JEE Main 2018 Physics Paper With Solutions Shift 1 Jan 10

1. It is found that if a neutron suffers an elastic collinear collision with deuterium at rest, fractional loss of its energy is p_d; while for its similar collision with carbon nucleus at rest, fractional loss of energy is p_C. The values of p_d and p_c are respectively:

a. (0, 0)

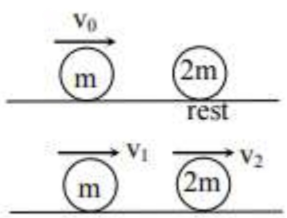
b. (0, 1)

c. (.89,.28)

d. (.28,.89)

Answer: (c)

Solution



L.M.C

$mv_1 + 2m\,V_2 = mV_0$

$V_1 + 2V_2 = V_0$ …(1)

$$e = \frac{V_2 - V_1}{V_0} = 1$$

$V_2 – V_1 = V_0$…(2)

On solving

$V_2 = 2V_0/3$ and $V_1 = V_0/3$

Final KE of neutron= $(1/2)mV_1^2 = (1/2)m(V_0/3)^2$

$$= \frac{1}{9}\left(\frac{1}{2}mV_0^2\right)$$

Loss of K.E = $(8/9)\,(1/2\,mv_0^2)$

Fractional loss $P_d = (8/9) = 0.89$

Similarly collision between N and C

$mV_1 + 12m.V_2 = mV_0$

$V_1 + 12V_2 = V_0$ …(1)

$V_1 – V_2 = V_0$ …(2)

On Solving

$V_2 = 2V_0/13$

And $V_1 = 11V_0/13$

$$\text{Final KE} = \frac{1}{2}m\left(\frac{11V_0}{13}\right)^2 = \frac{121}{169}\left(\frac{1}{2}mV_0^2\right)$$

$$\text{Loss in KE} = \frac{48}{169}\left(\frac{1}{2}mV_0^2\right)$$

Fractional loss $P_c = (48/169) = 0.28$

2. The mass of a hydrogen molecule is 3.32 x 10^{-27} kg. If 10^{23} hydrogen molecules strike, per second, a fixed wall of area 2 cm^2 at an angle of 45^0 to the normal, and rebound elastically with a speed of 10^3 m/s, then the pressure on the wall is nearly:

a. 2.35 x 10^2 N/m^2
b. 4.70 x 10^2 N/m^2
c. 2.35 x 10^3 N/m^2
d. 4.70 x 10^3 N/m^2

Answer: (a)

Solution

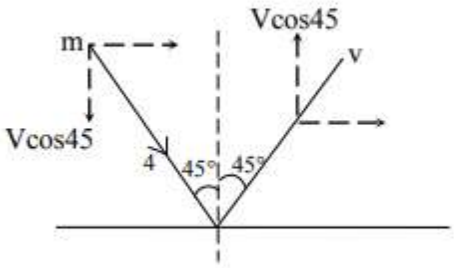
Change in momentum of one molecule

$$\Delta P_1 = 2\,mv\cos 45° = \sqrt{2}\,mv$$

$$\text{Force } F = \frac{\Delta P}{\Delta t} = n \times \Delta P_1$$

Where n $\rightarrow$ no. of molecules incident per unit time

Pressure P = Force/Area



$$P = \frac{n \times \sqrt{2}mv}{A}$$

$$P = \frac{10^{23} \times \sqrt{2} \times 3.32 \times 10^{-27} \times 10^{3}}{2 \times 10^{-4}}$$

$$P = \frac{3.32}{1.41} \times 10^{3} = 2.35 \times 10^{3}\ N/m^{2}$$

3. A solid sphere of radius r made of a soft material of bulk modulus K is surrounded by a liquid in a cylindrical container. A mass less piston of area a floats on the surface of the liquid, covering entire cross section of cylindrical container. When a mass m is placed on the surface of the piston to compress the liquid, the fractional decrement in the radius of the sphere,(dr/r) is:

a. mg/3Ka

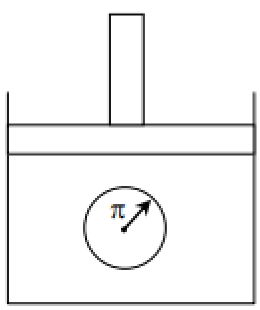
b. mg/Ka

c. Ka/mg

d. Ka/3mg

Answer: (a)

Solution



Bulk modulus

$$K = \left(\frac{-dP}{dV/V}\right)$$

$$\frac{dV}{V} = \frac{dP}{K}$$

$$\frac{dV}{V} = \frac{mg}{Ka} \qquad \ldots (1)$$

$$V = \frac{4}{3}\pi r^3$$

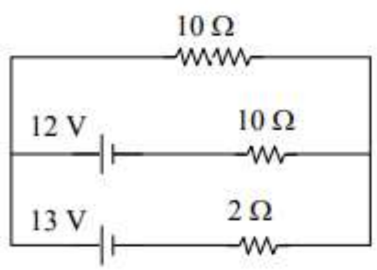
$$\frac{dV}{V} = 3\frac{dr}{r} \qquad \ldots (2)$$

