JEE MAIN SEP 2020 (MEMORY BASED) | 3RD SEP SHIFT-2

Note: The answers are based on memory based questions which may be incomplete and incorrect.

1. In a spring-mass system mass m is performing in SHM on a line with amplitude A and frequency f. Suddenly half of the mass comes to rest just at the moment, when it crosses mean position, then the new amplitude becomes λA, then λ will be

(1) $\frac{1}{2}$ (2) $\frac{1}{\sqrt{2}}$ (3) $\sqrt{2}$ (4) 1

Ans. (3)

Sol. $V_i = A\omega = A\sqrt{\frac{k}{m}}; V_f = A'\omega' = A'\sqrt{\frac{k}{\frac{m}{2}}}$

As the external force is absent, by conservation of linear momentum

$m_i V_i = m_f V_f$

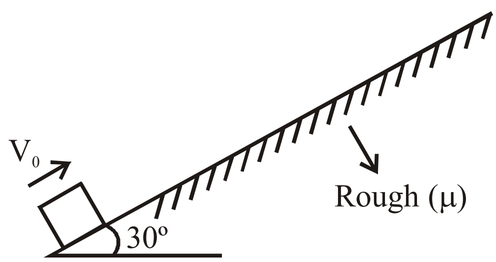
$m.A\omega = \frac{m}{2}A'\omega'$

$m.A\sqrt{\frac{k}{m}} = \frac{m}{2}A'\sqrt{\frac{k}{m/2}}$

$A = \frac{1}{2}\sqrt{2}A'$

$A' = \sqrt{2}A$

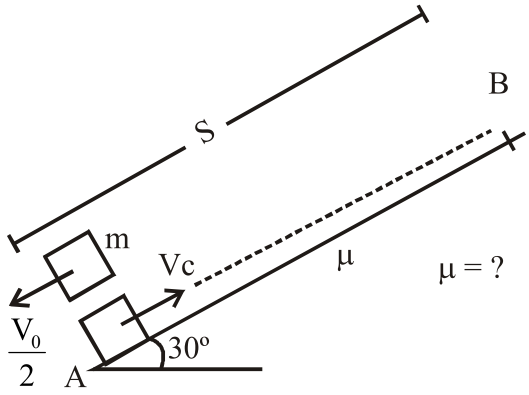
2. A block starts going up a rough inclined plane with speed V_0 as shown in figure. After some time it reaches to starting point again, with a speed $\frac{V_0}{2}$. Find coefficient of friction 'μ'. Given $g = 10\ m/s^2$.



(1) 0.15 (2) 0.35 (3) 0.75 (4) 0.80

Ans. (2)

Sol.



For up the inclined motion $(A \rightarrow B)$

$a_1 = g\sin 30° + \mu g\cos 30° = 5 + 5\sqrt{3}\mu$

and

$V_0^2 - 2a_1(s) = 0$

$s = \frac{V_0^2}{a_1}$ ....(i)

For down the inclined motion $(B \rightarrow A)$

$a_2 = g\sin 30° - \mu g\cos 30° = 5 - 5\sqrt{3}\mu$

and

$\left(\frac{V_0}{2}\right)^2 = 2a_2\,(s)$

$s = \frac{V_0^2}{4a_2}$ ....(ii)

From equation (i) and (ii)

$\frac{V_0^2}{a_1} = \frac{V_0^2}{4a_2}$

$\Rightarrow a_1 = 4a_2$

$\Rightarrow 5 + 5\sqrt{3}\mu = 4\{5 - 5\sqrt{3}\mu\}$

$\Rightarrow 5 + 5\sqrt{3}\mu = 20 - 20\sqrt{3}\mu \Rightarrow 25\sqrt{3}\mu = 15 \Rightarrow \mu = \frac{\sqrt{3}}{5} = 0.35$

3. An ideal gas is heated by 160 J of heat at constant pressure, its temperature rises by 50ºC and if 240 J of heat is supplied at constant volume, temperature rises by 100ºC, then its degree of freedom should be :

(1) 3 (2) 5 (3) 6 (4) 7

Ans. (3)

Sol. At constant pressure :

$\Delta Q = nC_P\Delta T$

$\Rightarrow 160 = nC_P\, 50$ ...(1)

