 10^8 m / s$

(D) $1.8 \times 10^8 m / s$

CORRECT ANSWER: D

SOLUTION:

$$v = \frac{c}{\sqrt{\mu_e \varepsilon_r}}$$

$$= \frac{3 \times 10^8}{\sqrt{1.3 \times 2.14}} = 1.8 \times 10^8 m/\sec$$

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Q-6 - 12230385

Light waves of 5895 wavelength travels from vaccum to medium of refractive index of1.5.Velocity of light and wavelength In medium will be

$(1) 2 \times 10^8 m/\sec, 3330, (2) 3 \times 10^8 m/\sec, 3930$

$2 \times 10^8 m/\sec, 3390$,(4) None

SOLUTION:

(2) if velocity of light in vaccum is $c$then velocity of light

in medium is

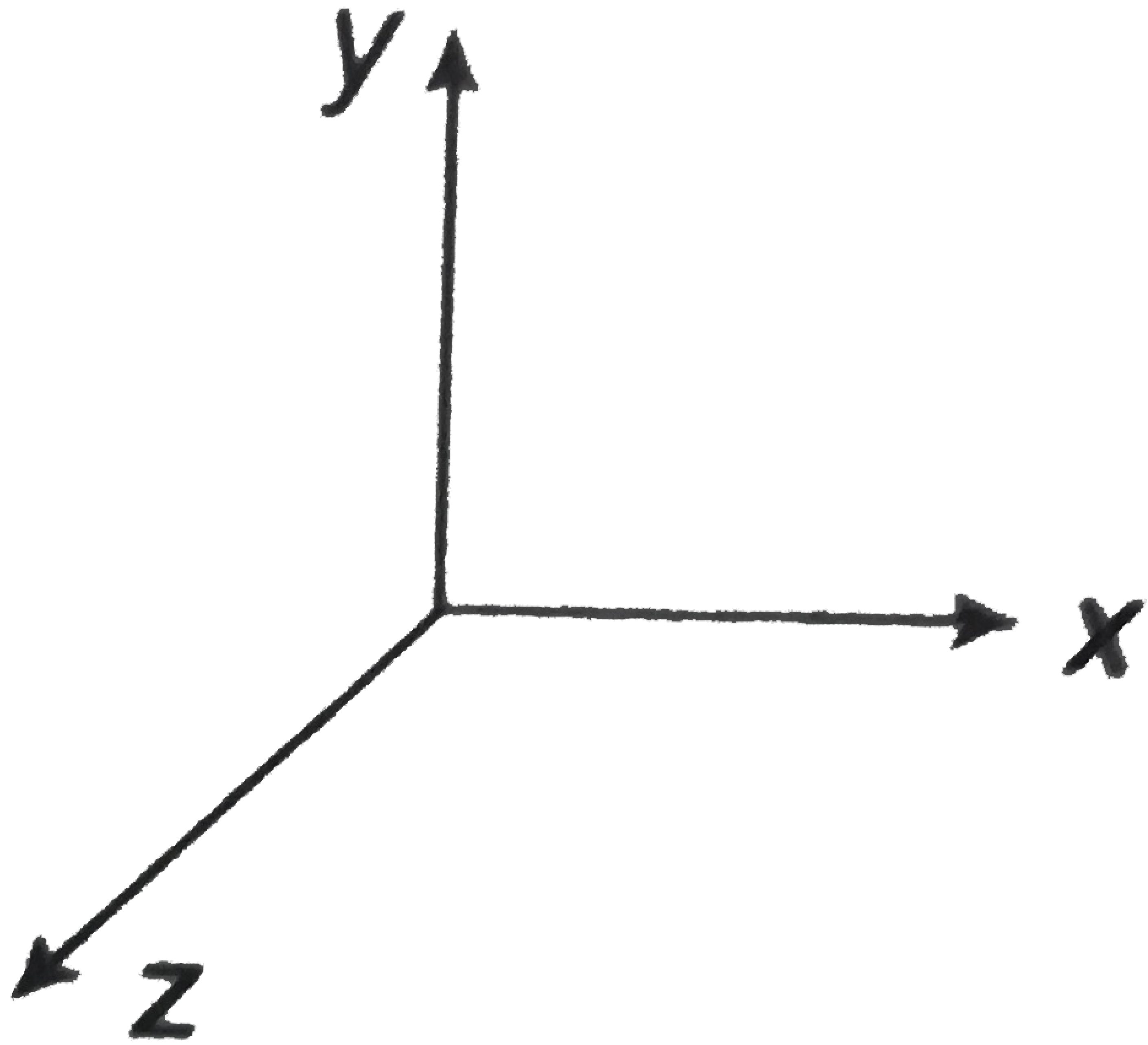
$$v = \frac{c}{n} = \frac{3 \times 10^8}{1.5}$$
$$= 2 \times 10^8 m / \sec$$

wavelength of light in medium is

$$\lambda_w = \frac{\lambda}{n} = \frac{5895}{1.5}$$
$$= 3930 A^0$$

Q-7 - 11971254

Light wave is travelling along y-direction. If the corresponding $\vec{E}$ vector at any time is along the$x$-axis, the direction of $\vec{B}$ vector at that time is along



(A) y-axis

(B) x-axis

(C) $+z$-axis

(D) $-z$axis

CORRECT ANSWER: D

SOLUTION:

Direction of wave propagation is given by $\vec{E} \times \vec{B}$.

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Q-8 - 10060292

An electromagnetic wave of frequency $v = 3.0MHz$ passes from vacuum into a dielectric medium with permittivity $\varepsilon = 4.0$. Then

(A) wave length is halved and ferquency remains unchanged

(B) wave length is doubled and frequency becomes half

(C) wave length is doubled and the frequency remains unchanged

(D) wave length and frequency both remain unchanged.

CORRECT ANSWER: A

SOLUTION:

Frequency remains constant during refraction

$$v_{med} = \frac{1}{\sqrt{\mu_0 \varepsilon_0 \times 4}}$$

$$= \frac{c}{2}$$

$$\frac{\lambda_{med}}{\lambda_{air}} = \frac{v_{med}}{v_{air}} = \frac{c}{2}$$

$$= \frac{1}{2}$$

wavelength is halved and frequency remains unchanged

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Q-9 - 19037221

choose the correct option. If speed of gamma rays, X-rays and microwaves are V_g, V_x and V_m.

(A) $V_g < V_x < V_m$

(B) $V_g > V_x > V_m$

(C) $V_g > V_x < V_m$

(D) $V_g = V_x = V_m$

SOLUTION:

(d)

Q-10 - 19037224

If at a certain instant, the magnetic induction of the electromagnetic wave in vacuum is 6.7×10^{-12}T, then the magnitude of of electric field intensity will be

(A) $2 \times 10^{-3} \quad N/C$

(B) $3 \times 10^{-3} \quad N/C$

(C) $4 \times 10^{-3} \quad N/C$

(D) $1 \times 10^{-3} \quad N/C$

SOLUTION:

(a)

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Q-11 - 9729031

The electric field in an electromagnetic wave is given by $E(50N(C^{-1}))\sin\omega\left(t - \frac{x}{c}\right)$.

Find the energy contained in a cylinder of cross section 10 cm^2

and length 50 cm along the x- axis.

SOLUTION:

Solution:

The energy density is

$(u_a v)$

$$= \left(\left(\frac{1}{2}(\varepsilon_0)(E_0^2)\right)\right.$$

$$= \left(\frac{1}{2}\right.$$

$$\times \left(8.85\right.$$

$$\times (10^{-12})(C^2)\left(N^{-1}\right.$$

$$)(m^{-2}))$$

$$\times \left((50NC^{-1})^2\right)$$

$$= 1.1 \times (10^{-8})Jm^{-3}$$

.

The volume of the cylinder is

$$V = 10(cm^2) \times 50cm$$

$$= 5 \times (10^{-4})(m^3).$$

The energy contained in this volume is

U

$$= (1.1 \times (10^{-8})Jm^{-3})$$

$$\times \left(5 \times (10^{-4})m^3\right)$$

` = 5.5 xx (10^(-12))J.

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Q-12 - 12013889

An electric field in an e.m.wave is given by

$$E = 200 \sin . \frac{2\pi}{\lambda}(ct - x) NC^{-1}$$

.

Find the energy contained in a cylinder of crossection $20 cm^2$ and length 40 cm along the x-axis.

CORRECT ANSWER: $1.42 X X 10^{-10} J$

SOLUTION:

Here, $E_0 = 200 NC^{-1}$,

$A = 20 cm^2 = 20 \times 10^{-4} m^2, l = 0.40 m$

Volume of cylinder,

$V = Al$

$= (20 \times 10^{-4})$

$\times 0.40$

$= 8 \times 10^{-4} m^2$

Energy contained in cylunder is

U=volume x energy density

$= V \times \frac{1}{2} \in_0 E_0^2$

$= (8 \times 10^{-4}) \times \frac{1}{2}$

$\times (8.85 \times 10^{-12})$

$\times (200)^2$

$= 1.42 \times 10^{-10} J$

Q-13 - 11971386

A plane electromagnetic wave of intensity of $10W/m^2$ strikes a small mmirror of area $20cm^2$, held perpendicular to the approcaching wave. The radiation froce on the mirror will be:

(A) 6.6×10^{-11} N

(B) 1.33×10^{-11} N

(C) 1.33×10^{-10} N

(D) 6.6×10^{-10} N

CORRECT ANSWER: C

SOLUTION:

Radiation force = momentum transferred per sec by electromagnetic wave to the mirror

$$= \frac{2S_{as}A}{c}$$

$$= \frac{2 \times (10) \times (20 \times 10^4)}{(3 \times 10^8)}$$

$= 1.33 \times 10^{-10} N$

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Q-14 - 19037227

An object is placed at some distance from a radio station. If the interval between transmission and reception of pulses is $2.66 \times 10^{-2} \text{S}$, then find the distance.