From eq. (1) and (2)

$$\frac{dr}{r} = \frac{mg}{3Ka}$$

4. Two batteries with e.m.f. 12 V and 13 V are connected in parallel across a load resistor of 10 Ω. The internal resistances of the two batteries are 1 Ω and 2 Ω respectively. The voltage across the load lies between.

a. 11.4 V and 11.5 V
b. 11.7 V and 11.8 V
c. 11.6 V and 11.7 V
d. 11.5 V and 11.6 V



$$E_{eq} = \frac{\frac{E_1}{r_1} + \frac{E_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{\frac{12}{1} + \frac{13}{2}}{\frac{1}{1} + \frac{1}{2}} = \frac{37}{3}$$

$$r_{eq} = \frac{1 \times 2}{1+2} = \frac{2}{3}\,\Omega$$

$$V = \frac{E_{eq}}{R + r_{eq}} R = 11.56\text{ V}$$

5. A particle is moving in a circular path of radius a under the action of an attractive potential $U = -k/2r^2$. Its total energy is

a.zero

b. $-\frac{3}{2}\frac{k}{a^2}$

c. $-\frac{k}{4a^2}$

d. $\frac{k}{2a^2}$

Answer: (a)

Solution

$$U = -\frac{k}{2r^2}$$

$$F = -\frac{du}{dr} = +\frac{k}{2}\left(\frac{-2}{r^3}\right)$$

$$F = -\frac{k}{r^3}$$

$$\text{Centripetal force } \frac{mv^2}{r} = \frac{k}{r^3}$$

$$mv^2 = \frac{k}{r^2}$$

$$kE = \frac{1}{2}mv^2 = \frac{k}{2r^2}$$

$$\text{Total Energy } E = K + U = O$$

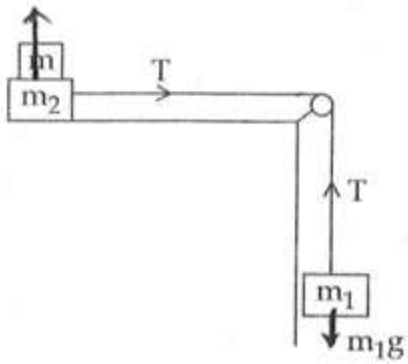
6. Two masses m_1 = 5 kg and m_2 = 10 kg, connected by an inextensible string over a frictionless pulley, are moving as shown in the figure. The coefficient of friction of horizontal surface is 0.15. The minimum weight m that should be put on top of m2 to stop the motion is:

a. 43.3 Kg

b. 10.3 Kg

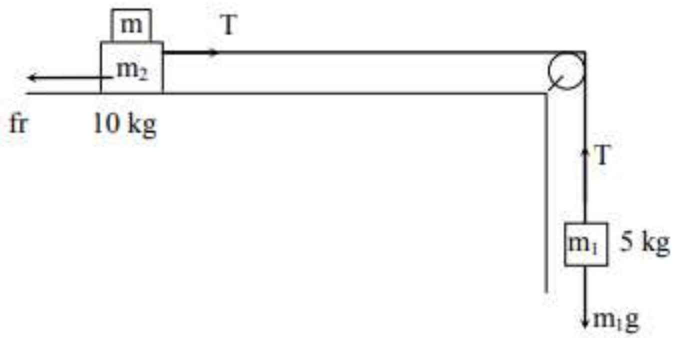
c. 18.3 Kg

d. 27.3 Kg



Answer: (d)

Solution



at equilibrium $f_r = T = m_1g$

$f_{rmax} = \mu(m_2 + m)g$

$\mu(10+m)g = 5g$

$10 + m = 5/0.15$

$10+m = 100/3$

$m = (70/3)kg = 23.3$ kg.

The minimum weight in the options is 27.3 kg.

7. If the series limit frequency of the Lyman series is ν_L, then the series limit frequency of the Pfund series is:

a. $\nu_L/16$
b. $\nu_L/25$
c. $25\nu_L$
d. $16\nu_L$

Answer: (b)

Solution

Series limit is

Lyman : ∞
$\rightarrow 1$

P fund : ∞
$\rightarrow 5$

ν_{Lyman} = RC

ν_{Pfund} = RC/25

8. Unpolarized light of intensity I passes through an ideal polarizer A. Another identical polarizer B is placed behind A. the intensity of light beyond B is found to be I/2. Now another identical polarizer C is placed between A and B. The intensity beyond B is now found to be I/8. The angle between polarizer A and C is:

a. 45^0

b. 60^0

c. 0^0

d. 30^0

Answer: (a)