At constant volume

$\Delta Q = nC_V\Delta T$

$\Rightarrow 240 = nC_V\, 100$ ...(2)

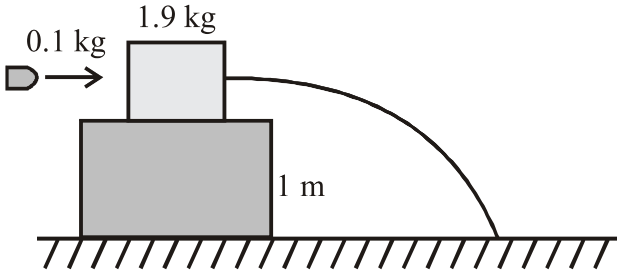
Equation (1) divided by (2)

$$\frac{160}{240} = \frac{C_P}{C_V}\frac{50}{100}$$

$$\frac{C_P}{C_V} = \frac{4}{3} = 1 + \frac{2}{f}$$

f = 6

4. In the given diagram a 0.1 kg bullet moving with speed 20 m/sec strikes 1.9 kg mass and get embedded in it. Find the kinetic energy of the mass with which it will strikes the ground is.



(1) 11 J (2) 21 J (3) 25 J (4) 30 J

Ans. (2)

Sol. Conservation of linear momentum

$0.1 \times 20 = (0.1 + 1.9) \times v$

$v = 1$ m/s

Using work energy theorem

$W_g = \Delta k$

$2 \times g \times 1 = k - \frac{1}{2} \times 2 \times 1^2$

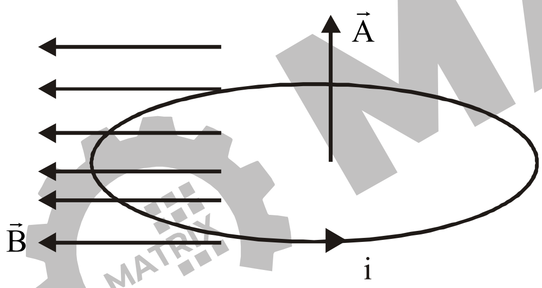
$\therefore\ k = 21$ J

5. A loop of area 'S' m^2 and N turns carrying current 'i' is placed in a uniform magnetic field 'B' with its plane parallel to $\vec{B}$. If torque 'τ' is experienced by loop due to magnetic field, find $|\vec{B}|$

(1) $\frac{\tau}{NiS}$ (2) $\frac{N\tau}{iS}$ (3) $\frac{i\tau}{NS}$ (4) $\frac{S\tau}{Ni}$

Ans. (1)

Sol.



$\tau = |\vec{M} \times \vec{B}| = NiABsin(90^\circ)$

$= NiAB = Ni\,S\,B$

$\Rightarrow \quad B = \frac{\tau}{Ni\,S}$

6. Dimension of solar constant is :

(1) $M^1L^0T^{-3}$ (2) $M^1L^1T^{-3}$ (3) $M^0L^0T^3$ (4) $M^1L^2T^{-3}$

Ans. (1)

Sol. Solar constant $= \frac{\text{Energy}}{\text{Time Area}}$

$= \frac{M^1L^2T^{-2}}{TL^2} = M^1L^0T^{-3}$

7. A body cools from 50ºC to 40ºC in 5 minutes in surrounding temperature 20ºC. Find temperature of body in next 5 minutes.

(1) 13.3ºC (2) 23.3ºC (3) 43.3ºC (4) 33.3ºC

Ans. (4)

Sol. Using Newton's Law of cooling

$$\frac{50-40}{5\text{Min}} = K\left(\frac{50+40}{2} - 2\right) \quad ....(i)$$

Next 5 Min.

$$\frac{40-\theta}{5} = K\left(\frac{40+\theta}{2} - 20\right) \quad ....(ii)$$

Dividing (ii) / (i)