(A) 4000 km

(B) 2000 km

(C) 3000 km

(D) 2500 km

SOLUTION:

(a) $2x = ct$

$$x = \frac{ct}{2}$$

$$= \frac{3 \times 10^8 \times 2.66 \times 10^{-12}}{2}$$

$$\Rightarrow x \cong 4000 Km$$

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Q-15 - 11971440

The electric field part of an electromagnetic wave in a medium is represented by

$E_x = 0$,

$$E_y = 2.5 \frac{N}{C} \cos\left[\left(2\pi \times 10^6 \frac{rad}{m}\right)t - \left(\pi \times 10^{-2} \frac{rad}{s}\right)x\right]$$

$E_z = 0$.

The wave is

(A) moving along y-direction with frequency

$2\pi \times 10^6 Hz$ and wavelength $200m$.

(B) moving along x-direction with frequency $10^6 Hz$ and

wavelength $100m$

(C) moving along x-direction with frequency $10^6 Hz$ and

wavelength $100m$

(D) moving along x-direction with frequency $10^6 Hz$ and

wavelength $200m$

CORRECT ANSWER: C

SOLUTION:

The standard equation of electromagnetic wave

$E_y = E_0 \cos(\omega t - kx)$

The given equation

$$E_y = 2.5\frac{N}{C}\cos\left[\left(2\pi \times 10^6\frac{rad}{m}\right)t - \left(\pi \times 10^{-2}\frac{rad}{\sec}\right)x\right]$$

Comparing with standard equation

we get

$$\omega = 2\pi f = 2\pi \times 10^6$$
$$\Rightarrow \lambda f = 10^6 Hz$$

Moreover, we know that

$$\frac{2\pi}{\lambda} = k = \pi \times 10^{-2}m^{-1} \Rightarrow f = \lambda = 200m$$

Hence, the wave is moving along positive x-direction

with ftequency $10^6 Hz$ and wavelength $200m$.

Q-16 - 11311816

Two coherent sources emit light waves which superimpose at a point where these can be expressed as

$E_1 = E_0 \sin(\omega t + \pi / 4)$

$E_2 = 2E_0 \sin(\omega t - \pi / 4)$

Here, E_1 and E_2 are the electric field strenghts of the two waves at the given point.

If I is the intensity of wave expressed by field strenght E_1, find the resultant intensity

---

SOLUTION:

Intensity of wave expressed by field strenght

$E_1, I \propto E_0^2$

[intensity $\propto (\text{amplitude})^2$]

Intensity of wave expressed by $E_2, I' \propto (2E_0)^2$

$$\frac{I'}{I} = 4 \text{ or } I' = 4I$$

phase diffenence between the two waves is

$$(\omega t + \pi/4) - (\omega t - \pi/4) = \frac{\pi}{2}$$

Resultant intensity is given by

$$I_R = I + I' + 2\sqrt{II'}\cos\phi$$

$$\left[I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi\right]$$

$$I_R = I + 4I + 2\sqrt{I(4I)}\cos\pi/2$$

$$\Rightarrow I_R = 5I$$

Thus, resultant intensity is five times the intersity of wave expressed by E_1.

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Q-17 - 12013839

The electric field of a plane electromagnetic wave in vacuum is represented by $\overrightarrow{E}_x = 0$,

$\overrightarrow{E}_y$

$= 0.5\cos\left[2\pi \times 10^8\left(t - \frac{x}{c}\right)\right]$,

$\overrightarrow{E}_z = 0$

(a) What is the direction of propagation of electromagnetic wave?

(b) Determine the wavelength of the wave.

(c) Compute the component of associated magnetic field

SOLUTION:

(a) Equation second shows that the electromagnetic wave travels along the positive x-axis.

(b) Wavelength of wave,

$$\lambda = \frac{c}{v} = \frac{c}{(\omega / 2\pi)}$$
$$= \frac{2\pi c}{\omega}$$
$$= \frac{2\pi \times (3 \times 10^8)}{2\pi \times 10^8}$$
$$= 3.0m$$

(c) Since the magnetic ffield is perpendicular to electric feild as well as the direction of propagation of e.m. wave hence magnetic field must be varying along z-axis. Therefore

$$\overrightarrow{B}_x = 0, \overrightarrow{B}_y = 0,$$
$$\text{and } \overrightarrow{B}_z = \frac{0.5}{3 \times 10^8} \cos\left[2\pi \times 10^8 (t - x / c)\right] [\because E / B = c]$$

Q-18 - 12307257

A plane electromagentic wave $E = E_m \cos(\omega t - kr)$ where $E_m E_m e_y, k = ke_x, e_y$ are the unit vectors of the x, y axes, propagates in vacuum. Find the vector H at the point with radius vector $r = xe_x$ at the moment $(a) t = 0, (b) t = t_0.$ Consider the case when

$E_m = 160V/m, k$

$= 0.51m^{-1}, x = 7.7m,$

and $t_0 = 33ns.$

SOLUTION:

As in the previous problem

$$\overrightarrow{H} = \frac{\overrightarrow{k} \times \overrightarrow{E}_m}{\mu_0} \cos\left(\omega t - \overrightarrow{k} . \overrightarrow{r}\right)$$

$$= \frac{E_m}{\mu_0 c} \hat{e}_x \cos(kx - \omega t)$$

$$= \sqrt{\frac{\varepsilon_0}{\mu_0}} E_m \hat{e}_x \cos(kx - \omega t)$$

Thus

(a) at

$t = 0, \overrightarrow{H} = \sqrt{\frac{\varepsilon_0}{\mu_0}} E_m \hat{e}_x \cos kx$

(b) at

$$t = t_0, \overrightarrow{H} = \sqrt{\frac{\varepsilon_0}{\mu_0}} E_m \hat{e}_x \cos(kx - \omega t_0)$$

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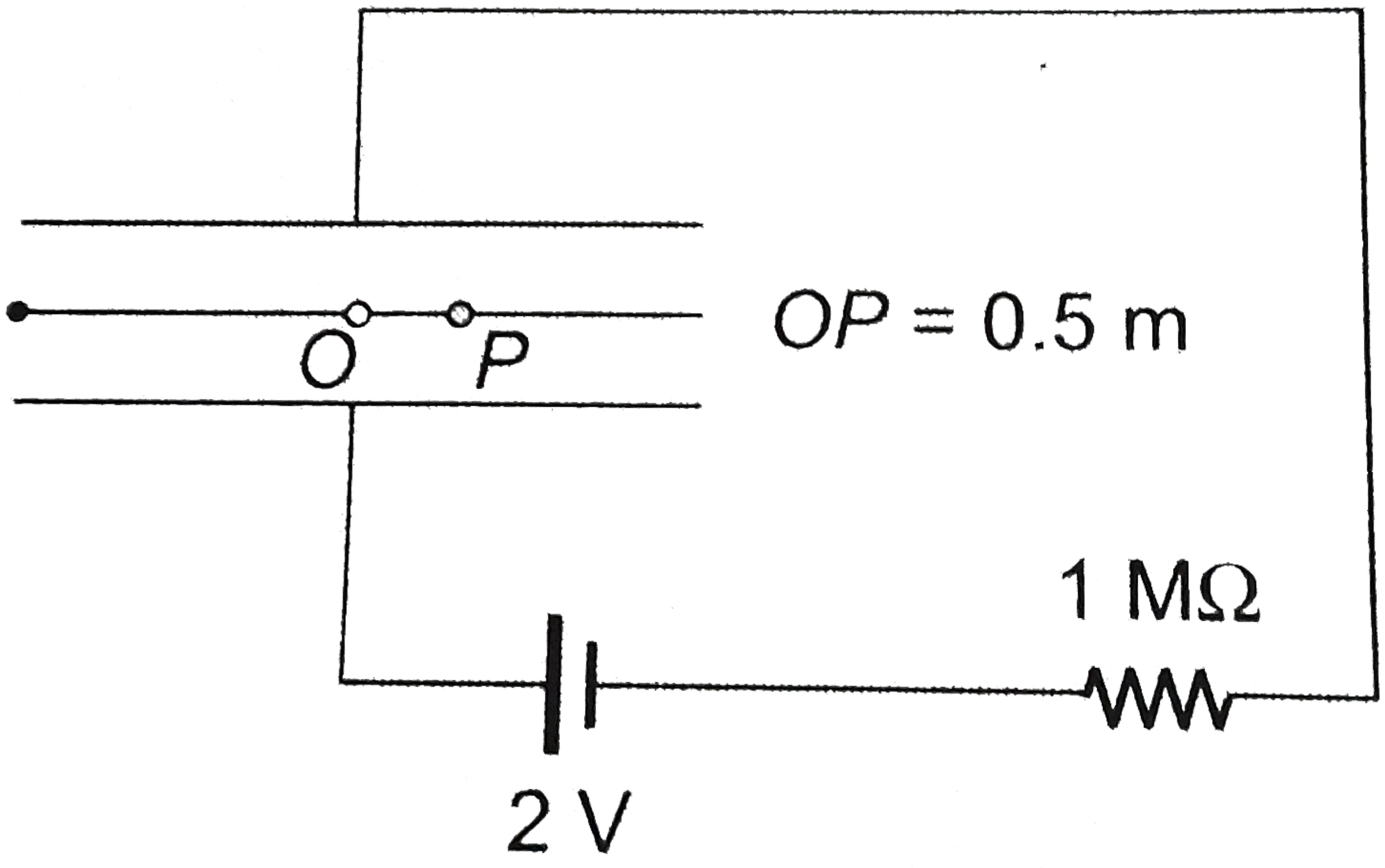
Q-19 - 13156890

