JUPITER ACADEMY

EXCELLENCE PRUDENCE

JEE Mains Paper-2022

PHYSICS

1. If the time period of simple pendulum is T, then find its time period inside a lift moving upward with an acceleration of g m/s^2

(1) T

(2) $2T$

(3) $\frac{T}{2}$

(4) $\frac{T}{\sqrt{2}}$

Sol: Answer (4)

Time period of pendulum is $T = 2\pi\sqrt{\frac{l}{g}}$

If lift is moving up with acceleration 'g'

$$\therefore g_{eff} = g + g = 2g$$

So, new time period is

$$T_{new} = 2\pi\sqrt{\frac{l}{g_{eff}}} = 2\pi\sqrt{\frac{l}{2g}}$$

$$\therefore T_{new} = \frac{T}{\sqrt{2}}$$

2. A ball is thrown vertically upward at the max height which of the following is zero?

(1) Momentum

(2) P.E

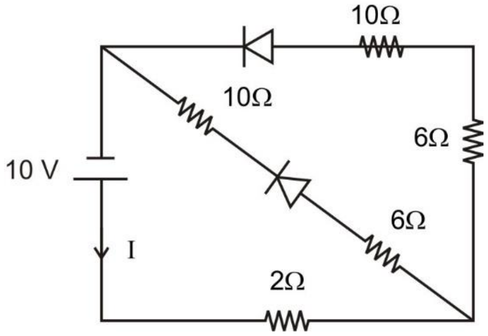
(3) Acceleration

(4) Force

Sol. Answer (1)

At maximum height the ball will be momentarily at rest so we have v = 0 and thus momentum is zero.

3. In the diagram value of current I is



(1) 1 A

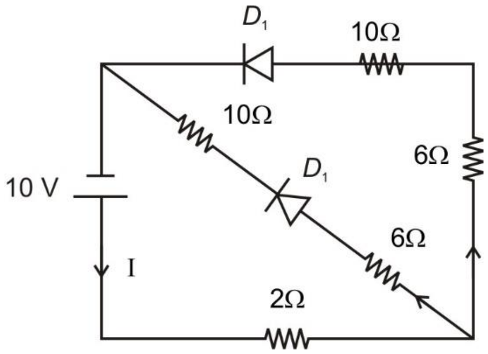
(2) 2 A

(3) 0.5 A

(4) 4 A

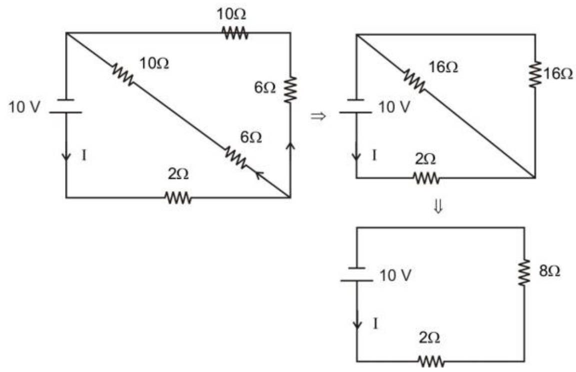
Sol. Answer (1)

As the diodes are forward biased and assuming them to be ideal we can say that no resistance will be offered by them so



Both the diode are connected in forward bias. Considering them ideal and its resistance as zero.