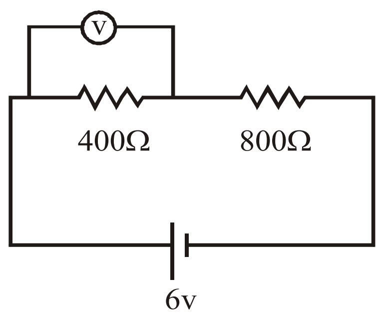
$$\frac{40-\theta}{10} = \frac{40+\theta-40}{50+40-40} = \frac{\theta}{50}$$

$$40 - \theta = \frac{\theta}{5}$$

$$200 - 5\theta = \theta$$

$$\therefore \theta = \frac{200}{6} = 33.3^\circ C$$

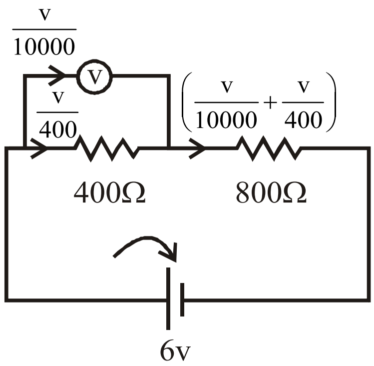
8. In the given diagram resistance of voltmeter is 10 kΩ. Find reading of the voltmeter.



(1) 4v (2) 3.23v (3) 1.95v (4) 1.26v

Ans. (3)

Sol.



Let voltmeter reading is v

$$\frac{v}{400}\times 400+\left(\frac{v}{10000}+\frac{v}{400}\right)800=6$$

$$\Rightarrow \quad v+\frac{8v}{100}+2v=6$$

$$\frac{77v}{25}=6$$

$$v=\frac{150}{77}=1.95v$$

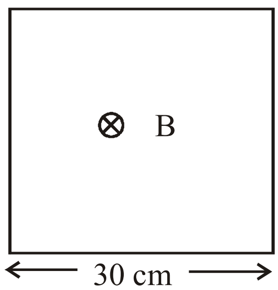
9. A square wire loop of side 30 cm & wire cross section having diameter 4 mm is placed perpendicular to a magnetic field changing at the rate 0.2 T/s. Find induced current in the wire loop.

(**Given:** Resistivity of wire material is 1.23×10^{-8} Ωm)

(1) 5.34×10^2 A (2) 15.3 A (3) 7.34×10^2 A (4) 1.34×10^2 A

Ans. (2)

Sol.



Radius of cross section of wire $= \frac{d}{2} = 2\text{mm} = 2\times10^{-3}\text{ m}$

$\frac{dB}{dt} = 0.2\frac{T}{s}$

$R = \frac{\rho l}{a} = \frac{(1.23\times10^{-8})(4\times0.3)}{\pi\times(2\times10^{-3})^2} = 0.1175\times10^{-2}$

$\phi = BA = B(0.3)^2$

$|\in| = \frac{d\phi}{dt} = (0.3)^2\frac{dB}{dt} = 0.018$

$i = \frac{\in}{R} = \frac{0.018}{0.1175\times10^{-2}} = 15.3\text{A}$

10. Electric field of an electromagnetic wave is $\vec{E} = E_0\cos(\omega t - kx)\,\hat{j}$. The equation of corresponding magnetic field at $t = 0$ should be :

(1) $\vec{B} = E_0\sqrt{\mu_0 \in_0}\cos kx\,\hat{k}$

(2) $\vec{B} = \frac{E_0}{\sqrt{\mu_0 \in_0}}\cos kx\,\hat{k}$

(3) $\vec{B} = E_0\sqrt{\mu_0 \in_0}\cos kx\left(-\hat{k}\right)$

(4) $\vec{B} = \frac{E_0}{\sqrt{\mu_0 \in_0}}\cos kx\left(-\hat{k}\right)$

Ans. (1)

Sol. $B_0 = \frac{E_0}{C} = \frac{E_0}{1/\sqrt{\mu_0 \in_0}} = E_0\sqrt{\mu_0 \in_0}$

As the light is propagating in x direction

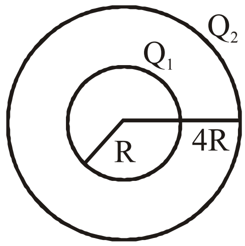
& $\hat{E}\times\hat{B} \parallel \hat{C}$