Solution

Unpolarized light passes the A

$I_{after\ A} = I/2$

$I_{after\ B} = I/2$ (given)

The angle between A and B is 90^0

Let A and C have angle θ

$I_{after\ c} = (I/2)\cos^2\theta$

$I_{after\ B} = (I/2)\cos^2\theta\cos^2(90 - \theta) = I/8 \therefore [\cos\theta\sin\theta]^2 = 1/4$

Sin 2 θ = 1

Therefore, $\theta = 45^0$

9. An electron from various excited states of hydrogen atom emit radiation to come to

the ground state. Let λ_n, λ_g be the de Broglie wavelength of the electron in the n^{th} state and the ground state respectively. Let Λ_n be the wavelength of the emitted photon in the transition from the n^{th} state to the ground state. For large n, (A, B are constants)

a. $\Lambda^2_n \approx A + B\lambda^2_n$

b. $\Lambda^2_n \approx \lambda$

c. $\Lambda_n \approx A + (B/\lambda^2 n)$

d. $\Lambda_n \approx A + B\lambda_n$

Answer: (c)

Solution

$mvr = (nh/2\pi)$

$\lambda_{de\ Broglie} = (h/p) = (2\pi r/n)$

$\lambda_n = (2\pi r_n/n)$

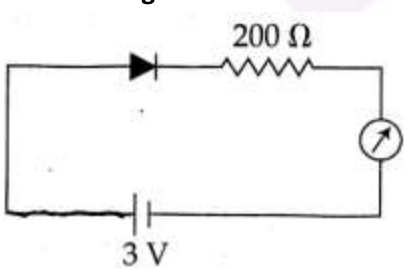
$$\lambda_g = \frac{2\pi r_1}{1} = 2\pi r_1 \qquad \therefore \frac{\lambda_n}{\lambda_g} = \frac{r_n}{n r_1} = n$$

$$\frac{1}{\lambda} = R\left[1 - \frac{1}{n^2}\right]$$

$$\Rightarrow \Lambda_n = \frac{n^2}{R(n^2-1)} = \frac{1}{R}\left[\frac{\lambda_n^2}{\lambda_n^2 - \lambda_g^2}\right]$$

$$= \frac{1}{R}\left[\frac{1}{1-\left(\frac{\lambda_g}{\lambda_n}\right)^2}\right] \approx \frac{1}{R}\left[1 + \left(\frac{\lambda_g}{\lambda_n}\right)^2\right] = A + \frac{B}{\lambda_n^2}$$

10. The reading of the ammeter for a silicon diode in the given circuit is:



a. 11.5 mA

b. 13.5 mA

c. 0

d. 15 mA

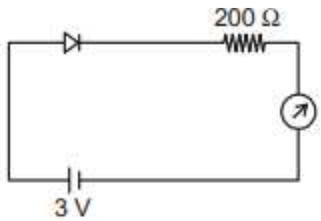
Answer: (a)

Solution

$$I = \frac{V - V_{diode}}{R}$$

$$= \left[\frac{3 - 0.7}{200} \times 1000\right] \text{ mA}$$

$$= 11.5 \text{ mA}$$



11. An electron, a proton and an alpha particle having the same kinetic energy are moving in circular orbits of radii r_e, r_p, r_α respectively in a uniform magnetic field B. The relation between r_e, r_p, r_α is:

a. $r_e < r_p < r_\alpha$

b. $r_e < r_\alpha < r_p$

c. $r_e > r_p = r_\alpha$

d. $r_e < r_p = r_\alpha$

Answer: (d)

Solution

r = mv/qB = p/qB

K = (1/2)mv^2-------same

= (p^2/2m)

Therefore, $p \propto \sqrt{m}$

B same

$r \propto (p/q)$ or $\sqrt{m}/q$

$q_p = q_e$

$m_p = 183\ m_e$

$q_\alpha = 2\ q_p$

$m_\alpha = 4\ m_p$

Mass of electron is least and charge qe = e

So, $r_e < r_p = r_\alpha$

12. A parallel plate capacitor of capacitance 90 pF is connected to a battery of emf 20V. If a dielectric material of dielectric constant k = 5/3 is inserted between the plates, the magnitude of the induced charge will be:

a. 2.4 nC

b. 0.9 nC

c. 1.2 nC

d. 0.3 nC

Answer: (c)

Solution

Battery remains connected as dielectric is introduced

So E, V unchanged

$q_0 = C_0V$

$q = kC_0V$

Induced charge $q' = q - q_0$

$= C_0V(k-1)$

$= 90 \times 10^{-12} \times 20((5/3)-1) = 1.2$ nC

13. For an RLC circuit driven with voltage of amplitude V_m and frequency $\omega_0 = \frac{1}{\sqrt{LC}}$ the current exhibits resonance. The quality factor, Q is given by:

a. $\frac{R}{(\omega_0 C)}$

b. $\frac{CR}{\omega_0}$

c. $\frac{\omega_0 L}{R}$

d. $\frac{\omega_0 R}{L}$

Answer: (c)