A parallel plate capacitor with circular plates of radius $1m$ has a capacitor of $1nF$. At $t = 0$, it is connected for charging in series with a resistor $R = 1M\Omega$ across a $2V$ battery. Calculate the magnetic field at a point P, halfway between the cnetre and the periphery of the plates, after $t = 10^{-3}$ sec.



SOLUTION:

The charge on capcitor at anytime t

$$q = CE\left(1 - e^{-t/RC}\right),$$

$$I = \frac{dq}{dt} = \frac{E}{R}e^{-t/RC}$$

$$RC = 10^6 \times 10^{-9}$$
$$= 10^{-3}$$

$$t/RC = \frac{10^{-3}}{10^{-3}} = 1,$$
$$\frac{E}{R} = \frac{2}{10^6} = 2$$
$$\times 10^{-6} A$$

At
$$t = 10^{-3}\,\text{sec}, I$$
$$= \frac{2 \times 10^{-6}}{e}$$

The electric field between plates

$E = \frac{q}{A \in_0} = \frac{q}{\pi \in_0}$ [since $A = \pi r^2 = \pi (1)^2 = \pi$]

Consider a circular loop of radius $1/2m$ parallel to plates through P.

flux through the loop

$$\phi_E = EA'$$

$$= \frac{q}{\pi \in_0} \pi \left(\frac{1}{2}\right)^2$$

$$= \frac{Q}{4 \in_0}$$

Displacement current at $t = 10^{-3}\,\text{sec}$

$$i_d = \in_0 \frac{d\phi_E}{dt} =$$

$$\frac{\in_0}{4 \in_0} \frac{dq}{dt} = \frac{1}{4} \frac{dq}{dt} = \frac{1}{4} i$$

$$= \frac{1}{4}$$

$$\times \left(2 \times 10^{-6}\right) e^{-1}$$

$$= \frac{0.5 \times 10^{-6}}{e}$$

QAmpere-Maxwell law

$$\oint \overrightarrow{B} . d\overrightarrow{l}$$

$$= \mu_0 (i_c + i_d)$$

$$B.2\pi\frac{1}{2} = 4\pi \times 10^{-7}\left(0 + \frac{0.5 \times 10^{-6}}{e}\right)$$

$$B = 0.75 \times 10^{-3} T \ (\because e = 2.7)$$

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Q-20 - 9729057

A plane electromagnetic wave is incident on a material surface. The wave delivers momentum p and energy E.

(A) $p = 0, E \neq 0.$

(B) p!=0, E=0.

(C) p!=0, E!=0.

(D) p=0, E=0.

CORRECT ANSWER: A

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Q-21 - 13156912

If the total electromagnetic energy falling on a surface is U then the total momentum delivered (for complate absorption) is

(A) U / c

(B) cU

(C) U / c^2

(D) c^2U

CORRECT ANSWER: A

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Q-22 - 12013663

In an electomegnetic wave, the amplitude of electric field is

$10V/m$. The frequency of wave is

$5 \times 10^{14} Hz$. The wave is propagating along Z-axis, find (i) the

average

energy density of electric field (ii) the average energy density of

magnetic field (iii) the total average energy density of e.m. wave.

SOLUTION:

Here,

$E_0 = 10Vm^{-1}, v = 5$

$\times 10^{14} Hz$

.

(i) Average energy density due to electric field is

$$u_E = \frac{1}{2} \in_0 E_{rms}^2 = \frac{1}{2}$$

$$\in_0 \left(\frac{E_0}{\sqrt{2}}\right)^2 = \frac{1}{4}$$

$$\in_0 E_0^2$$

$$= \frac{1}{4} \times \left(8.85 \times 10^{-12}\right) \times (10)^2 = 2.21 \times 10^{-10} J/m^3$$

(ii) Average energy density due to magnetic field is

$$u_B = \frac{1}{2}\frac{B_{rms}^2}{\mu_0}$$

$$= \frac{1}{2\mu_0}\left(\frac{B_0}{\sqrt{2}}\right)^2$$

$$= \frac{1}{4}\frac{B_0^2}{\mu_0}$$

$$= \frac{1}{4}\frac{(E_0/c)^2}{\mu_0}$$

$$= \frac{1}{4\mu_0}\frac{E_0^2}{c^2}$$

$$= \frac{1}{4\mu_0}\frac{E_0^2}{(1/\mu_0 \in_0)}$$

$$= \frac{1}{4} \in_0 E_0^2 = u_E$$

$= 2.21 \times 10^{-10} J / m^3$

(iii) Total average energy density of e.m. waves

$u = u_E + u_B = 2.21 \times 10^{-10} + 2.21 \times 10^{-10} = 4.42 \times 10^{-10} J / m^3$

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Q-23 - 12013841

Electromagnetic wave travel in medium at a speed of $2.0 \times 10^8 ms^{-1}$. The relative permeability of the medium is 1.0. Find the relative permitivity.

SOLUTION:

Here

$v = 2 \times 10^8 ms^{-1}, \mu_r = 1, c = 3 \times 10^8 ms^{-1}$

Speed of e.m. wave in a medium is given by

$$\frac{1}{\sqrt{\mu \in}}$$

$$= \frac{1}{\sqrt{\mu_0 \mu_r (\in_0 \quad \in_r)}}$$

$$= \frac{1}{\sqrt{\mu_0 \in_0}}$$

$$\times \frac{1}{\sqrt{\mu_r \mu_r}}$$

or

$$\in_r = \frac{c^2}{v^2 \mu_r}$$

$$= \frac{\left(3 \times 10^8\right)^2}{\left(2 \times 10^8\right)^2 \times 1}$$

$$= 2.25$$

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Q-24 - 11971398

The magnetic field in the plane electromagnetic wave is given by

$B_z = 2 \times 10^{-7} \sin\left(0.5 \times 10^3 x + 1.5 \times 10^{11} t\right)$ tesla.

The expression for electric field will be:

(A)
$E_z = 30\sqrt{2} \sin\left(0.5 \times 10^3 x + 1.5 \times 10^{11} t\right) V/m$

(B)
$E_z = 60 \sin\left(0.5 \times 10^3 x + 1.5 \times 10^{11} t\right) V/m$

(C)
$E_y = 30\sqrt{2} \sin\left(0.5 \times 10^{11} x + 0.5 \times 10^3 t\right) V/m$

(D)

$E_y = 60 \sin(0.5 \times 10^3 x$
$+ 1.5 \times 10^{11} t) V / m$

CORRECT ANSWER: D

SOLUTION:

Wave is propagating along positive X-axis, magnetic field is directed along Z-axis so electric field must be directed along $\left(\hat{k} \times \hat{i}\right) = \hat{i}$, along Y-axis.

Amplitude of electric field

$E_0 = B_0 c = 2 \times 10^{-7}$
$\times 3 \times 10^8 = 60 V / m$

So choice (d) is correct.

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Q-25 - 12013945

The electric field of a plane electromagnetic wave varies with time of amplitude $2Vm^{-1}$ propagating along z-axis. The average energy density of the magentic field is (in Jm^{-3})

(A) 13.29×10^{-12}

(B) 8.86×10^{-12}

(C) 17.72×10^{-12}

(D) 4.43×10^{-12}

CORRECT ANSWER: B

SOLUTION:

Here,

$E_0 = 2Vm^{-1}, B_0 = E_0 / c \text{ and } c = \frac{1}{\sqrt{\mu_0 \in_0}}$

Average energy density of magnetic field is

$$U_B = \frac{1}{2}\frac{B_0^2}{\mu_0} = \frac{1}{4}\frac{E_0^2}{\mu_0 c^2}$$

$$= \frac{1}{4} \in_0 E_0^2$$

$$= \frac{1}{4} \times (8.85 \times 10^{-12}) \times 2^2$$

$$= 8.854 \times 10^{-12} Jm^{-3} = 8.86 \times 10^{-12} Jm^{-3}$$

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Q-26 - 12929352

A point source of electromagnetic radiation has an average power output of $800W$. The maximum value of electric field at a distance $3.5m$ from the source will be $62.6\frac{V}{m}$, the energy density at a distance $3.5m$ from the source will be- (in joule $/m^3$)

(A) 1.73×10^{-5}

(B) 1.73×10^{-6}

(C) 1.73×10^{-7}

(D) 1.73×10^{-8}

CORRECT ANSWER: D

SOLUTION:

Energy density $U = \frac{1}{2}\varepsilon_0 E_m^2$

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Q-27 - 10968232

A plane electromagnetic wave of frequency $25Mhz$ travels in free space along the x-direction. At a particular point in space and time, $E = (6.3j)V/m$. What is B at this point?

