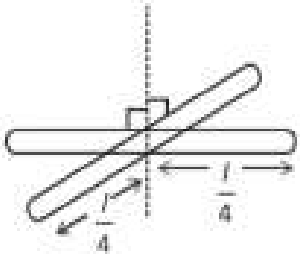
PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. The moment of inertia of a uniform rod of mass m and length l is α when rotated about an axis passing through centre and perpendicular to the length. If the rod is broken into equal halves and arranged as shown, then the moment of inertia about the given axis is



(1) 2α

(2) $\frac{\alpha}{2}$

(3) 4α

(4) $\frac{\alpha}{4}$

Answer (4)

Sol. $I_i = \frac{ml^2}{12} = \alpha$

$$I_f = 2\frac{\left(\frac{m}{2}\left(\frac{l}{2}\right)^2\right)}{12} = \frac{ml^2}{48}$$

$$I_f = \frac{\alpha}{4}$$

2. Two point charges q and $9q$ are placed at distance of l from each other. Then the electric field is zero at a

(1) Distance $\frac{l}{4}$ from charge $9q$

(2) Distance $\frac{3l}{4}$ from charge q

(3) Distance $\frac{l}{3}$ from charge $9q$

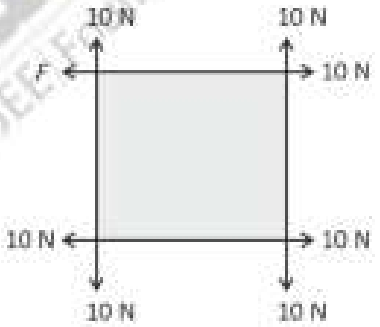
(4) Distance $\frac{l}{4}$ from charge q

Answer (4)

Sol. $\frac{Kq}{x^2} = \frac{K9q}{(l-x)^2} \Rightarrow 3x = l - x$

$$x = \frac{l}{4}$$

3. A square shape lamina of mass M kg is at rest. Find value of F (in N).



(1) 10 N (2) 15 N

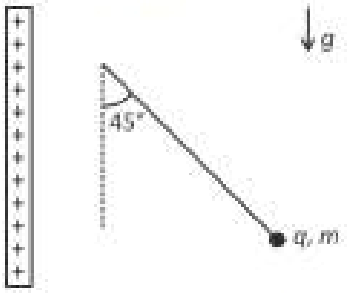
(3) 20 N (4) 30 N

Answer (1)

Sol. In equilibrium net force most zero.

So, $F = 10$ N

4. The figure shows an infinite plane having uniform charge density σ and a small charged particle having charge q and mass m suspended by a light insulating thread. Find σ if the charge is in equilibrium.



(1) $\frac{2\varepsilon_0 mg}{q}$ (2) $\frac{\varepsilon_0 mg}{2q}$

(3) $\frac{2q}{\varepsilon_0 mg}$ (4) $\frac{2q\varepsilon_0}{mg}$

Answer (1)

Sol. $\tan\theta\frac{q\left(\frac{\sigma}{2\varepsilon_0}\right)}{mg}=\tan45°$

$\Rightarrow \sigma=\frac{2\varepsilon_0 mg}{q}$

5. Find the ratio of $\left(\gamma=\frac{C_p}{C_v}\right)$ for two gases having degree of freedoms $f = 3$ & $f = 5$.

(1) $\frac{21}{25}$

(2) $\frac{3}{7}$

(3) $\frac{25}{21}$

(4) $\frac{7}{3}$

Answer (3)

Sol. $\gamma=1+\frac{2}{f}$

$\gamma_1=1+\frac{2}{3}=\frac{5}{3}$

$\gamma_2=1+\frac{2}{5}=\frac{7}{5}$

$\frac{\gamma_1}{\gamma_2}=\frac{25}{21}$

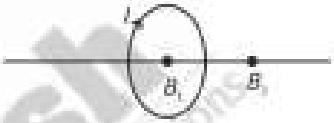
6. A current carrying wire is in form of a circle of radius R. Find ratio of magnetic field at centre to the magnetic field at axial point at a distance R from it's centre.

(1) 2 (2) $2\sqrt{2}$

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

Answer (2)

Sol.