$\therefore$ $\vec{B}$ should be in $\hat{k}$ direction

$\therefore$ $\vec{B} = B_0\cos(\omega t - kx)\,\hat{k}$

At $t = 0$, $\vec{B} = B_0\cos kx$

11. In the given figure, there are two concentric spherical shells, find potential difference between the spheres



(1) $\frac{3}{8\pi\epsilon_0}\cdot\frac{Q_1}{R}$ (2) $\frac{3}{16\pi\epsilon_0}\cdot\frac{Q_2}{R}$ (3) $\frac{3}{4\pi\epsilon_0}\cdot\frac{Q_1}{R}$ (4) $\frac{3}{16\pi\epsilon_0}\cdot\frac{Q_1}{R}$

Ans. (4)

Sol. $V_{inner} = \frac{KQ_1}{R} + \frac{KQ_2}{4R}$

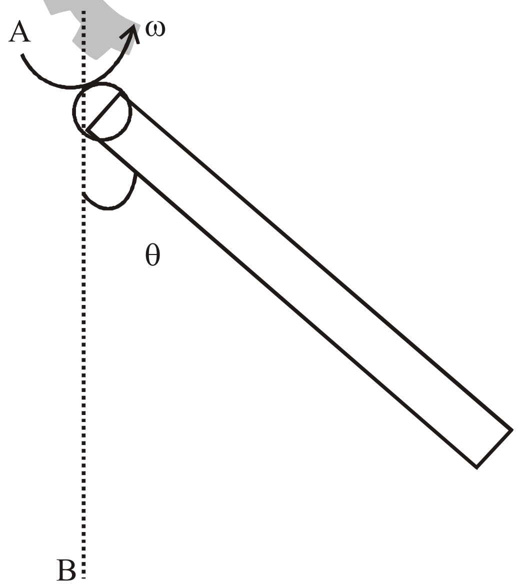
$V_{outer} = \frac{KQ_1}{4R} + \frac{KQ_2}{4R}$

Potential difference

$$\Delta V = V_{inner} - V_{outer}$$

$$= \frac{3}{4}\cdot\frac{KQ_1}{R} = \frac{3}{16\pi\epsilon_0}\cdot\frac{Q_1}{R}$$

12. A rod is rotating with constant angular velocity ω about axis AB. Find cosθ



(1) $\frac{g}{2\ell\omega^2}$ (2) $\frac{g}{\ell\omega^2}$ (3) $\frac{2g}{\ell\omega^2}$ (4) $\frac{3g}{2\ell\omega^2}$

Ans. (4)

Sol. Torque of centrifugal force $\tau_{cf} = dm.x\sin\theta\omega^2 x\cos\theta = \frac{m}{\ell}\omega^2 \sin\theta\cos\theta\int_0^{\ell} x^2 dx$

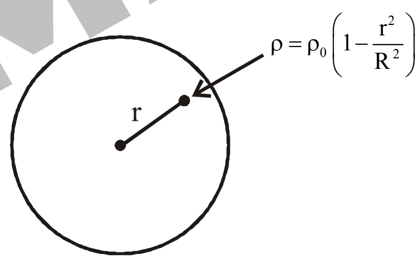
$$\tau_{ef} = \frac{m\ell^2\omega^2 \sin\theta\cos\theta}{3}$$

$\tau_{mg} = \tau_{cf}$

$$mg.\frac{\ell}{2}\sin\theta = \frac{m\ell^2\omega^2\sin\theta\cos\theta}{3}$$

$$\cos\theta = \frac{3g}{2\ell\omega^2}$$

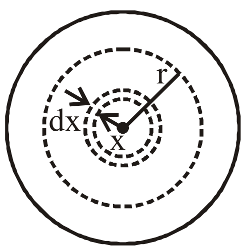
13. Mass density of a sphere having radius R varies as $\rho = \rho_0\left(1-\frac{r^2}{R^2}\right)$. Find maximum magnitude of gravitational field.



(1) $\frac{4}{3}\pi G\rho_0 R$ (2) $\frac{2\sqrt{3}}{5}\pi G\rho_0 R$ (3) $\frac{8\sqrt{5}}{27}\pi G\rho_0 R$ (4) $\frac{2\sqrt{5}}{27}\pi G\rho_0 R$

Ans. (3)

Sol.