So,



So, $I = \dfrac{10}{2+8} = 1\,A$

4. When do you experience weightless in a lift?

(1) Moving upward with constant velocity

(2) Moving upward with constant acceleration

(3) Moving downward with constant velocity

(4) Moving downward with constant acceleration

Sol. Answer (4)

Effective acceleration due to gravity while lift is accelerating down is given as

$$g_{eff} = g - a$$

(where a is downward acceleration)

$\therefore$ *for weightlessness*

$$g' = 0, a = g$$

5. A ring of mass M and radius R is rotating with angular velocity of ω. Two point masses of equal mass m are placed at diametrically opposite points. The value of new angular velocity will be

(1) $\left(\dfrac{M}{2M-m}\right)\omega$ (2) $\left(\dfrac{2M}{M+2m}\right)\omega$

(3) $\left(\dfrac{2m}{M+m}\right)\omega$ (4) $\left(\dfrac{M}{M+2m}\right)\omega$

Sol. Answer (4)

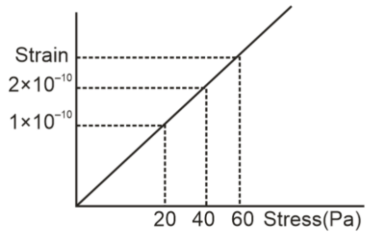
Angular momentum of system will be conserved

$L_i = L_f$

$(MR^2)\omega = (MR^2 + 2mR^2)\omega'$

$$\omega' = \frac{MR^2\omega}{(M+2m)R^2} = \frac{M\omega}{M+2m}$$

6. In the graph the value of energy density when strain is 5×10^{-10} is



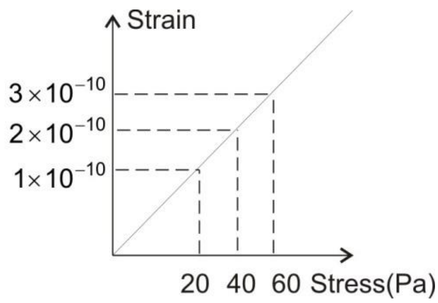
(1) 4.0×10^{-6} J/m^3

(2) 1.5×10^{-8} J/m^3

(3) 2.5×10^{-8} J/m^3

(4) 2.5×10^{-10} J/m^3

Sol. Answer (3)



Extrapolating the graph gives value of stress as 100 Pa when strain is 5×10^{-10}

Strain energy density = $\dfrac{1}{2} \times \sigma \times E$

$$= \left(\frac{1}{2}\right)(100)(5 \times 10^{10})$$

$$= 2.5 \times 10^{-8}\,\frac{J}{m^3}$$

7. An aeroplane is flying horizontally with the velocity of 200m/sec. When it is just above a cannon the cannon fires a shell at a speed of 400m/sec at an angle of θ with horizontal. The value of θ for which shell hits aeroplane,is

(1) 45°

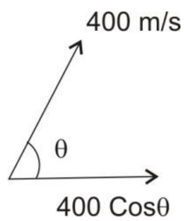
(2) 30°

(3) 37°

(4) 60°

Sol. Answer (4)

To hit the plane horizontal velocity of plane and shell must be same



200 = 400 Cos θ

Cos θ = $\frac{1}{2}$ $\Rightarrow \theta = 60°$

8. P = $\frac{\alpha}{\beta}\log_e\left(\frac{kx}{\beta}\right)$, P is dimensionless

If k = kinetic energy

X = displacement

Find dimensions of α

(1) $M^{\circ} L^{-1} T$

(2) $ML^3 T^{-2}$

(3) $ML^2 T^{-1}$

(4) $ML^{\circ} T^{-3}$

Sol. Answer (2)

$$P = \frac{\alpha}{\beta}\log_e\left(\frac{kx}{\beta}\right)$$

$$\left[\frac{kx}{\beta}\right] = [M^{\circ} L^{\circ} T^{\circ}]$$

$$\frac{[ML^2 T^{-2}]\,[L]}{[\beta]} = [M^{\circ}L^{\circ}T^{\circ}]$$

$$[\beta] = [ML^3\, T^{-2}]$$

$$\left(\frac{\alpha}{\beta}\right) = [P] = [M^{\circ}L^{\circ}T^{\circ}]$$

$$[\alpha] = [\beta] = [ML^3\, T^{-2}]$$

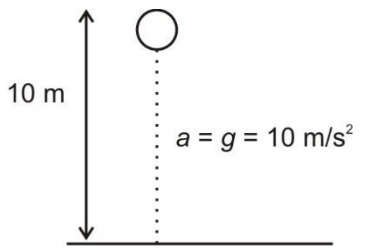
9. If a point mass of 0.5 kg is dropped from a height of 10 m. At what height is the magnitude of velocity is equal to the magnitude of acceleration of mass (g = 10 m/s^2)