$B_1=\frac{\mu_0 I}{2R}$

$B_2=\frac{\mu_0 IR^2}{2\cdot(2R^2)^{3/2}}=\frac{\mu_0 I}{2\cdot2\sqrt{2}R}$

$\frac{B_1}{B_2}=2\sqrt{2}$

7. Two SHMs are superimposed on a particle moving along x axis as $x_1 = A\sin\omega t$ and $x_2 = A\sin(\omega t + \pi/3)$ then acceleration of particle is (given $\omega = 5$)

(1) $-25A\sin(5t+\pi/3)$

(2) $-25A\sin(5t+\pi/6)$

(3) $-25\sqrt{3}A\sin(5t+\pi/6)$

(4) $25\sqrt{3}A\sin(5t-\pi/6)$

Answer (3)

Sol. $x = x_1 + x_2 = 2A\sin(\omega t + \pi/6)$

$$\cos\left(\frac{\pi}{6}\right) = \sqrt{3}\,A\sin(\omega t + \pi/6)$$

$$\Rightarrow \quad a = -\sqrt{3}A\omega^2\sin(\omega t + \pi/6)$$

$$= -25\sqrt{3}\,A\sin(5t + \pi/6)$$

8. What is the ratio of radius of n^{th} orbit in H, He^+ and Li^{+2}? (assume Bohr model is applicable)

(1) 6 : 3 : 1

(2) 6 : 3 : 2

(3) 3 : 6 : 2

(4) 4 : 3 : 2

Answer (2)

Sol. $r_n = \dfrac{n^2 r_0}{Z}$

$$r_H : r_{He^+} : r_{Li^{+2}} = 1 : \frac{1}{2} : \frac{1}{3}$$

$$= 6 : 3 : 2$$

9. Find the dimension of $\dfrac{a}{b^2}$ from the given formula $\left(P + \dfrac{a}{v^2}\right)(v - b) = RT$ where symbols have their usual meaning.

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

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

(3) ML^2L^{-2}

(4) MLT

Answer (2)

Sol. $a = Pv^2$

$b = v$

$$\frac{a}{b^2} = \frac{Pv^2}{v^2} = P = \frac{ML^{-1}T^{-2}}{L^3}$$

10. Match the List-I with the List-II.

	List-I		List-II
(i)	Coefficient of viscosity	(a)	$M^0L^0T^0$
(ii)	Strain	(b)	$M^{-1}LT^2$
(iii)	Compressibility	(c)	$ML^{-2}T^{-2}$
(iv)	Pressure gradient	(d)	$ML^{-1}T^{-1}$

(1) (i)-(a), (ii)-(c), (iii) -(d), (iv)-(b)

(2) (i)-(d), (ii)-(a), (iii) -(b), (iv)-(c)

(3) (i)-(b), (ii)-(d), (iii) -(c), (iv)-(a)

(4) (i)-(c), (ii)-(b), (iii) -(d), (iv)-(a)

Answer (2)

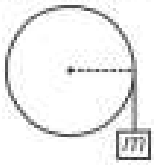
Sol. [Coefficient of viscosity] = $MT^{-1}T^{-1}$

$$[\text{Compressibility}] = \frac{1}{[\text{Bulk Modulus}]} = M^{-1}LT^2$$

[Strain] = dimensionless

$$[\text{Pressure gradient}] = \frac{[\text{Pressure}]}{[\text{Length}]} = ML^{-2}T^{-2}$$

11. The figure shows a disc of mass 5 kg and radius 10 cm having axis fixed and free to rotate about its axis. A 2 kg block is suspended with the help of a string wound around the disc and released from rest. The angular velocity of the disc when the block moves by 0.2 m is (Take $g = 10\ ms^2$)



(1) $\dfrac{40}{9}$ rad/s

(2) $\dfrac{40}{3}$ rad/s

(3) $\dfrac{30}{7}$ rad/s

(4) $\dfrac{28}{5}$ rad/s

Answer (2)

Sol. From work energy theorem

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{MR^2}{2}\right)\omega^2$$

Also $v = \omega R$

$$\Rightarrow \quad \omega = \sqrt{\frac{4mgh}{(2m+M)R^2}}$$

$$= \frac{40}{3} \text{ rad/s}$$

12. Speed of a boat in still water is 27 km/hr and speed of river flow is 9km/hr. If boat rows at angle 150° with the river flow and it takes 30 seconds to cross the river. Find with of the river.

(1) 56 m

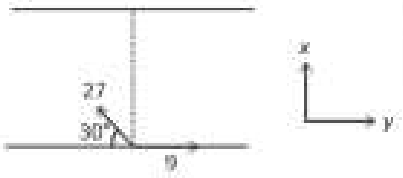
(2) 100 m

(3) 225 m

(4) 112.5 m

Answer (4)

Sol.