$dm = \rho \times 4\pi x^2 dx$

$= \rho_0\left(1-\frac{x^2}{R^2}\right)\times 4\pi x^2 dx$

gravitational field due to small element, $dE = \frac{Gdm}{r^2}$

$$E = \int_0^r \frac{G\rho_0\left(1-\frac{x^2}{R^2}\right)4\pi x^2 dx}{r^2}$$

$$E = \frac{G\rho_0 4\pi}{r^2}\int_0^r\left(x^2-\frac{x^4}{R^2}\right)dx$$

$$= \frac{G\rho_0 4\pi}{r^2}\left[\frac{r^3}{3}-\frac{r^5}{5R^2}\right]$$

$$= G\rho_0 4\pi\left[\frac{r}{3}-\frac{r^3}{5R^2}\right]$$

E is maximum when $\frac{dE}{dr} = 0 \Rightarrow \frac{dE}{dr} = 4\pi G\rho_0\left(\frac{1}{3}-\frac{3r^2}{5R^2}\right) = 0$

$$\Rightarrow \frac{3r^2}{5R^2} = \frac{1}{3} \Rightarrow r^2 = \frac{5R^2}{9} \Rightarrow r = \frac{\sqrt{5}}{3}R$$

$$E_{max} = 4\pi G\rho_0 \times \frac{\sqrt{5}R}{3}\left[\frac{1}{3}-\frac{1}{5}\times\frac{5}{9}\right]$$

$$E_{max} = \frac{8\sqrt{5}}{27}\pi G\rho_0.R$$

14. An object is placed at principle axis of a spherical mirror at a distance of 30 cm from mirror. Spherical mirror forms its real image at a distance of 10 cm from mirror. If object start moving with velocity 9 cm/sec. Find initial velocity of image.

(1) –9 cm/sec (2) –4 cm/sec (3) –1 cm/sec (4) –3 cm/sec

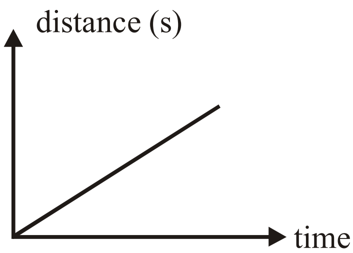
Ans. (3)

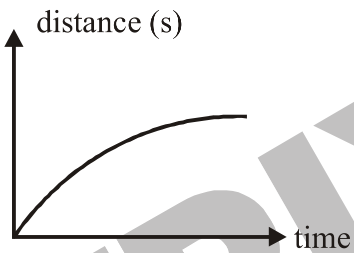
Sol. $v_i = -\frac{v^2}{u^2} v_0$

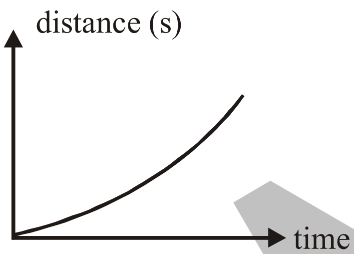
$= -\left(\frac{10}{30}\right)^2 (9)$

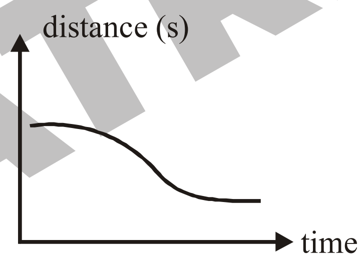
$= -1 \text{cm/sec}$

15. Constant power P is supplied to a particle havign mass m, initially at rest. Choose correct graph.

(1)


(2)


(3)


(4)


Ans. (3)

Sol. $P.t = \frac{1}{2} mv^2 \Rightarrow v = \left(\sqrt{\frac{2P}{m}}\right) t^{1/2}$

$s = \int_0^t vdt = \sqrt{\frac{2P}{m}} \int_0^t t^{1/2} dt$

$= \sqrt{\frac{2P}{m}} . \frac{t^{3/2}}{3/2}$

$s = \sqrt{\frac{8P}{9m}} . t^{3/2}$

16. Two points sources radiates having same power of 200W. One source is emitting photons of $\lambda_1 = 500$ nm and other emitting X–ray photons of $\lambda_2 = 1$nm. Find ratio of photon density from both the sources?