SOLUTION:

$$c = \frac{E_0}{B_0} \text{ or } = \frac{E}{B}$$

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

Substituting the values in SI units,

$$B = \frac{6.3}{3 \times 10^8}$$

$$2.1 \times 10^{-8} T$$

From the relation $c = E \times B$

We can see that B is along positive z-direction.

Because,E is along $\hat{j}$ direction and c along $\hat{i}$ direction.

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Q-28 - 12013950

Arrange the following electromagnetic radiations per quantum in the order of increasing energy: A Blue light B: Yellow light C:X-rays D:Radiowave

(A) D,B,A,C

(B) A,B,D,C

(C) C,A,B,D

(D) B,A,D,C

CORRECT ANSWER: A

Q-29 - 9729057

A plane electromagnetic wave is incident on a material surface. The wave delivers momentum p and energy E.

(A) $p = 0, E \neq 0.$

(B) p!=0, E=0.

(C) p!=0, E!=0.

(D) p=0, E=0.

CORRECT ANSWER: A

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Q-30 - 11971258

If a source is transmiting electric wave of fiequency 8.2×10^6 Hz, then wavelength of the electromagnetic waves transmitted from the source will be

(A) $36.6m$

(B) $40.5m$

(C) $42.3m$

(D) $50.9m$

CORRECT ANSWER: A

SOLUTION:

$$\lambda = \frac{c}{v} = \frac{3 \times 10^8}{8.2 \times 10^6}$$
$$= 36.5m$$

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Q-31 - 11971415

A T.V. tower has a height of $100m$. How much population is covered by T.V. broadcast, if the population density around the tower is $1000 / km^2$?

(A) 39.5×10^5

(B) 19.5×10^6

(C) 29.5×10^7

(D) 9×10^4

CORRECT ANSWER: A

SOLUTION:

Total population covered $2\pi hR_e$ x population density

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Q-32 - 16267336

Radio wave diffract around building although light waves do not.

The reason is that radio waves

(A) Travel with speed larger than c

(B) Have much larger wavelength than light

(C) Carry news

(D) Are not electromagnetic waves

CORRECT ANSWER: B

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Q-33 - 13166906

Assertion (A) : Radio waves diffract pronouncedly around the sharp edges of the buildings than visible light waves.

Reason (R) : Wave length of radio waves in comparable to the dimension of the edges of the building.

(A) Both 'A' and 'R' are true and 'R' is the correct explanation of 'A'

(B) Both 'A' and 'R' are true and 'R' is not the correct explanation of 'A'

(C) A' is true and 'R' is false

(D) A' is false and 'R' is true

CORRECT ANSWER: A

A radio station broadcasts at 720 kHz. If the radio waves travel at a velocity of $3 \times 10^8 ms^{-1}$, calculate the wavelength of the radio waves.

CORRECT ANSWER: 416.67 M

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Q-35 - 13657272

A particle of charge 16×10^{-18} coulomb moving with velocity $10m/s$ along the $x-$ axis enters a region where a magnetic field of induction B is along the $y-$ axis, and an electric field of magnitude $101/m^{-1}$ is along the negative $Z-$ axis. If the charged particle continues moving along the $X-$ axis, the magnitude to B is

(A) $1Wb/m^2$

(B) $10^5 Wb / M^2$

(C) $10^6 Wb / m^2$

(D) $10^{-3} Wb / m^2$

CORRECT ANSWER: 1

SOLUTION:

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

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Q-36 - 10060625

The magnetic field In a tranvelling dectromagnetic wave has a penk value of $20nT$ The peak value of electron field strength is :

(A) $3Vm$

(B) $6Vm$

(C) $9Vm$

(D) $12Vm$

CORRECT ANSWER: B

SOLUTION:

from question ,
$B_0 = 20nT = 20$
$\times 10^{-9}$

$\because$ velocity of light in vacume $C = 3 \times 10^8 ms^{-1})$

$\overline{E}_0 = \overline{B}_0 \times \overline{C}$
$|\overline{E}_0| = |\overline{B}_0|, |\overline{C}| = 20$
$\times 10^{-9} \times 310^8$

$= 6Vm$`

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Q-37 - 9717087

A plane electromagenic wave having a frequency $v = 23.9 GHz$ 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 ?

(A)

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

(B)

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

(C)

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

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

CORRECT ANSWER: A

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Q-38 - 11971295

In an electromagnetic wave, the electric and magnetizing field are $100V/m$ and $0.265A/m$. The maximum energy flow is:

(A) $26.5W/m^2$

(B) $36.5W/m^2$

(C) $46.7W/m^2$

(D) $76.5W/m^2$

CORRECT ANSWER: A

SOLUTION:

$$S = E_0 \times H_0 = 100$$
$$\times 0.265 = 26.5W / m^2$$

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Q-39 - 14949377

If the dimension of a physical quantity $\frac{EB}{\mu}$ is $M^a L^b T^c$. Find the value of $\left(\frac{b-c}{a}\right)$. Here

$E \Rightarrow$ magnitude of electric field

$B \Rightarrow$ Magnitude of magnetic field

$\mu \Rightarrow$ Permeability of medium

CORRECT ANSWER: 3

SOLUTION:

$$\frac{EB}{\mu} = \frac{B^2C}{\mu} = \text{Energy density} \times \text{speed}$$

$$= \text{Energy per unit volume} \times \text{speed}$$

$$= \frac{\text{Energy}}{\text{volume}} \times \text{speed}$$

$$\frac{ML^2T^{-2}}{L^3} \times LT^{-1}$$

$$= ML^0T^{-3}$$

Here

$$a = 1, b = 0c = -3$$

$$\Rightarrow \frac{b-c}{a}$$

$$= \frac{0-(-3)}{1} = 3$$

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Q-40 - 15003351

Match List - I (Electromagnetic wave type) with List - II (Its association/application) and select the correct option from the choices given below the lists:

	List1	List2
1.	Infrared waves	(i)To treat muscular strain
2.	Radio waves	(ii)For broadcasting
3.	X- rays	(iii)To defect fracture of bones
4.	Ultraviolet rays	(iv)absorbed by the ozone layer of the atmo

(A)

	1	2	3	4
(a)	(iv)	(iii)	(ii)	i

(B)

	1	2	3	4
(b)	(i)	(ii)	(iv)	iii

(C)

	1	2	3	4
(c)	(iii)	(ii)	(i)	iv

Q-41 - 12929378

An EM wave radiates out wards from a dipole antenna with E_0 as the amplitude of its electric filed vector. The electric field E_0 which transports significant energy from the source falls off as

(A) $\frac{1}{r^3}$

(B) $\frac{1}{r^2}$

(C) $\frac{1}{r}$

(D) remains constant

CORRECT ANSWER: C

SOLUTION:

A diode antenna radiates the electromagnetic waves out wards. The amplitude of electric field (E_0) which transports significant energy from the source falls intensity inversely as the distance (r) from the antenna i.e, $E_0 \propto \frac{1}{r}$

Q-42 - 14998787

An electromagnetic wave with frequency ω and wavelength λ travels in the + y direction. Its magnetic field is along + xaxis. The vector equation for the associated electric field (of amplitude E_0) is

(A)

$$\overrightarrow{E} = -E_0 \cos\left(\omega t + \frac{2\pi}{\lambda} y\right)\widehat{x}$$

(B)

$$\overrightarrow{E} = E_0 \cos\left(\omega t - \frac{2\pi}{\lambda} y\right)\widehat{x}$$

(C)

$$\vec{E} = E_0 \cos\left(\omega t - \frac{2\pi}{\lambda} y\right) \hat{z}$$

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Q-43 - 11971454

An em wave is propagating in a medium whith a velocity $\vec{v} = v\hat{i}$. The instantaneous oscillating electric field of this of em wave is along $+y$ axis. Then the direction of oscillating magnetic field of the em wave will be along