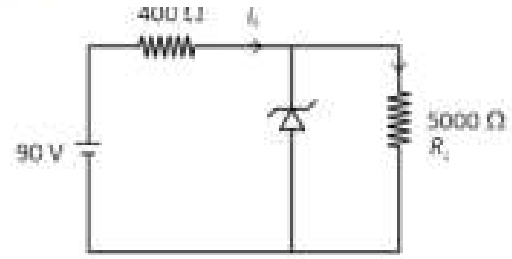


$$V_r = 27 \times \frac{1}{2} \text{ km/h}$$

$$W = \frac{27}{2} \times \frac{5}{18} \times 30$$

$$W = 112.5 \text{ m}$$

13. The figure shows an electrical circuit with a zener diode having a rated voltage $V_z = 30$ V. Find the current through the diode in mA



(1) 6 mA

(2) 150 mA

(3) 144 mA

(4) 154 mA

Answer (3)

Sol. $V_{(across)}$ Zener = 30 V $\quad i$ through $= \frac{30}{5000} = 6$ mA

V_{across} $R = 90 - 30$ V $= 60$ V $\quad i$ through $R = \frac{60}{400} = 150$ mA

150mA = $i_2 + i_R$ $\quad i_2 = 144$ mA

150 mA = $i_2 + 6$ mA

14. Correct relation between permeability of vacuum μ_0, relative permeability μ_r, permeability of medium μ and magnetic susceptibility χ is

(1) $\mu = \chi\mu_0$

(2) $\mu = (\mu_{r+1})\mu_0$

(3) $\mu = (1 + \chi)\mu_0$

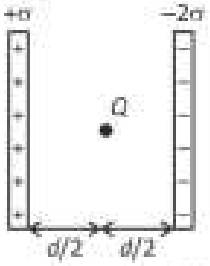
(4) $\mu = \chi(\mu_r + 1)$

Answer (3)

Sol. $\mu_r = 1 + \chi \quad \mu = \mu_r\mu_0$

$\mu = (1 + \chi)\mu_0$

15. Two uniformly charged sheets are shown in the figure. Find net force on the charge Q placed symmetrically between the plates.

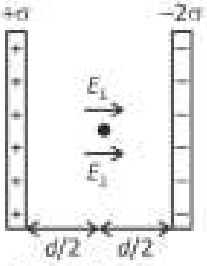


(1) $\frac{3\sigma Q}{\varepsilon_0}$ (2) $\frac{2\sigma Q}{\varepsilon_0}$

(3) $\frac{3}{2}\frac{\sigma Q}{\varepsilon_0}$ (4) Zero

Answer (3)

Sol.



$F = E_1 + E_2$

$= \frac{\sigma}{2\varepsilon_0} + \frac{2\sigma}{2\varepsilon_0}$

$= \frac{3}{2}\frac{\sigma}{\varepsilon_0}$

$F = \frac{3}{2}\frac{\sigma Q}{\varepsilon_0}$

16. In a single slit diffraction using light of wavelength λ, the 2nd minima is formed at θ_1 and 3rd maxima is at θ_2. If $\theta_1 + \theta_2 = 30°$, then the slit width is

(1) $\frac{66\lambda}{\pi}$ (2) $\frac{22\lambda}{\pi}$

(3) $\frac{33\lambda}{\pi}$ (4) $\frac{11\lambda}{\pi}$

Answer (3)

Sol. 2nd minima is formed at $\theta_1 = \frac{2\lambda}{a}\left(\theta = \frac{n\lambda}{a}\right)$

3rd maxima is formed at $\theta_2 = \frac{7\lambda}{2a}\left(\theta = (2n+1)\frac{n\lambda}{a}\right)$

$\theta_1 + \theta_2 = \frac{\pi}{6} \Rightarrow \frac{2\lambda}{a} + \frac{7\lambda}{2a} = \frac{\pi}{6}$ or $a = \frac{33\lambda}{\pi}$

17. A wine having length 2 m having yang modulus $Y = 2 \times 10^{11}$ N/m^2. Axial strain is 0.2 and Poisson ratio is 0.01 for a deformation. Find energy density for elastic energy stored in rod.