(1) 7.5 m (2) 2 m

(3) 5 m (4) 6 m

Sol. Answer (3)

Given, (g = 10 m/s^2)



Magnitude of velocity should be equal to magnitude of acceleration as per question.

So, v = 10 m/s

Hence, $v^2 - u^2 = 2as$

$\Rightarrow (10)^2 - (0)^2 = 2\times 10\times s$

$\Rightarrow s = 5$ m

10. If length of the wire is increased by 0.4% through stretching, then find the percentage change in resistance.

(1) 0.4% (2) 0.2%

(3) 0.6% (4) 0.8%

Sol. Answer (4)

Volume of the wire is constant

$V = AL$

$$\frac{\Delta A}{A} + \frac{\Delta L}{L} = 0$$

$$\frac{\Delta L}{L} = -\frac{\Delta A}{A}$$

$$R = \rho\frac{L}{A}$$

$$\frac{\Delta R}{R}\% = \frac{\Delta L}{L}\% - \frac{\Delta A}{A}\%$$

$$= 2\frac{\Delta L}{L}\%$$

$$= 2\times 0.4 = 0.8\%$$

Resistance increased by 0.8%.

11. What is the efficiency of Carnot engine between steam point and ice points?

(1) 26.80%

(2) 36.71%

(3) 46.71%

(4) 56.6%

Sol. Answer (1)

Efficiency of Carnot engine:

$$\eta = 1 - \frac{T_1}{T_2}$$

$$\eta = 1 - \frac{273}{373}$$

$$= \frac{100}{373} = 0.268 = 26.8\%$$

12. For the nuclear reaction

$${}^{238}_{92}\text{U} \rightarrow {}^{206}_{82}\text{Pb}$$

The number of α and β particles emitted respectively are

(1) 8, 6

(2) 6, 8

(3) 8, 4

(4) 6, 4

Sol. Answer (1)

$^{238}_{92}U \to \ ^{206}_{82}Pb$

*Mass number decreases by 32 which happens only in 'α' decay. So, no. of α particle $\frac{32}{4}$ = 8.

*Atomic no. should have been decreased by 8 × 2 = 16. So, new atomic no = 92 – 16 = 76. But as atomic no. is 82 in final product. So, '6' β particles must be emitted.

13. An electron moving with speed *v* has wavelength equal to that of a photon moving with speed *c*. Then the ratio of their energies is

(1) v/2c

(2) 2v/c

(3) v/c

(4) c/v

Sol. Answer (1)

Let the wavelength of electron is λ_e and that of photon is λ_p

$$\frac{\lambda}{mv} = \frac{\lambda c}{E_p}$$

E_P = mvc

$E_e = \frac{1}{2}mv^2$

$$\frac{E_e}{E_p} = \frac{\frac{1}{2}mv^2}{mvc} = \frac{v}{2c}$$

14. An alpha particle and a proton moving with same speed are accelerated in uniform magnetic field, then find the ratio of radius of alpha particle to that of proton.