Solution:

Quantity factor

$$Q = \frac{\omega_0 L}{R}$$ -------from theory

14. A telephonic communication service is working at carrier frequency of 10 GHz. Only 10% of it is utilized for transmission. How

a. 2×10^5

b. 2×10^5

c. 2×10^3

d. 2×10^4

Answer: (a)

Solution

No of channels =(carrier frequencyx0.1)/channel bandwidth

$= (0.1 \times 10 \times 10^9)/(5 \times 10^3) = 2 \times 10^5$

15. A granite rod of 60 cm length is clamed at its middle point and is set into longitudinal vibrations. The density of granite is 2.7×10^3 kg/m^3 and its Young's modulus is 9.27×10^{10} Pa. What will be the fundamental frequency of the longitudinal vibrations?

a. 10 kHz

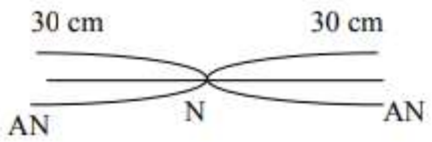
b. 7.5 kHz

c. 5kHz

d. 2.5 kHz

Answer: (c)

Solution



$$v = \sqrt{\frac{Y}{\rho}} \quad \frac{\lambda}{4}$$

$$= \frac{\ell}{2} \Rightarrow \lambda = 2\ell$$

$$\therefore \quad n = \frac{v}{\lambda} = \frac{1}{2\ell}\sqrt{\frac{Y}{\rho}}$$

$$= \frac{1}{2\times0.6}\sqrt{\frac{9.27\times10^{10}}{2.7\times10^{3}}} = 4.88\text{ kHz} \approx 5\text{ kHz}$$

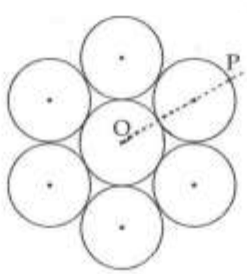
16. Seven identical circular planar disks, each of mass M and radius R are welded symmetrically as shown. The moment of inertia of the arrangement about the axis normal to the plane and passing through the point P is:

a. $\frac{73}{2}MR^2$

b. $\frac{181}{2}MR^2$

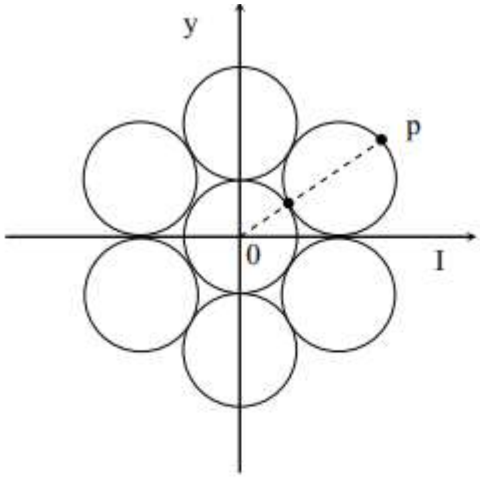
c. $\frac{19}{2}MR^2$

d. $\frac{55}{2}MR^2$



Answer: (b)

Solution



M.I. about origin

$$I_0 = \frac{MR^2}{2} + 6\left[\frac{MR^2}{2} + M(2R)^2\right]$$

$$I_0 = \frac{MR^2}{2} + 27MR^2$$

$$\boxed{I_0 = \frac{55}{2}MR^2}$$

$$I_p = I_0 + 7M(3R)^2$$

$$I_p = \frac{55}{2}MR^2 + 63MR^2$$

$$\boxed{I_p = \frac{181}{2}MR^2}$$

17. Three concentric metal shells A, B and C of respective radii a, b and c (a < b < c) have surface charge densities + σ, –σ and + σ respectively. The potential of shell B is:

a. $\frac{\sigma}{\epsilon_0}\left[\frac{b^2 - c^2}{b} + a\right]$

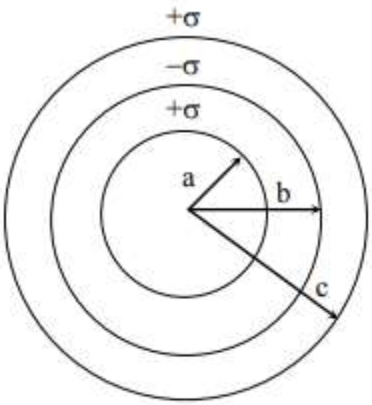
b. $\frac{\sigma}{\epsilon_0}\left[\frac{b^2 - c^2}{c} + a\right]$

c. $\frac{\sigma}{\epsilon_0}\left[\frac{a^2 - b^2}{a} + c\right]$

d. $\frac{\sigma}{\epsilon_0}\left[\frac{a^2 - b^2}{b} + c\right]$

Answer: (d)

