Question paper - 1

(1) Answer [B]

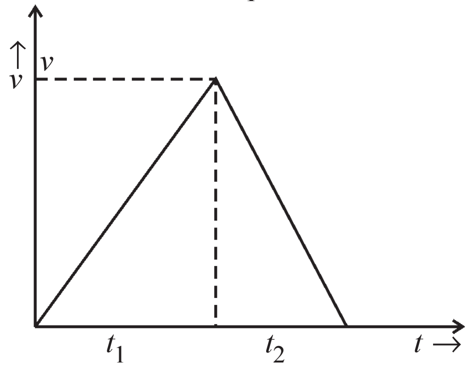
Solution :

In sentence, digits are without decimal point. So, zero at right side are not significant digits. so, there are three significant digits in 37,800 thus, statement is true.

All digits without zero are significant digits so, cause is true. But cause is not true explanation of statement.

(2) Answer [D]

Solution : For first part



$v = v_0 + at$, $v = o + xt_1$, $\therefore t_1 = v/x$

For second part

$v = v_0 + at$, $0 = v - yt_2$, $\therefore t_2 = v/y$

Now, $t = t_1 + t_2 = v/x + v/y$, $t = v\left(\dfrac{x+y}{xy}\right)$

$\therefore v = \dfrac{xyt}{x+y}$, distance travelled in time t,

Area enclosed by $v \rightarrow t$ graph

$= \frac{1}{2}\, vt = \frac{1}{2}\left(\dfrac{xy}{x+y}\right) t \cdot t = \dfrac{xyt^2}{2(x+y)}$

(3) Answer [C]

Solution : $F \le N\, mv$, $N > \dfrac{F}{mv} = \dfrac{60}{1 \times 3} = 20$

$N > 20$

(4) Answer [B]

Solution : Velocity of sphere at point B $v_o = d/t = 12/4 = 3\ ms^{-1}$, If length of slope BC is d then,

$v^2 - v_o^2 = 2ad$, $\therefore 25 - 9 = 2\, g \sin \theta d$

[$\because$ acceleration parallel to surface of slope $a = g \sin \theta$]

$\therefore 16 = 2 \times 10 \times \frac{1}{\sqrt{2}}\, d$, $\therefore d = \frac{4\sqrt{2}}{5}$

Work $W = mg \sin 45°\, d = \dfrac{3 \times 10 \times 4\sqrt{2}}{5 \times \sqrt{2}} = 24$ J.

(5) Answer [C]

Solution : Here, $m_1 = m$, $\Delta r_1 = L/2$

$m_2 = (m + M)$, $\Delta r_2 = ?$

$\Delta r_2 = \Delta r_1 \dfrac{m_1}{m_2} = \dfrac{mL}{2(m+M)}$ downward.

(6) Answer [B]

Solution : from, $F = \dfrac{Gm_1m_2}{r^2}$ $F \propto \dfrac{1}{r^2}$

Gravitational force between two particle is independent of medium between two particle.

$\therefore F_1 \propto \dfrac{1}{r_1^2}$ and $F_2 \propto \dfrac{1}{r_2^2}$

$\therefore \dfrac{F_2}{F_1} = \dfrac{r_1^2}{r_2^2} = \left(\dfrac{10}{20}\right)^2 = \dfrac{1}{4}$, $\therefore F_2 = F_1/4$

Here $F_1 = F \Rightarrow F_1 = F/4$

(7) Answer [A]

Solution : $Y = 3K(1 - 2\mu)$ ...(1)

and $n = \dfrac{Y}{2(1+\mu)}$ ...(2)

From equation (1) $\mu = \frac{1}{2}\, [1 - Y/3K]$ ...(3)

From equation (2) $\mu = \dfrac{Y}{2n} - 1$ ...(4)

$\therefore$ from comparison of equation (3) and (4)

$\frac{1}{2}\left[1 - \dfrac{Y}{3K}\right] = \dfrac{Y}{2n} - 1$, $\dfrac{9}{Y} = \dfrac{3}{n} + \dfrac{1}{K}$

$\therefore Y = \dfrac{9nK}{n + 3K}$

(8) Answer [C]

Solution : $T_F = \frac{9}{5}\, T_C + 32$, $\Delta T_F = \frac{9}{5}\, \Delta T_C$

$= \frac{9}{5} \times 50\ °C = 90\ °F$

(9) Answer [A]