(1) 4 : 1

(2) 1 : 4

(3) 2 : 1

(4) 1 : 2

Sol. Answer (3)

Given,

Particles are moving with same speed

$m_\alpha = 4m_p$

$m_\alpha \to$ mass of $\alpha -$particle

$q_\alpha = 2q_p$

$m_p \to$ mass of proton

$$R = \frac{mv}{qB} \Rightarrow R \propto \frac{m}{q}$$

$$\frac{R_\alpha}{R_p} = \frac{m_\alpha}{q_\alpha} \times \frac{q_p}{m_p} = \frac{4m_p}{2q_p} \times \frac{m_p}{q_p}$$

$$\frac{R_\alpha}{R_p} = \frac{2}{1}$$

15. Magnetic flux in a region is given by $\phi = 4t^3 + 2t^2 + t + 1$

If the resistance of the loop is $R = 34\Omega$, the current in it at *t* = 1, is

(1) 0.5 units

(2) 2 units

(3) 0.8 units

(4) 4 units

Sol. Answer (1)

Magnetic flux(ϕ) = $4t^3 + 2t^2 + t + 1$

Induced emf $|E_{ind}| = \frac{d\phi}{dt}$

$$= \frac{d}{dt}(4t^3 + 2t^2 + t + 1)$$

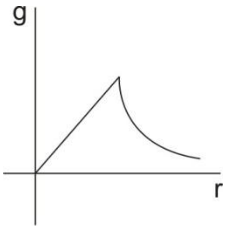
$$E_{ind} = 12t^2 + 4t + 1$$

$$\text{(Induced current)}_{ind} = \frac{E_{ind}}{R} = \frac{12t^2 + 4t + 1}{34}$$

So, $I_{ind(t=1)} = \frac{12(1)^2 + 4(1) + 1}{34}$

= 0.5 unit

16. Graph is plotted between acceleration due to gravity of earth and distance from centre. Then choose the correct graph

(1)


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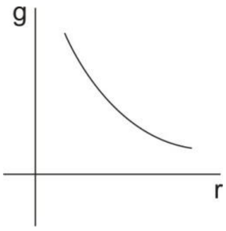

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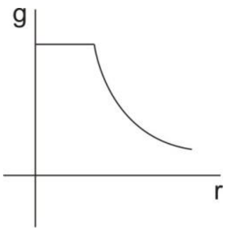

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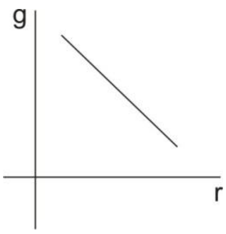
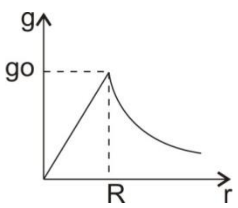


Sol. Answer (1)



$$g = \frac{GM}{R^3}r = g_0\frac{r}{R} \qquad r \le R$$

$$g = \frac{GM}{r^2} = \frac{g_0R^2}{r^2} \qquad r > R$$

g_o is acceleration due to gravity at the surface of earths

Based on above expression option 1 correctly depicts variation of g with distance.

17. Find the ratio of orbital radius for the second orbit of hydrogen atom and third orbit of Li^{++}

(1) 3/4

(2) 4/3

(3) 2

(4) 1/2

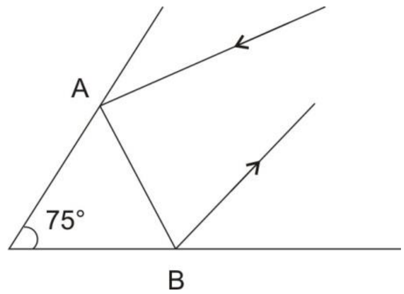
Sol. Answer (2)

$$R = \frac{R_o n^2}{Z}$$

$$\frac{R_H}{R_{Li}} = \frac{n_H^2}{Z_H} \times \frac{Z_{Li}}{n_{Li}^2} = \frac{2^2}{1} \times \frac{3}{3^2}$$