Solution



$$V_B = \frac{k(\sigma \times 4\pi a^2)}{b} - \frac{k(\sigma \times 4\pi b^2)}{b} + \frac{k(\sigma \times 4\pi c^2)}{c}$$

$$V_B = \frac{\sigma}{\epsilon_0}\left[\frac{a^2}{b} - b + c\right]$$

$$V_B = \frac{\sigma}{\epsilon_0}\left[\frac{a^2 - b^2}{b} + c\right]$$

18. In a potentiometer experiment, it is found that no current passes through the galvanometer when the terminals of the galvanometer when the terminals of the cell are connected across 52 cm of the potentiometer wire. If the cell is shunted by a resistance of 5 Ω, a balance is found when the cell is connected across 40 cm of the wire. Find the internal resistance of the cell.

a. 2 Ω

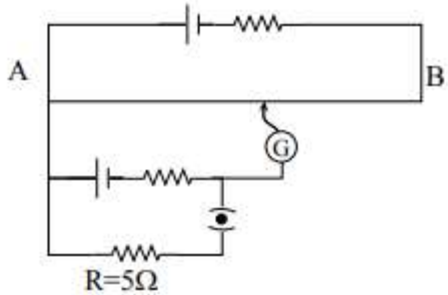
b. 2.5 Ω

c. 1 Ω

d. 1.5 Ω

Answer: (d)

Solution



When switch s is opened

$E = \lambda L_1$----------(I)

Where λ is potential gradient

when switch is closed $E - ir = \lambda L_2$ ... (II)

$$\frac{(II)}{(I)} \quad \frac{E - ir}{E} = \frac{L_2}{L_1}$$

$$1 - \frac{ir}{E} = \frac{L_2}{L_1}$$

$$\text{Replace } i = \frac{E}{R + r}$$

$$1 - \frac{r}{R + r} = \frac{L_2}{L_1}$$

$$\frac{R}{R + r} = \frac{L_2}{L_1}$$

$$r = R\left(\frac{L_1}{L_2} - 1\right) = 5\left(\frac{52}{40} - 1\right) = 5 \times \frac{12}{40} = 1.5\,\Omega$$

19. An EM wave from air enters a medium. The electric fields are $\vec{E}_1 = E_{01}\hat{x}\cos\left[2\pi\nu\left(\frac{z}{c} - t\right)\right]$ in air and $\vec{E}_2 = E_{02}\hat{x}\cos\left[k(2z - ct\right]$ in medium, where the wave number k and frequency ν refer to their values in air. The medium is nonmagnetic. If ε_{r1} refer ε_{r2} to relative permittivities of air and medium respectively, which of the following options is correct?

a. $\frac{\epsilon_{r_1}}{\epsilon_{r_2}} = \frac{1}{4}$

b. $\frac{\epsilon_{r_1}}{\epsilon_{r_2}} = \frac{1}{2}$

c. $\frac{\epsilon_{r_1}}{\epsilon_{r_2}} = 4$

d. $\frac{\epsilon_{r_1}}{\epsilon_{r_2}} = 2$

Answer: (a)

Solution

$$E_1 = E_{01}\hat{x}\cos\left[2\pi v\left(\frac{z}{c}-t\right)\right]$$

$$E_2 = E_{02}\hat{x}\cos\left[k(2z-ct)\right] = E_{02}\hat{x}\cos\left[\frac{2\pi}{\lambda}\times c\left(\frac{2z}{c}-t\right)\right]$$

$$= E_{02}\hat{x}\cos\left[2\pi v\left(\frac{2z}{c}-t\right)\right]$$

Velocity in new medium

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

$$\frac{1}{\sqrt{\mu_0 \epsilon_2}} = \frac{1}{2}\times\frac{1}{\sqrt{\mu_0 \epsilon_1}}$$

$$\boxed{\frac{\epsilon_1}{\epsilon_2} = \frac{1}{4}} \qquad \{\text{relative permittivity } \epsilon_r = \frac{\epsilon}{\epsilon_0}\}$$

20. The angular width of the central maximum in a single slit diffraction pattern is 60^0. The width of the slit is 1μm. The slit is illuminated by monochromatic plane waves. If another slit of same width is made near it, Young's fringes can be observed on a screen placed at a distance 50 cm from the slits. If the observed fringe width is 1 cm, what is slit separation distance? (i.e., distance between the cenrtres of each slit.)