(A) $-x$ direction

(B) $-z$ direction

(C) $-y$ direction

(D) $+z$ direction

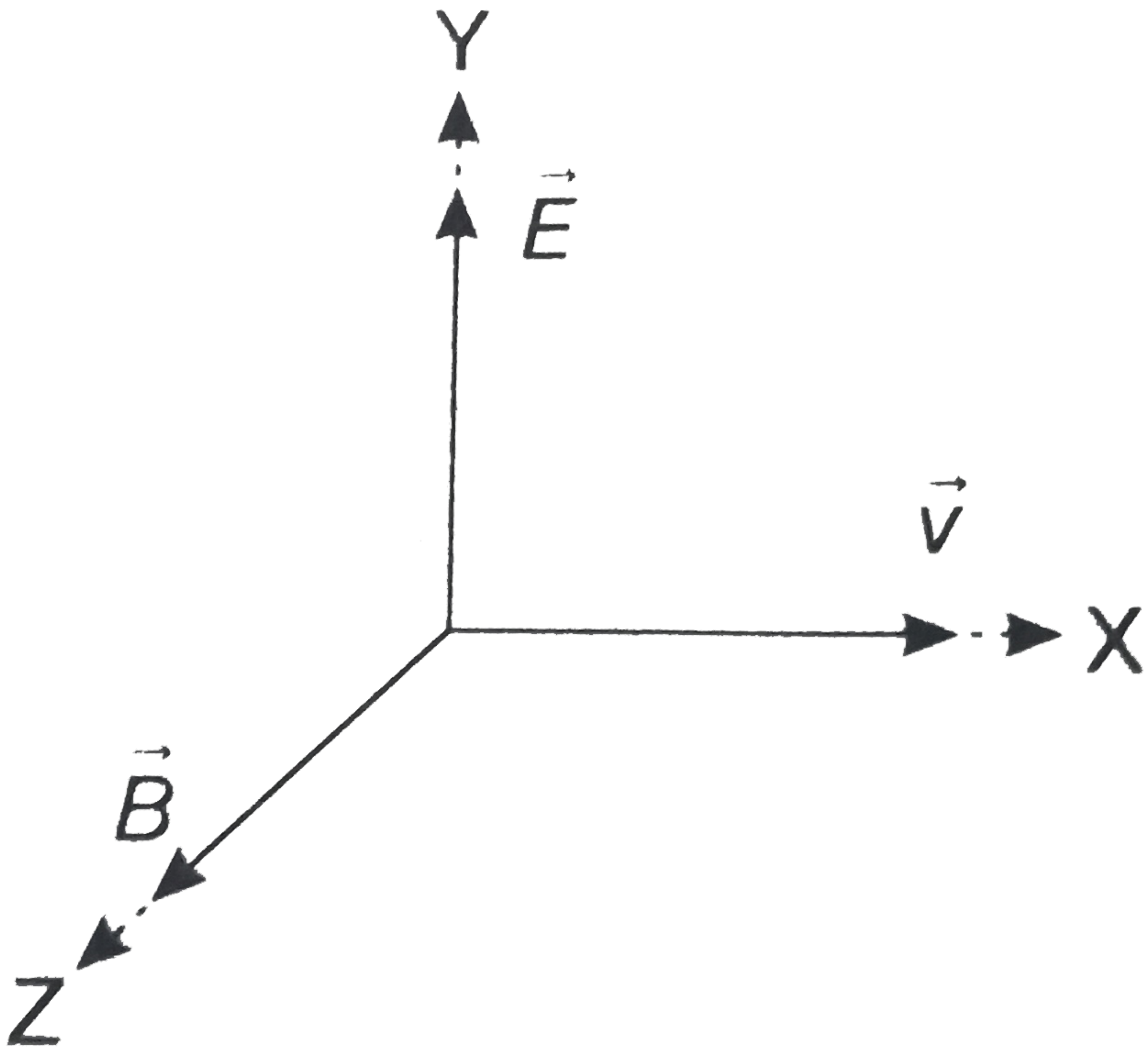
CORRECT ANSWER: D

SOLUTION:

We know $\widehat{V} = \widehat{E} \times \widehat{B}, \hat{i} = \hat{j} \times \hat{k}$

$\therefore \widehat{B} = \hat{k},$

$+ zdirection$



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Q-44 - 9364274

The electric field of EM wave is 6 volt/m. The magntic field associated with the wave if the wave is propagating in $+v$ direction and electric field along y-axis is: (A) $10^{-8} T\widehat{K}$ (B) $2 \times 10^{-8} T\widehat{K}$ (C) $3 \times 10^{-8} T\widehat{K}$ (D) $4 \times 10^{-8} T\widehat{K}$

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Q-45 - 11971451

A 100Ω resistance and a capacitor of 100Ω reactance are connected in series across a 220 V source. When the capacitor is 50 % charged, the peak value of the displacement current is

(A) $4.4A$

(B) $11\sqrt{2}A$

(C) $2.2A$

(D) $11A$

CORRECT ANSWER: D

SOLUTION:

$$(i_d)_{\max} = (i_c)_{\max}$$
$$= i_0 \frac{\varepsilon_0}{Z}$$
$$= \frac{200\sqrt{2}}{\sqrt{100^2 + 100^2}}$$

$$\Rightarrow (i_d)_{\max} = \frac{200\sqrt{2}}{100\sqrt{2}}$$
$$= 2.24$$

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

Q-46 - 12013948

A red LED emits light of 0.1 watt uniformaly around it. The amplitude of the electric field of the light at a distance of 1m from the diode is

(A) $1.73V/m$

(B) $2.45V/m$

(C) $5.48V/m$

(D) $7.75V/m$

CORRECT ANSWER: B

SOLUTION:

Intensity of light, $I = \frac{P}{4\pi r^2} = u_{av} \times c$

where $u_{av} = \frac{1}{2} \in_0 E_0^2$

$\therefore \frac{P}{4\pi r^2} = \frac{1}{2} \in_0 E_0^2 \times c$

or

$$E_0 = \sqrt{\frac{2P}{4\pi r^2 \in_0 c}}$$

$$= \sqrt{\frac{2 \times 0.1 \times 9 \times 10^9}{1^2 \times 3 \times 10^8}}$$

$2.45V / m$

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Q-47 - 11971379

A lamp emits monochromatic green light uniformly in all directions. The lamp is 3 % efficient in converting electrical power to electromagnetic waves and consumes $100W$ of power. The amplitude of the electric field associated with the electromagnetic radiation at a distance of 5 m from the lamp will be:

(A) $1.34V / m$

(B) $2.68V / m$

(C) $4.02V / m$

(D) $5.36V / m$

CORRECT ANSWER: B

SOLUTION:

Mean Intensity

$$= \frac{P}{4\pi r^2} = \frac{1}{2} \in_0 E^2$$
$$\times C$$

$$\therefore E = \sqrt{\frac{P}{2\pi r^2 \in_0 C}}$$
$$= 2.68 V m_{-1}$$

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Q-48 - 16464410

A 160 watt light source is radiating light of wavelength 6200

uniformly in all directions. The photon flux at a distance of 1.8 m is of the order of (Planck's constant $6.63 \times 10^{-34} J - s$)

(A) $10^{2} m^{-2} s^{-1}$

(B) $10^{12} m^{-2} s^{-1}$

(C) $10^{19} m^{-2} s^{-1}$

(D) $10^{25} m^{-2} s^{-1}$

CORRECT ANSWER: C

Q-49 - 10968259

Light with an energy flux $20W / cm^2$ falls on a non-reflecting surface at normal incidence. If the surface has an area of $30cm^2$. the total momentum delivered (for complete absorption)during 30 minutes is

(A) $36 \times 10^5 kg - m/s$

(B) $36 \times 10^4 kg - m/s$

(C) $1.08 \times 10^4 kg - m/s$

(D) $1.08 \times 10^7 kg - m/s$

CORRECT ANSWER: B

SOLUTION:

In case of perfectly non reflecting surface,

$$\Delta p = \frac{E}{c}$$

where

$$e = 20 \times 30 \times 30 \times 60$$

$$= 1.08 \times 10^6 j$$

$$\Delta p = \frac{1.08 \times 10^6}{3 \times 10^8}$$

$$36 \times 10^{-4} kg - m/s.$$

Q-50 - 16464240

The following travelling electromagnetic wave

$E_x = 0, E_y$
$= E_0 \sin(kx + \omega t), E_z$
$= 2E_0 \sin(kx\omega t)$

is-

(A) elliptically polarized

(B) circularly polarized

(C) linearly polarized

(D) unpolarized

CORRECT ANSWER: B

Q-51 - 16757056

Two identical photocathode receive light of frequencies f_1 and f_2. If the maximum velocities of the photoelectrons (of mass m) coming out are respectively v_1 and v_2 then:

(A) $v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$

(B) $v_1 + v_2 = \left[\frac{2h}{m}(f_1 + f_2]^{\frac{1}{2}}\right.$

(C) $v_1^2 + v_2^2 = \frac{2h}{m}(f_1 + f_2)$

(D) $v_1 - v_2 = \left[\frac{2h}{m}(f_1 - f_2]^{\frac{1}{2}}\right]$

Q-52 - 9729034

A plane electromagnetic wave propagating in the x-direction has a wavelength of 5.0 mm. The electric field is in the y-direction and its maximum magnitude is $30V\left(m^{-1}\right)$. Write suitable equations for the electric and magnetic fields as a function of x and t.