Solution : $v_{rms} = \sqrt{\frac{3P}{\rho}}$

$= \sqrt{\frac{3 \times 1.01 \times 10^5}{8.9 \times 10^{-2}}} = 1845\ ms^{-1}$

(10) Answer [C]

Solution : $n = 40,\ \therefore\ \phi = 2\pi - \frac{\pi}{6} = \frac{11\pi}{6}$

phase after n oscillation, $\theta = [2\pi n + \phi]$

$= \left[80\pi + \frac{11\pi}{6}\right] = \frac{480\pi + 11\pi}{6}$

$= 491\ \frac{\pi}{6}$ rad

(11) Answer [A]

Solution : Series connection of last three capacitors of right side, its equivatent co pacitance is $\frac{1}{C^1} = \frac{1}{9} + \frac{1}{9} + \frac{1}{9} = \frac{1}{3}$,

$\therefore$ C' = 3 μF

Now due to the parallel connection of C_1 and C', the equivalent capacitance of last part of network is C' = 3 + 6 = 9 μF. Continuous calculation on left side in last combination of capacitors such like that its equivalent capacitance is 3 μF.

(12) Answer [D]

Solution : $R_\theta = R_0 (1 + \alpha\theta)$

$R_{50} = R_0 [1 + 50\ \alpha]$

$5 = R_0 [1 + 50\ \alpha]$ ...(1)

and $R_{100} = R_0 [1 + 100\alpha]$

$6 = R_0 [1 + 100\alpha]$ ...(2)

taking ratio of equation (2) and (1)

$\frac{6}{5} = \frac{1 + 100\,\alpha}{1 + 50\,\alpha} \Rightarrow 6 + 300\ \alpha = 5 + 500\ \alpha$

$1 = 200\ \alpha\ \therefore\ \alpha = \frac{1}{200} = 0.005\ °C^{-1}$

suostiluting this value in equation (1)

$5 = R_0 [1 + 50 \times 0.005],\ 5 = R_0 [1 + 0.25]$

$5 = R_0 [1.25],\ \therefore\ R_0 = \frac{5}{1.25} = 4\ \Omega$

(13) Answer [C]

Solution : Here $r = \frac{\sqrt{2mK}}{Bq}$ and $A = \pi r^2$

$\therefore\ A = \frac{\pi(2mK)}{B^2 q^2}\ \therefore\ A \propto K$

(14) Answer [C]

Solution : induced current $I = \frac{-E}{R}$

$= \frac{-NBA\,(\cos\theta_2 - \cos\theta_1)}{R\ \Delta t}$

$\therefore\ I = \frac{-1000 \times 0.1 \times 10^{-2}\,[\cos(90°) - \cos 30°]}{20 \times 5 \times 10^{-2}}$

= 1 A

(15) Answer [C]

Solution : Increase of electric current in L – R circuit is

$I = I_0 \left(1 - e^{\frac{-Rt}{L}}\right)$

magnetic energy $U_{max} = \frac{1}{2} L I_0^2$

But $U = \frac{U_{max}}{4}$

$\therefore\ \frac{1}{2} LI^2 = \frac{1}{4}\ [\frac{1}{2} L I_0^2] \Rightarrow LI^2 = \frac{1}{4} L I_0^2$

$\Rightarrow I = \frac{I_0}{2},\ \therefore\ \frac{I_0}{2} = I_0 \left[1 - e^{-Rt/L}\right]$

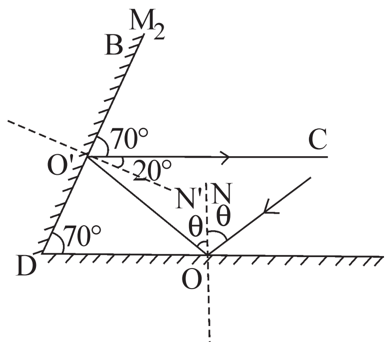
($\because$ from equation (1))

$$\Rightarrow \frac{1}{2} = 1 - e^{\frac{-Rt}{L}}, \therefore e^{\frac{-Rt}{L}} = \frac{1}{2} \Rightarrow 2 = e^{\frac{Rt}{L}}$$

$$\therefore ln(2) = \frac{Rt}{L}, \therefore t = \frac{L}{R}\, ln(2) = 0.693 \left(\frac{L}{R}\right)$$

(16) Answer [D]

Solution :