(1) 200 (2) 500 (3) 250 (4) 0.4

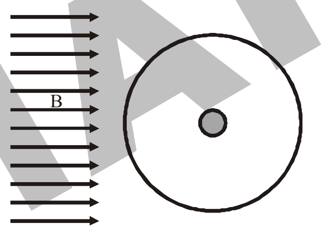
Ans. (2)

Sol. P_S – Power of sources

$P_S = n\frac{hc}{\lambda}$; n = no. of photons emitted /s

$\Rightarrow \quad n \propto \lambda \quad \Rightarrow \quad \frac{n_1}{n_2} = \frac{\lambda_1}{\lambda 2} = 500$

17. In the given diagram a diamagnetic sphere has a small cavity at its centre and now paramagnetic material is inserted in the cavity. The sphere is kept in a external magnetic field B then net magnetic field at the centre of sphere will be :-



(1) 0 (2) B (3) $B_0 > B$ (4) $B_0 < B$

Ans. (1)

Sol. When magnetic field is applied diamagnetic substance produces magnetic field in opposite direction so net magnetic field will be zero.

18. A p - n junction becomes active as photons of wavelength ; $\lambda = 400$ nm falls on it. Find the energy band gap?

(1) 3.1 eV (2) 4.51 eV (3) 2.45 eV (4) 5.34 eV

Ans. (1)

Sol. $\lambda = 400$ nm

Band gap $E_g = \frac{hc}{\lambda} = \frac{1240}{400} \approx 3.1eV$

19. Two light rays having the same wavelength λ in vacuum are in phase initially. Then the first ray travels a path L_1 through a medium of refractive index n_1 while the second ray travels a path of length L_2 through a medium of refractive index n_2. The two waves are then combined to produce interference. The phase difference between the two waves at the point of interference is :

(1) $\frac{2\pi}{\lambda}(L_2 - L_1)$ (2) $\frac{2\pi}{\lambda}(n_1L_1 - n_2L_2)$ (3) $\frac{2\pi}{\lambda}(n_2L_1 - n_1L_2)$ (4) $\frac{2\pi}{\lambda}\left(\frac{L_1}{n_1} - \frac{L_2}{n_2}\right)$

Ans. (2)

Sol. Here, optical path for first ray $= n_1L_1$

Optical path for second ray $= n_2L_2$

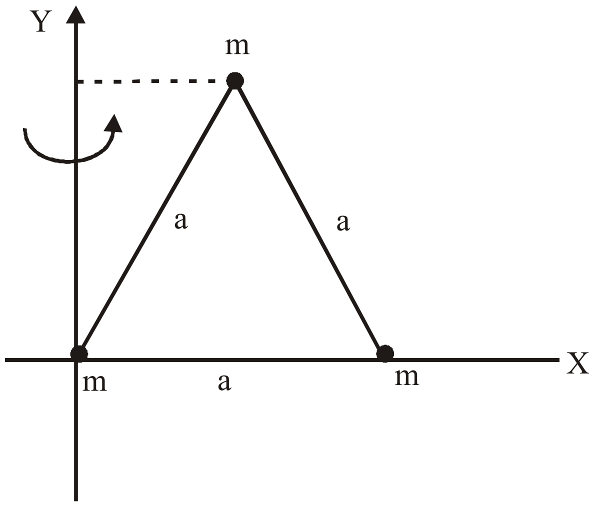
Path difference $= n_1L_1 - n_2L_2$

Now, phase difference

$$= \frac{2\pi}{\lambda} \times \text{path difference}$$

$$= \frac{2\pi}{\lambda} \times (n_1L_1 - n_2L_2)$$

20. In the diagram three point masses 'm' each are fixed at the corners of an equilateral triangle. Moment of inertia of the system about y-axis is $\frac{N}{20}ma^2$, N is :



(1) 25 (2) 50 (3) 75 (4) 100

Ans. (1)

Sol. $I = m \times O^2 + ma^2 + m\left(\frac{a}{2}\right)^2$

$= \frac{5}{4}ma^2 = \frac{25}{20}ma^2$

N = 25