SOLUTION:

Solution:

The equation for the electric and the magnetic fields in the wave may be written as

$$E = (E_0)\sin\omega\left(t - \left(\frac{x}{c}\right)\right)$$

$$B = (B_0)\sin\omega\left(t - \left(\frac{x}{c}\right)\right)$$

We have,

$$\omega = (2\pi v) = \left(2\frac{\pi}{\lambda}\right)c.$$

$$ThusE$$

$$= (E_0)\sin\left[2\frac{\pi}{\lambda}(ct\right.$$

$$\left. - x)\right]$$

$$= \left(30Vm^{-1}\right.$$

$$\left.\right)\sin\left[\left(2\frac{\pi}{5.0}mm\right)(ct - x)\right]$$

$$.$$

$$The \max i\mu mmag$$

$$\neq ticfieldis$$

$$(B_0) = \frac{E_0}{c}$$

$$= \left(30V\frac{m^{-1}}{3}\right.$$

$$\left.\times (10^8)m\left(s^{-1}\right)\right)$$

$$= \left(10^{-7}\right)T.$$

So, B

$$= B_0 \sin\left[\left(2\frac{\pi}{\lambda}\right)(ct - x)\right]$$

$$= (10^{-7})T \sin\left[\left(2\frac{\pi}{5.0}mm\right)(ct - x)\right].$$

$Themag \neq ticfieldisalongthez - a\xi s.$

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Q-53 - 13397071

A charged particle goes undeflected in a region containing electric and magnetic field. It is possible that

(i) $\vec{E} \| \vec{B}.\ \vec{v} \| \vec{E}$

(ii) $\overrightarrow{E}$ is not parallel to $\overrightarrow{B}$

(iii) $\overrightarrow{v} \mid \mid \overrightarrow{B}$ but $\overrightarrow{E}$ is not parallel to $\overrightarrow{B}$

(iv) $\overrightarrow{E} \mid \mid \overrightarrow{B}$ but $\overrightarrow{v}$ is not parallel to $\overrightarrow{E}$

(A) (i), (ii)

(B) (ii), (iv)

(C) (ii), (iii)

(D) (i), (iv)

CORRECT ANSWER: A

SOLUTION:

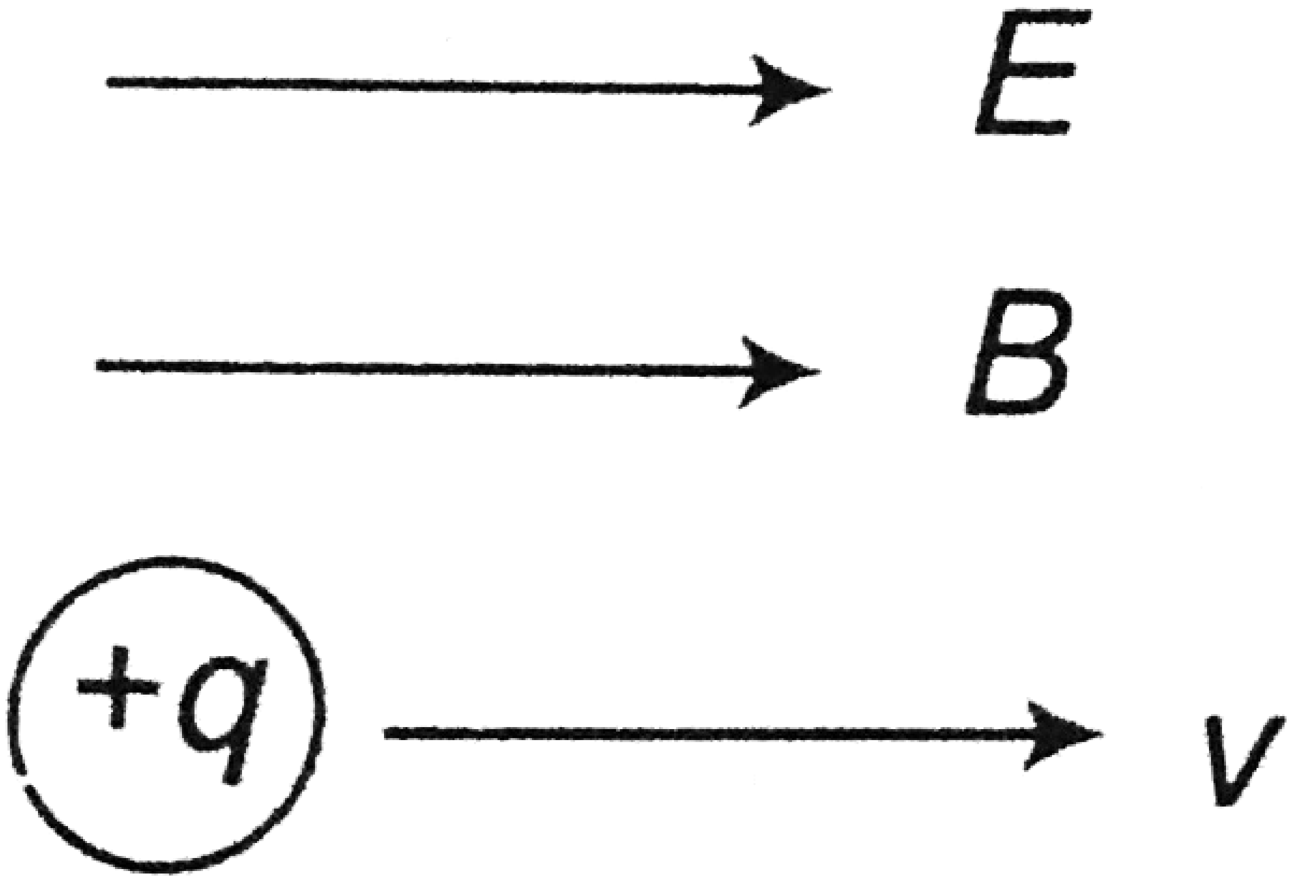
The particle is moving in a straight line.

(i) $\overrightarrow{E} \Big|\Big| \overrightarrow{B}, \overrightarrow{v} \Big|\Big| \overrightarrow{E}$

$F_m = 0, F_e = qE$

$\rightarrow E$

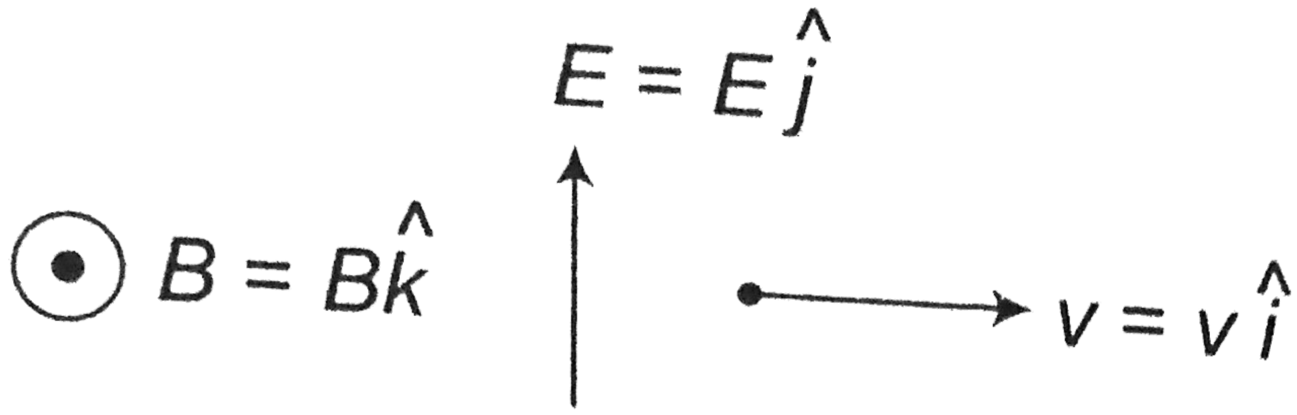
$\rightarrow B$

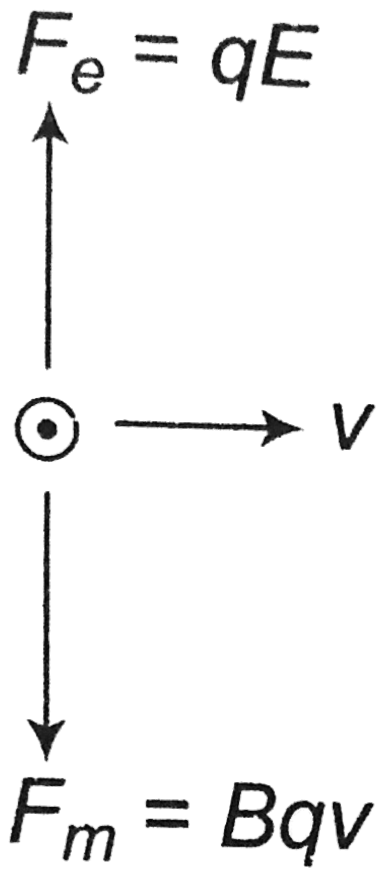


The path is straight line, O.K.