a. 75 μm

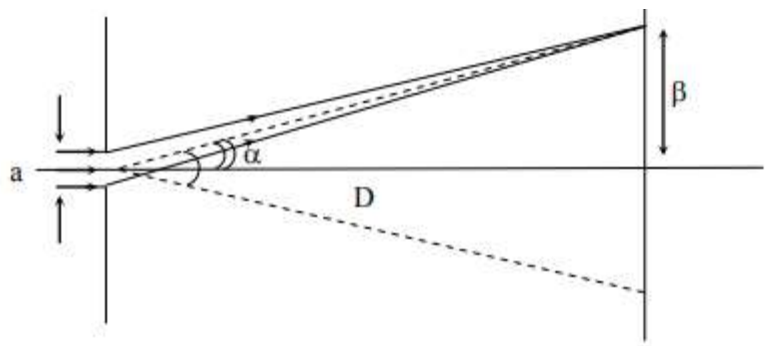
b. 100 μm

c. 25 μm

d. 50 μm

Answer: (c)

Solution



$2\alpha = 60^0$

a=1 μm

D = 50 cm

(Cond. for minima/Path diff $\Delta x = a \sin \theta = n \lambda$)

a=1 μm and $\theta = 30^0$ and n=1

$\lambda = 0.5$ μm

If same setup is used for YDSE

Fringe width $\beta = \lambda D/d$ = 1cm

$d = 0.5 \times 10^{-6} \times 0.5/0.01$ = 25 μm

d = 25 μm

21. A silver atom in a solid oscillates in simple harmonic motion in some direction with a frequency of 10^{12}/sec. What is the force constant of the bonds connecting one atom with the other? (Mole wt. of silver = 108 and Avagadro number = 6.02×10^{23} gm $mole^{-1}$

a. 2.2 N/m

b. 5.5 N/m

c. 6.4 N/m

d. 7.1 N/m

Answer: (d)

Solution

Frequency $f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$k = m\,(2\pi f)^2$

Mass of 1 atom

$$m = \frac{108}{6.02 \times 10^{23}} = 18 \times 10^{-23} \text{ gm} = 18 \times 10^{-26} \text{ kg}$$

$k = 18 \times 10^{-26}(2\pi \times 10^{12})^2 = 4\pi^2 \times 18 \times 10^{-2}$

$k = 7.2$ N/m ($\pi^2 = 10$)

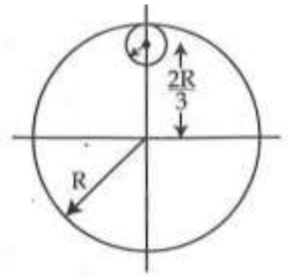
22. From a uniform circular disc of radius R and mass 9 M, a small disc of radius R/3 is removed as shown in the figure. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through centre of disc is:

a. $10\ MR^2$

b. $(37/9)\ MR^2$

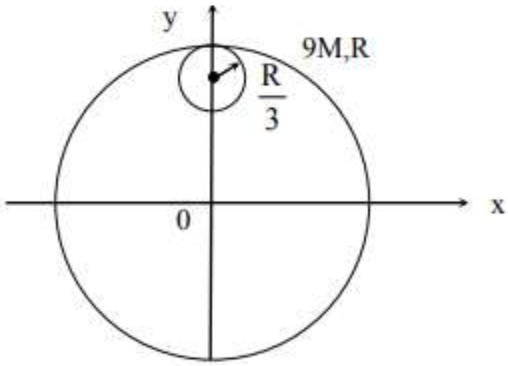
c. $4\ MR^2$

d. $(40/9)MR^2$



Answer: (c)

Solution



Mass ∝ Area, M ∝ R^2
Mass of portion removed

$$\frac{M_1}{M_0} = \frac{1}{9}, \qquad M_1 = \frac{M_0}{9} = M$$

$$I_0 = \frac{9MR^2}{2} - \left[\frac{M\left(\frac{R}{3}\right)^2}{2} + M\left(\frac{2R}{3}\right)^2\right]$$

$$I_0 = \frac{9MR^2}{2} - \left[\frac{MR^2}{18} + \frac{4MR^2}{9}\right]$$

$$I_0 = \frac{9MR^2}{2} - \left[\frac{9MR^2}{18}\right] = \frac{9MR^2}{2} - \frac{MR^2}{2}$$

$$\boxed{I_0 = 4MR^2}$$

23. In a collinear collision, a particle with an initial speed v_0 strikes a stationary particle of the same mass. If the final total kinetic energy is 50% greater than the original kinetic energy, the magnitude of the relative velocity between the two particles, after collision, is:

a. $V_0/2$

b. $V_0/\sqrt{2}$

c. $V_0/4$

d. $\sqrt{2}\, V_0$

Answer: (d)

Solution

L.M.C

$mv_1 + mv_2 = mv_0$

$V_1 + V_2 = V_0$----------(I)