$$\frac{R_H}{R_{Li}} = \frac{4}{3}$$

18. Consider two reflections of a ray as shown



If the angle of reflection at B is 30°, find the net deviation of the ray

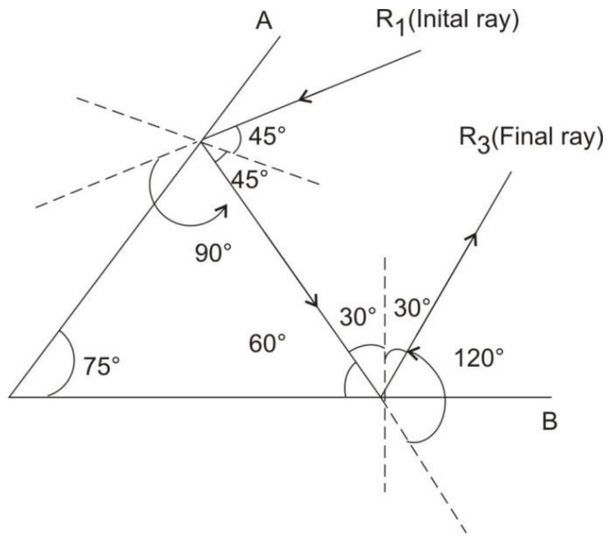
(1) 180

(2) 210°

(3) 240°

(4) 150°

Sol. Answer (2)



$\delta_{net} = \delta + \delta_2$

$= 90 + 120$

$= 210°$

19. The extension in a wire, kept vertical is 10^{-4} m when the experiment is done on earth's surface. If the experiment is done on the surface of another planet, the extension is 6×10^{-5} m. Find the value of acceleration due

to gravity on the surface of planet [Given : g_{Earth}=10 m/s^2]

(1) 6 m/s^2

(2) 8 m/s^2

(3) 9 m/s^2

(4) 10 m/s^2

Sol. Answer (1)

$$\Delta L = \frac{MgL}{AY}$$

$$\frac{\Delta L}{\Delta L_1} = \frac{\frac{MgL}{AY}}{\frac{Mg_1L}{AY}} = \frac{g}{g_1}$$

$$g_1 = \frac{\Delta L_1}{\Delta L} g$$

$$g_1 = \frac{6\times10^{-5}}{10^{-4}} g$$

$$g_1 = \frac{6g}{10} = 6 \text{ m/s}^2$$

20. A capacitor of capacitance C_1 was initially charged to voltage V_0 then the battery is removed. The charged capacitor C_1 is now connected to uncharged capacitor C_2, the charge on the capacitor C_2 will be

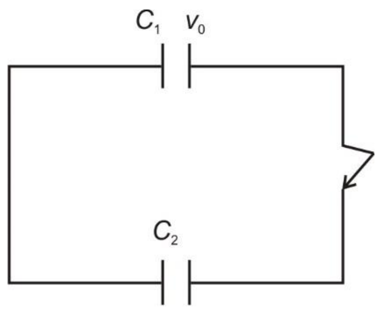
(1) $V_0 \dfrac{C_1C_2}{C_1+C_2}$

(2) $V_0\left(\dfrac{C_1+C_2}{C_1C_2}\right)$

(3) $V_0(C_1+C_2)$

(4) $V_0(C_1-C_2)$

Sol. Answer (1)



After switch is closed

Common potential

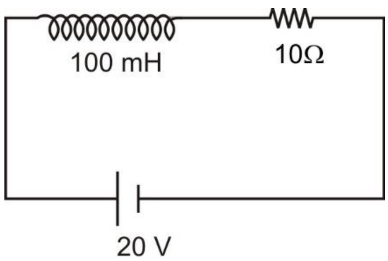
$$V = \frac{C_1V_0}{C_1+C_2}$$

Charge on $C_2 \Rightarrow Q_2 = C_2V$

$$= \frac{C_1C_2V_0}{C_1+C_2}$$

21. An inductor of 100 mH was connected to 20 V battery. Internal resistance of inductor is 10Ω. Suddenly switched is opened and current become zero in $100\ \mu s$. Find the average induced emf (in volts) in inductor

Sol. Answer ()



Initial current in the inductor immediately after the switch is opened $= \dfrac{20}{10} = 2$ A.