(ii) $\vec{E} \nparallel \vec{B}$

It may be



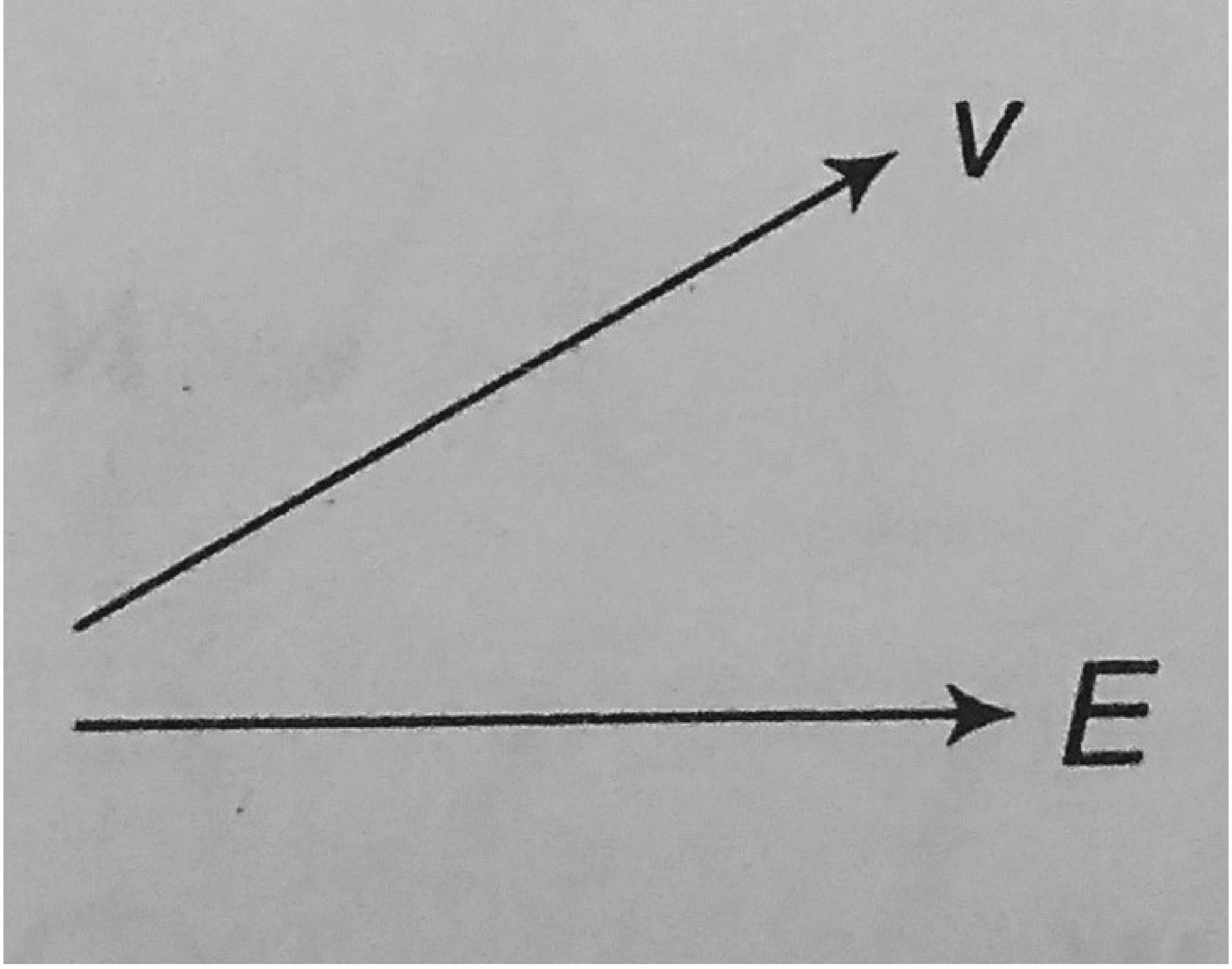


$F_e = F_m$, net force $= 0$

O.K.

(iii)

$\overrightarrow{v} \mid \mid \overrightarrow{B}, \overrightarrow{E} \nparallel \overrightarrow{B}, F_m$
$= 0$



The path will be parabola

(iv) $\vec{E} \mid \mid \vec{B}, \vec{v} \nparallel \vec{E}$, The path will not be straight line

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Q-54 - 11313814

A particle of mass m and charge q is moving in a region where uniform, constant electric and mangetic fields $\vec{E}$ and $\vec{B}$ are present. $\vec{E}$ and $\vec{B}$ are parallel to each other. At time $t = 0$, the velocity $\vec{v}_0$ of the particle is perpendicular to $\vec{E}$ (Assume that its speed is always $< < c$, the speed of light in vacuum). Find the velocity $\overrightarrow{v}$ of the particle at time t. You must express your answer in terms of t, q, m, the vector $\overrightarrow{v}_0, \overrightarrow{E}$ and $\overrightarrow{B}$ and their magnitudes $\overrightarrow{v}_0, \overrightarrow{E}$ and $\overrightarrow{B}$.

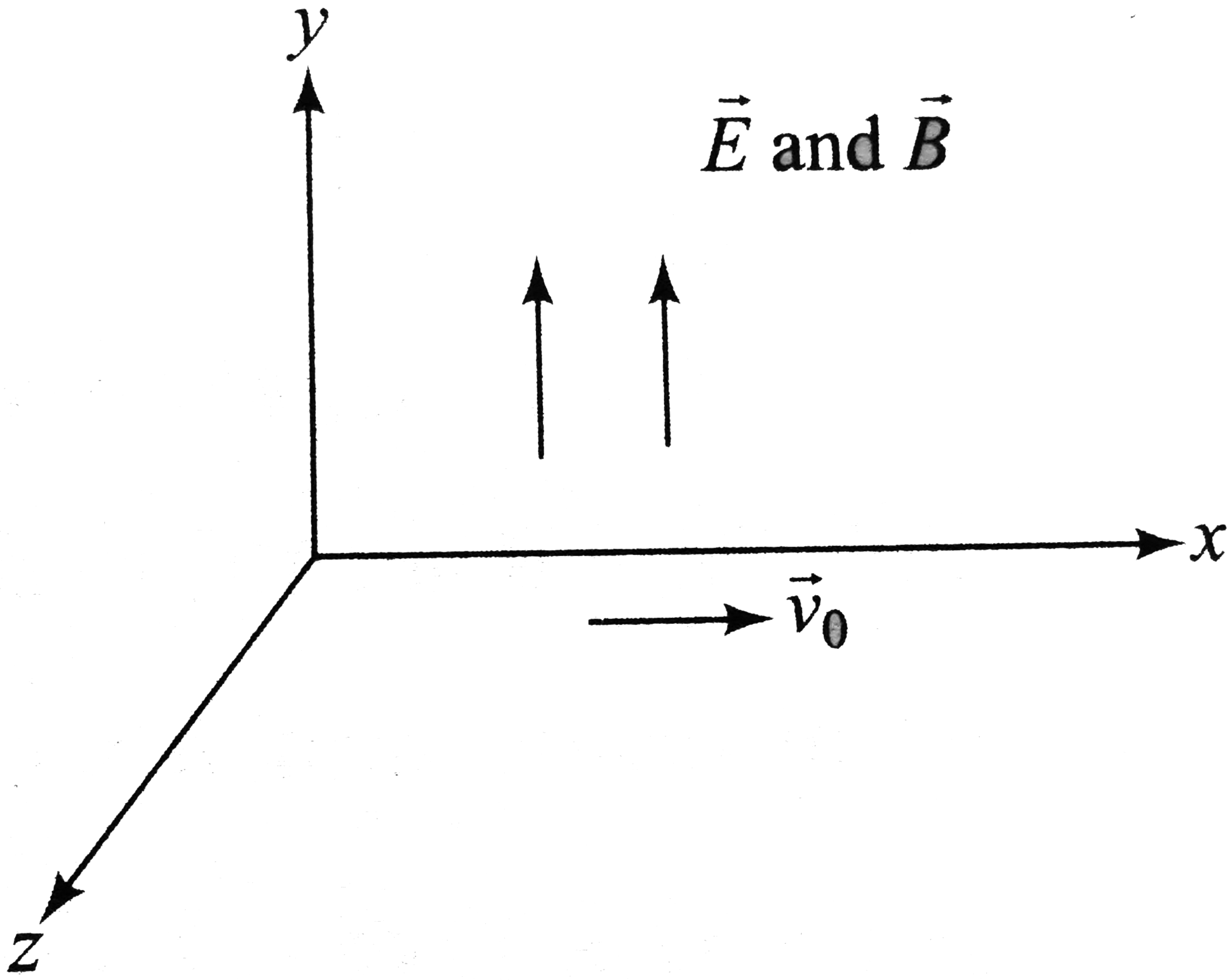
SOLUTION:

$$\hat{j} = \frac{\overrightarrow{E}}{E} \text{ or } \frac{\overrightarrow{B}}{B}, \hat{i} = \frac{\overrightarrow{v}_0}{v_0}, \hat{k} = \frac{\overrightarrow{v}_0 \times \overrightarrow{B}_0}{v_0 B}$$

Force due to electric field will be along y-axis. Magnetic force will not affect the motion of changed particle in the direction of electric field (or y-axis) so.

$$a_y = \frac{F_e}{m} = \frac{qE}{m}, v_y = a_y t$$

$= \frac{qE}{m}T$....(i)