Initial KE = $(1/2)mV_0^2$

Final KE = $(1/2)mV_1^2 + (1/2)mV_2^2$

final kE = (3/2)initial kE

$$\frac{1}{2}m\left(V_1^2 + V_2^2\right) = \frac{3}{2}\left(\frac{1}{2}mV_0^2\right)$$

$$V_1^2 + V_2^2 = \frac{3}{2}V_0^2 \qquad \dots \text{(II)}$$

$$\text{(I)}^2 - \text{(II)}$$

$$2V_1V_2 = -\frac{1}{2}V_0^2 \qquad \dots \text{(III)}$$

$$\left(V_1 - V_2\right)^2 = (V_1 + V_2)^2 - 4V_1V_2$$

$$\left(V_1 - V_2\right)^2 = V_0^2 + V_0^2 = 2V_0^2$$

$$V_{rel} = \left|V_1 - V_2\right| = V_0\sqrt{2}$$

24. The dipole moment of a circular loop carrying a current I, is m and the magnetic field at the centre of the loop is B_1. When the dipole moment is doubled by keeping the current constant, the magnetic field at the centre of the loop is B_2. The ratio B_1/B_2 is:

a. $\sqrt{2}$

b. $1/\sqrt{2}$

c. 2

d. $\sqrt{3}$

Answer: (a)

Solution

Dipole moment $\mu = niA$

$\mu = i \times \pi R^2$

If dipole moment is doubled keeping current const.

$R_2 = R_1\sqrt{2}$

Magnetic Field at center of loop

B= $\mu_0 i/2R$

$$\frac{B_1}{B_2}=\frac{R_2}{R_1}=\frac{\sqrt{2}}{1}$$

25. The density of the material in the shape of a cube is determined by measuring three sides of the cube and its mass. If the relative errors in measuring the mass and length are respectively 1.5% and 1%, the maximum error in determining the density is:

a. 4.5 %

b. 6 %

c. 2.5 %

d. 3.5 %

Answer: (a)

Solution

$$\rho=\frac{m}{V}=\frac{m}{\ell^3}$$

$$\frac{\Delta\rho}{\rho}\times 100 = \frac{\Delta m}{m}\times 100 + 3\,\frac{\Delta \ell}{\ell}\times 100$$

= 1.5 + 3 x 1 = 4.5

26. On interchanging the resistances, the balance point of a meter bridge shifts to the left by 10 cm.

The resistance of their series combination is 1 k Ω. How much was the resistance on the left slot

before interchanging the resistances?

a. 550 Ω

b. 910 Ω

c. 990 Ω

d. 505 Ω

Answer: (a)

Solution

Let balancing length be L

$$\frac{R_1}{R_2} = \frac{l}{(100 - l)}$$

$$\frac{R_2}{R_1} = \frac{(l - 10)}{(110 - l)}$$

$$(100 - l)(110 - l) = l(l - 10)$$

$$11000 + l^2 - 210l = l^2 - 10l$$

$$\Rightarrow \quad l = 55 \text{ cm}$$

$$R_1 = R_2\left(\frac{55}{45}\right)$$

$$R_1 + R_2 = 1000\ \Omega$$

$$R_1 = 550\ \Omega$$

27. In an a.c. circuit, the instantaneous e.m.f. and current are given by

e = 100 sin 30 t

i = 20 sin(30 t – (π/4))

In one cycle of a.c., the average power consumed by the circuit and the wattles current are, respectively:

a. ((50/√2),0)

b.50,0

c.50,10

d. ((1000//√2),10)

Answer: (d)

Solution

$$e = 100 \sin 30t \qquad \therefore \quad e_{rms} = \frac{100}{\sqrt{2}}$$

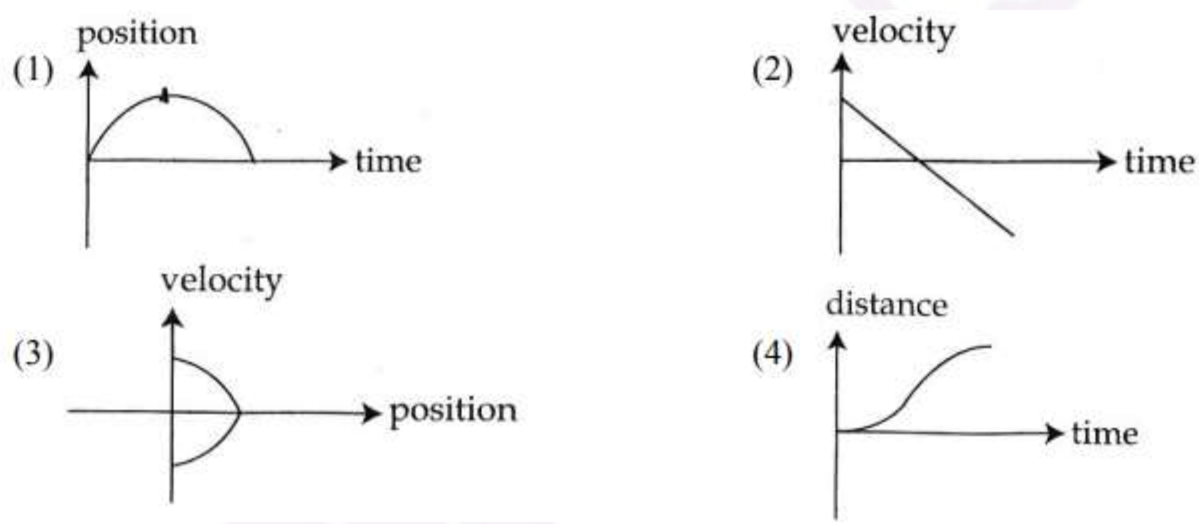
$$i = 20 \sin\left(30t - \frac{\pi}{4}\right) \qquad \therefore \quad i_{rms} = \frac{20}{\sqrt{2}}$$