Current become zero in 100 μs.

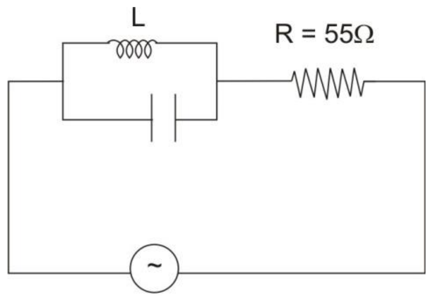
So,

Emf induced (E_{ind}) $= \left|L\dfrac{di}{dt}\right|$

$$= \left|(100\times10^{-3})\frac{(0-2)}{100\times10^{-6}}\right|$$

= 2000 volt or 2 k volt

22. if the given circuit is in resonance (i.e. $X_L = X_c$). Then the rms current in the circuit will be



(1) 2 AMP

(2) 4 AMP

(3) 0.5 AMP

(4) Zero

Sol. Answer (4)

$X_L = i\omega L$

$X_C = \frac{1}{i\,\omega C} = -\frac{i}{\omega C}$

Their resultant will be

$$\frac{X_C X_L}{X_C + X_L} = \frac{(i\,\omega L)\left(-\frac{i}{\omega C}\right)}{i\omega L + \left(-\frac{i}{\omega C}\right)}$$

$$= \frac{\frac{L}{C}}{iL\omega - \frac{1}{\omega C}} = \frac{L}{iC\left(L\omega - \frac{1}{C\omega}\right)}$$

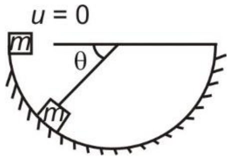
Given $L\omega = \frac{1}{C\omega}$

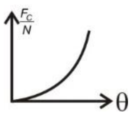
$Z \to \infty$

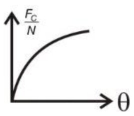
$I \to 0$

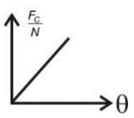
In case of resonance $\omega = \frac{1}{\sqrt{LC}}$

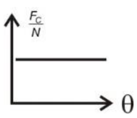
23. A block of mass m is released from the top-most point of a vertical fixed cylindrical surface of radius R. If the magnitude of centripetal force and normal reaction at a general θ are respectively F_c and N, then correct graph of Fc/Nverses θ will be



(1) 

(2) 

(3) 

(4) 

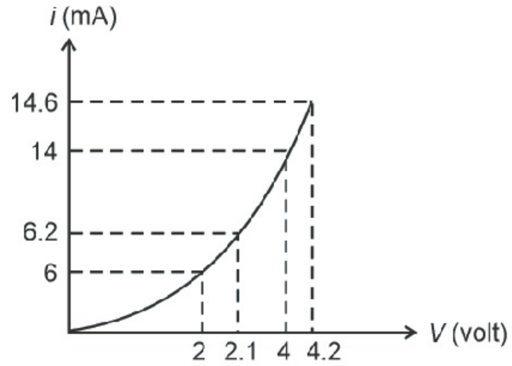
Sol. Answer (4)

$$V = \sqrt{2gh} = \sqrt{2gR\sin\theta},\ F_c = \frac{mv^2}{R} = 2mg\sin\theta$$

$$N = mg\sin\theta + \frac{mv^2}{R} = 3mg\sin\theta,$$

$$\frac{F_c}{N} = \frac{2}{3} = \text{constant}$$

24. Characteristic curve of a diode is as shown below. Its dynamic resistance at v = 2 volt and v = 4 volt will be respectively:



(1) 500Ω, 333.33Ω

(2) 333.33Ω, 500Ω

(3) 800Ω, 667Ω

(4) 667Ω, 800Ω

Sol. Answer (1)