The changed particle under the action of magnetic field describes a circle in x-z plane (perpendicular to $\overrightarrow{B}$) with $T = \frac{2\pi m}{Bq}$ or $\omega = \frac{2\pi}{T} = \frac{qB}{m}$

Initially $(t = 0)$ velocity was along x-axis. Therefore, magnetic force $\left(\overrightarrow{F}_m\right)$ will be along positive z-axis $\left[\overrightarrow{F}_m = q\left(\overrightarrow{v}_0 \times \overrightarrow{B}\right)\right]$. Let it this force makes an angle θ with x-axis at time t, then

$$\theta = \omega t$$

$$\therefore v_x = v_0 \cos \omega t$$

$$= v_0 \cos\left(\frac{qB}{m} t\right)$$

...(ii)

$$v_z = v_0 \sin \omega t$$

$$= v_0 \sin\left(\frac{qB}{m} t\right)$$

...(iii)

From Eqs. (i), (ii) and (iii)

$$\overrightarrow{v} = v_x \hat{i} + v_y \hat{j} + v_z \hat{k}$$

$$\therefore \overrightarrow{v}$$

$$= v_0 \cos\left(\frac{qB}{m} t\right)\left(\frac{\overrightarrow{v}_0}{v_0}\right)$$

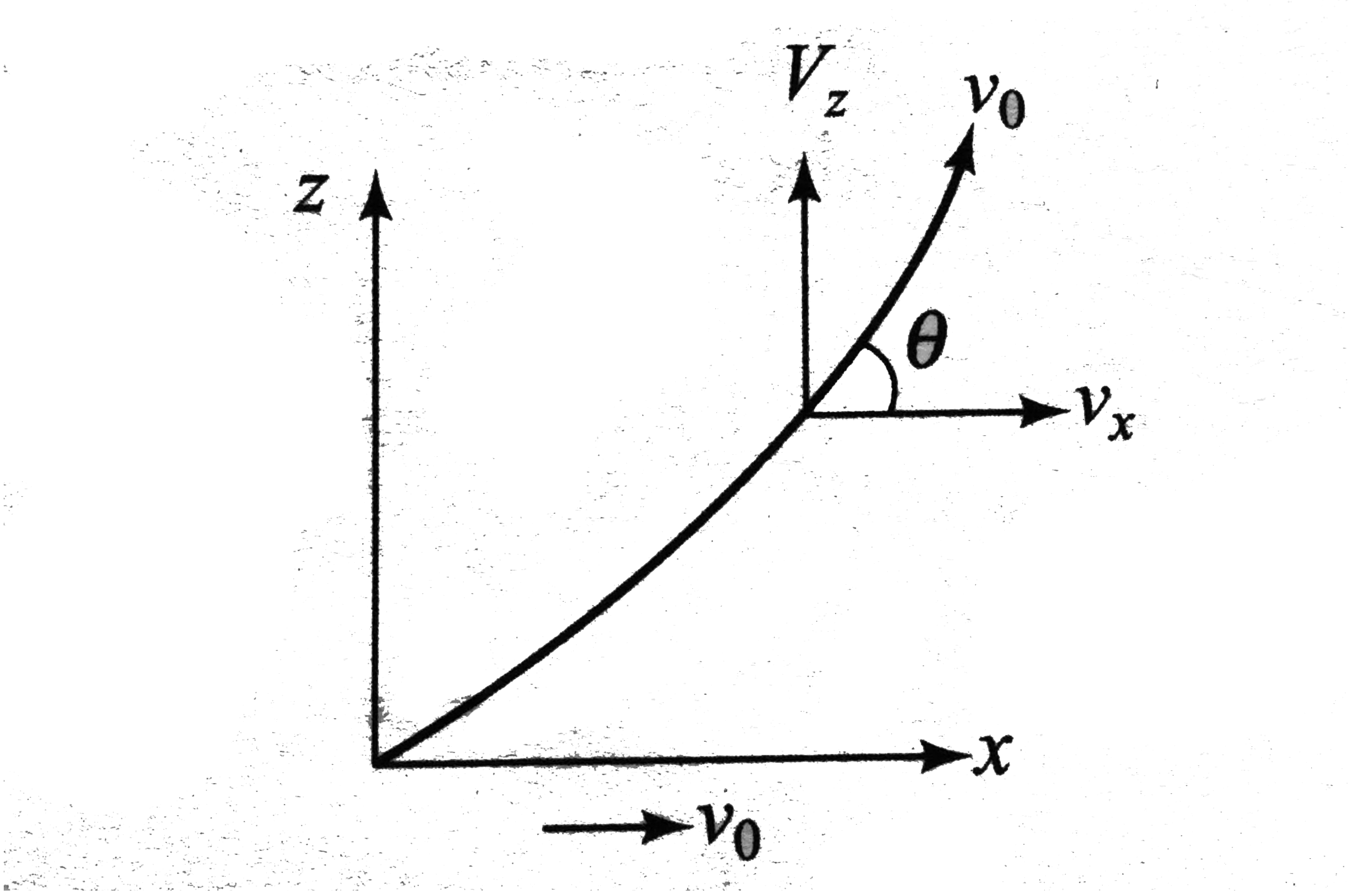
$$+ \frac{qE}{m} t \left(\frac{\overrightarrow{E}}{E}\right)$$

$$+ v_0 \sin\left(\frac{qB}{m} t\right)$$

$$\left(\frac{\overrightarrow{v}_0 \times \overrightarrow{B}}{v_0 B}\right)$$

Or

$$\vec{v} = \cos\left(\frac{qB}{m}t\right)\left(\vec{v}_0\right) + \left(\frac{q}{m}t\right)\left(\vec{E}\right) + \sin\left(\frac{qB}{m}t\right)\left(\frac{\vec{v}_0 \times \vec{B}}{B}\right)$$



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Q-55 - 12014524

Out of electric field vector, $\overrightarrow{E}$ and magnetic field vector, vec(B)` in an electromagnetic wave, which is more effective and why ?

SOLUTION:

$\overrightarrow{E}$ is more effective than $\overrightarrow{B}$. This is because when a charge q moving with a velocity v encounters an e.m. wave,

$$\frac{F_e}{F_m} = \frac{qE}{qvB} = \frac{E}{vB}$$
$$= \frac{c}{v}\left[\because \frac{E}{B} = c\right]$$

As

$c > > v, \therefore F_e >$
$> F_m$

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Q-56 - 15003355

A plane electromagnetic wave travels in free space along x-axis. At a particular point in space, the electric field along y-axis is $9.3Vm^{1}$. The magnetic induction (B) along z-axis is

(A) $3.1 \times 10^{-8}T$

(B) $3 \times 10^{-5}T$

(C) $3 \times 10^{-6}T$

Q-57 - 12929348

A wave is propagating in a medium of dielectric constant 2 and relative permeability 50. The wave impedance is

(A) 5Ω

(B) 376.6Ω

(C) 3776Ω

(D) 1883Ω

CORRECT ANSWER: D

SOLUTION:

Wave impedence

$$Z = \frac{E}{H} = \frac{CB}{H}$$

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

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Q-58 - 12013978

The speed of em wave in the unit of $10^8 m/s$, in a medium of dielectric constant 2.25 and relative permeablity 4 is:

CORRECT ANSWER: 1

SOLUTION:

The speed of em wave in medium is given by

$$v = \frac{1}{\sqrt{\mu \in}}$$

$$= \frac{1}{\sqrt{\mu_0 \mu_r \in_0 \in_r}}$$

$$= \frac{c}{\sqrt{\mu_r \in_r}}$$

$$= \frac{3 \times 10^8}{\sqrt{4 \times 2.25}}$$

$$1 \times 10^8 ms^{-1}$$

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Q-59 - 19037826

When a sound wave of wavelength λ is propagating in a medium, the maximum velocity of the particle is equal to the velocity. The ampilitude of wave is

(A) λ

(B) $\frac{\lambda}{2}$

(C) $\frac{\lambda}{2\lambda}$

(D) $\frac{\lambda}{4\lambda}$

CORRECT ANSWER: C

SOLUTION:

$$v_{\max} = v \Rightarrow A\omega = v$$
$$\Rightarrow A \times 2\pi v$$
$$= v\lambda \text{ or } A = \frac{\lambda}{2\pi}$$

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Q-60 - 14624134

A dye absorbs a photon of wavelength λ and re $-$ emits the same energy into two phorons of wavelengths λ_1 and λ_2 respectively.

The wavelength λ is related with λ_1 and λ_2 as :

(A) $\lambda = \dfrac{\lambda_1 + \lambda_2}{\lambda_1 \lambda_2}$

(B) $\lambda = \dfrac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$

(C) $\lambda = \dfrac{\lambda_1^2 \lambda_2^2}{\lambda_1 + \lambda_2}$

(D) $\lambda = \dfrac{\lambda_1 \lambda_2}{(\lambda_1 + \lambda_2)^2}$

CORRECT ANSWER: B

SOLUTION:

$$E = E_1 + E_2, \frac{hc}{\lambda}$$

$$= \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$$

$$\Rightarrow \quad \frac{hc}{\lambda}$$

$$= hc\left(\frac{\lambda_2 + \lambda_1}{\lambda_1 \lambda_2}\right), \lambda$$

$$= \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$$