(1) 2×10^9 J/m^3 (2) 4×10^9 J/m^3

(3) 10^9 J/m^3 (4) 5×10^8 J/m^3

Answer (2)

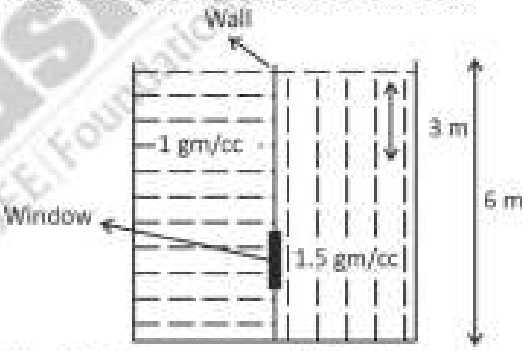
Sol. Energy stored per unit volume will

$= \bar{E} = \frac{1}{2}\sigma\varepsilon = \frac{1}{2}Y\varepsilon^2$

$= \frac{1}{2} \times 2 \times 10^{11} \times 0.2 \times 0.2$

$= 4 \times 10^9$ J/m^3

18. A concrete wall separates two liquids of densities 1 gm/cc and 1.5 gm/cc as shown. There is a square window of area 100 cm^2 of wood instead of concrete. Assuming no friction, find extend force needed to hold the window.



(1) 400 N (2) 300 N

(3) 150 N (4) 250 N

Answer (3)

Sol. $F = |p_1 - p_2|A = |\rho_2 - \rho_1|ghA$

$= 0.5 \times 10^3 \times 10 \times 3 \times 100 \times 10^{-4}$

$= 150$ N

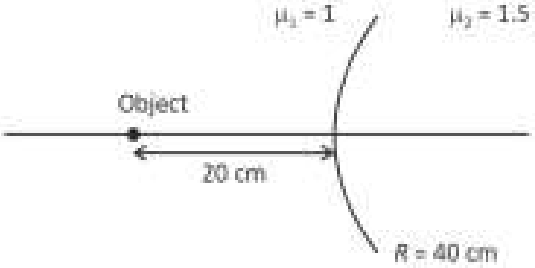
19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. The figure shows a spherical surface of radius 40 cm separating two mediums of refractive indices $\mu_1 = 1$ and $\mu_2 = 1.5$. A point object in the medium μ_2 at a distance 20 cm from the separation forms an image whose distance from the separation is x cm, where x is



Answer (40)

Sol. $\mu_1 = 1, \mu_2 = 1.5, R = +40$ cm, $u = -20$ cm

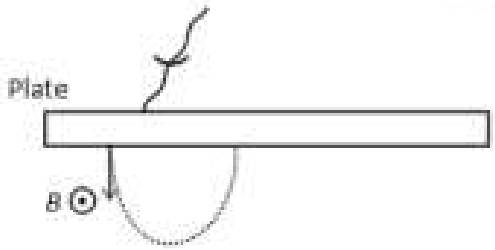
$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\frac{1.5}{v} - \frac{1}{-20} = \frac{1.5-1}{+40}$$

$$\frac{1.5}{v} = \frac{1}{80} - \frac{1}{20}$$

$$\Rightarrow v = -40 \text{ cm}$$

22. Photons of wavelength λ is incident on a metal of work function ϕ, there exist a magnetic field B, perpendicular to the initial velocity of photoelectron. If radius of photoelectron is $\frac{1}{eB}\sqrt{\alpha m\left(\frac{hc}{\lambda} - \phi\right)}$. Find value of α.



Answer (2)

Sol. $\frac{hc}{\lambda} - \phi = \frac{1}{2}mv^2$

$$R = \frac{mv}{qB} = \frac{m}{eB}\sqrt{\left(\frac{2hc}{\lambda} - 2\phi\right)\frac{1}{m}}$$

$$R = \frac{1}{eB}\sqrt{2m\left(\frac{hc}{\lambda} - \phi\right)}$$

23. Particle is moving with constant speed $V_1 = 5$ m/s for distance x and remaining $\frac{3x}{2}$ distance with constant speed V_2. Find V_2 (m/s) is average speed for the journey is $\frac{5}{7}$ m/s.

Answer (10)

Sol. $V_{av} = \frac{\text{Total distance}}{\text{Total time}}$

$$\text{Total distance} = x + \frac{3x}{2} = \frac{5x}{2}$$

$$\text{Total time} = \frac{x}{5} + \frac{3x}{2V_2}$$

$$\frac{50}{7} = \frac{\frac{5}{2}x}{\frac{x}{5} + \frac{3x}{2V_2}}$$

$$50\left(\frac{1}{5} + \frac{3}{2V_2}\right) = \frac{7 \times 5}{2}$$

$$20 + \frac{150}{V_2} = 35$$

$$V_2 = 10$$

24.

25.