$$P = e_{rms} \cdot I_{rms} \cdot \cos\frac{\pi}{4} = \frac{100}{\sqrt{2}} \times \frac{20}{\sqrt{2}} \times \frac{1}{\sqrt{2}} = \frac{2000}{2\sqrt{2}} = \frac{1000}{\sqrt{2}}$$

$$\text{Wattless current } I = I_{rms} \sin\frac{\pi}{4}$$

$$= \frac{20}{\sqrt{2}} \times \frac{1}{\sqrt{2}} = \frac{20}{2} = 10$$

28. All the graphs below are intended to represent the same motion. One of them does it incorrectly. Pick it up.



Answer: (4)

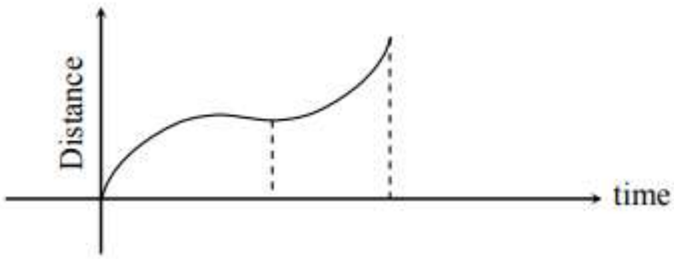
Solution

If V Vs t is a straight line with -ve slope acc = - ve const.

Displacement V_s time is a parabola opening downward

Only incorrect option is (4)

Correct distance Vs time graph is



29. Two moles of an ideal monoatomic gas occupies a volume V at 27^{0}C. The gas expands adiabatically to a volume 2 V. Calculate (a) the final temperature of the gas and (b) change in its internal energy.

(1) (a) 189 K (b) -2.7 kJ

(2) (a) 195 K (b) 2.7 kJ

(3) (a) 189 K (b) 2.7 kJ

(4) (a) 195 K (b) -2.7 kJ

Answer: (1)

Solution

$\gamma = \frac{5}{3}$ for monoatomic gas.

$T_1 = 27° C = 273 + 27 = 300$ K

$\frac{V_2}{V_1} = 2$

$T V \gamma - 1 = \text{const.}$

$T_2 V_2^{\gamma-1} = T_1 V_1^{\gamma-1}$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = \left(\frac{1}{2}\right)^{\frac{5}{3}-1} = \left(\frac{1}{2}\right)^{\frac{2}{3}} = \left(\frac{1}{4}\right)^{\frac{1}{3}} = 0.63$$

$T_2 = 300 \times 0.63 \qquad \therefore \quad T_2 = T_1 \times 0.63$

$= 189$ K

$$\Delta U = \frac{f}{2} nR\Delta T$$

$$\Delta U = \frac{-3}{2} \times 2 \times 8.3 \times 111$$

ΔU = -2.76 kJ

30. A particle is moving with a uniform speed in a circular orbit of radius R in a central force inversely proportional to the nth power of R. If the period of rotation of the particle is T, then:

a. $T \propto R^{(n+1)/2}$

b. $T \propto R^{n/2}$

c. $T \propto R^{n/2}$ for any n

d. $T \propto R^{(n/2)+1}$

Answer: (a)

Solution

$$\frac{mv^2}{R} = K \cdot \frac{1}{R^n}$$

$$v^2 = K \cdot \frac{R}{mR^n} = K \cdot \frac{1}{m\ R^{n-1}}$$

$$v = K' \cdot \frac{1}{R^{\frac{(n-1)}{2}}} \qquad \left[K' = \sqrt{\frac{k}{m}}\right]$$

$$T = \frac{2\pi R}{v} = \frac{2\pi R \times R^{\frac{n-1}{2}}}{K'} = \frac{2\pi}{K'} \cdot R^{\frac{n+1}{2}}$$

$$\therefore \quad T \propto R^{\frac{n+1}{2}}$$