At 2v

$$R_1 = \frac{\Delta v}{\Delta I} = \frac{2.1 - 2}{(6.2 - 6)\times 10^{-3}}$$

$$R_1 = 500\Omega$$

At 4 v

$$R_1 = \frac{\Delta v'}{\Delta I'} = \frac{4.2 - 4}{(14.6 - 14)\times 10^{-3}}$$

$$R_2 = \frac{0.2}{0.6}\times 1000$$

$$R_2 = 333.33\Omega$$

25. Choose the correct statement for in amplitude modulation:

(1) The amplitude of the modulated wave varies according to the massage signal

(2) The amplitude of the modulating wave varies according to the massage signal

(3) The frequency of the modulated wave varies according to the massage signal

(4) The frequency of the modulating wave varies according to the massage signal

Sol. Answer (1)

In amplitude modulation, amplitude of modulated wave varies according to the message signal.

26. One mole of an ideal gas having molecular mass M_0 is in a container moving with

velocity v. If container is suddenly stopped, then find the rise in temperature of Gas $[\gamma = 1.4]$

(1) $\frac{M_0 v^2}{5R}$

(2) $\frac{M_0 v^2}{3R}$

(3) $\frac{M_0 v^2}{7R}$

(4) Can't be determined

Sol. Answer (1)

$K.E. = \frac{1}{2} M_0 v^2$

$\gamma = 1.4 = \frac{7}{5} \Rightarrow f = 5$ (diatomic)

$\because K.E. = \frac{f}{2} R \Delta T$

$\frac{1}{2} M_0 v^2 = \frac{5}{2} R \Delta T$

$\Delta T = \frac{M_0 v^2}{5R}$

27. A wave of frequency 3 GHz strikes a particle of size $\frac{1}{100} th$ of wavelength of light then this phenomenon is called as

(1) Diffraction

(2) Scattering

(3) Reflection

(4) Refraction

Sol. Answer (2)

If the size of the particle is much smaller than wavelength of light, wave is scattered by the particle (Ray leigh's theory)

28. An electromagnetic wave is travelling in vaccum and its equation in the form of electric field is given by :

$\vec{E} = -a\sin(kz - \omega t)\hat{i} - b\sin(kz - \omega t)\hat{j}$, then its equation in the form of magnetic field will be

(1) $\vec{B} = \frac{b\hat{i} - a\hat{j}}{c} \sin(kz - \omega t)$

(2) $\vec{B} = \frac{b\hat{i} + a\hat{j}}{c} \sin(kz - \omega t)$

(3) $\vec{B} = \frac{-b\hat{i} - a\hat{j}}{c} \sin(kz - \omega t)$

(4) $\vec{B} = \frac{-b\hat{i} + a\hat{j}}{c} \sin(kz - \omega t)$

Sol. Answer (1)

$\vec{E} = -(-a\hat{i} - b\hat{j})\sin(kz - \omega t)\hat{i} \Rightarrow E_0 = \sqrt{a^2 + b^2}$

$\frac{E_0}{B_0} = C \Rightarrow B_0 = \frac{E_0}{c} = \frac{\sqrt{a^2 + b^2}}{c}$

$\Rightarrow |B| = \frac{\sqrt{a^2 + b^2}}{c} \sin(kz - \omega t)$

$\hat{B} = \hat{C} \times \hat{E} = (\hat{k}) \times \frac{a\hat{i} + b\hat{j}}{\sqrt{a^2 + b^2}} = \frac{b\hat{i} - a\hat{j}}{\sqrt{a^2 + b^2}}$

$\vec{B} = |\vec{B}|\hat{B} = \frac{\sqrt{a^2 + b^2}}{c} \sin(kz - \omega t) \times \frac{b\hat{i} - a\hat{j}}{\sqrt{a^2 + b^2}}$

$\vec{B} = \frac{b\hat{i} - a\hat{j}}{c} \sin(kz - \omega t)$

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