From figure, $\angle BO'C = 70°$, $\therefore \angle CO'N' = 20°$

$\therefore \angle NO'O = 20°$ (Reflection angle of incident)

$\therefore \angle ODO' = 70°$

$\Delta ODO'$ for $\angle O'OD = 180° - 70° - 70° = 40°$

$\therefore \angle NOO' = \theta = 50°$

(17) Answer [A]

Solution : $f_o + f_e = 36$ ...(1)

$$m = \frac{f_o}{f_e} = 5, f_o + \frac{f_o}{5} = 36, \text{ from equation (1))}$$

$$\therefore 6 f_o = 180,\ f_o = \frac{180}{6}, f_o = 30 \text{ cm}$$

$fe = 6$ cm

(18) Answer [A]

Solution : $v_{max} = 3 \times 10^8\ cms^{-1} = 3 \times 10^6\ ms^{-1}$

$$K_{max} = \frac{1}{2}\ mv^2_{max} = \frac{1}{2}\ (9 \times 10^{-31})\ (3 \times 10^6)^2$$

$$= 4.05 \times 10^{-18}\ J = \frac{4.05 \times 10^{-18}}{1.6 \times 10^{-19}}\ eV$$

$\therefore$ Stopping potential

$$[\phi_0] = \frac{K_{max}}{e} = \frac{25.3}{e}\ eV = 25.3\ V$$

(19) Answer [B]

Solution : $\tau_{1/2} = 28$ year $\Rightarrow$ 84 year $= 3\tau_{1/2}$

$$I = I_0 \left(\frac{1}{2}\right)^3 = \frac{I_0}{8} = 1.25\ mCi$$

$$= 1.25 \times 10^{-3} \times 3.7 \times 10^{10}$$

$$= 4.63 \times 10^7\ \frac{\text{disintegration}}{\text{second}}$$

(20) Answer [B]

Solution : $E_g = \frac{hc}{\lambda e}$ (eV) $\therefore$

$$E_g = \frac{6.62 \times 10^{-14} \times 3 \times 10^8}{1.724 \times 10^{-6} \times 1.6 \times 10^{-19}}$$

$\therefore E_g = 0.7199 \simeq 0.72$ eV

(21) Answer [C]

Solution : Due to the formation of 'n' plates, $(n - 1)$ capacitance forms and type are considered as in parallel connection.

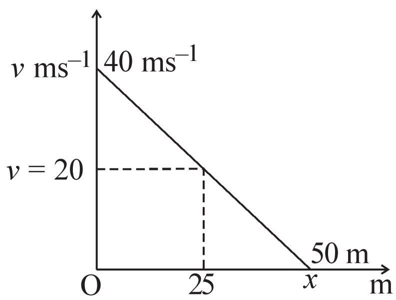
$\therefore$ equivalent capacitance in parallel

$C_{PQ} = C + C + C + \dots (n - 1) = (n - 1)\ C$

$$= (n - 1)\ \frac{A\varepsilon_o}{d}$$

(22) Answer [C]

Solution :



When displacement of particle is 25 m then velocity is 20 ms^{-1}. Now acceleration

$$a = \frac{dv}{dt} = \frac{dv}{dx} \cdot \frac{dx}{dt} = v\ \frac{dv}{dx} = 20\left(\frac{-20}{25}\right)$$

$= - 16\ ms^{-2}$

(23) Answer [D]

Solution : Tension force in string $T = \frac{4m_1m_2}{m_1 + m_2}g$

$= \frac{4 \times 15 \times 25}{15 + 25} \times 10 = \frac{4 \times 15 \times 25}{40} \times 10$

$= 375$ N

(24) Answer [B]

Solution : $I_Z = I_y$

$\frac{1}{2} MR^2 = \frac{1}{4} MR^2 + \frac{MC^2}{2}$

$MC^2 = MR^2 - \frac{1}{2} MR^2 = \frac{1}{2} MR^2$

$\therefore C = \frac{R}{\sqrt{2}}$

(25) Answer [A]

Solution : $\frac{t_1}{t_2} = ln\left(\frac{T_1 - T_O}{T_2 - T_O}\right)$ Here both time period is same. $t_1 = t_2$

$ln\left(\frac{80-20}{50-20}\right) = ln\left(\frac{50-20}{T_x - 20}\right)$

$\therefore \frac{60}{30} = \frac{30}{T_x - 20}$, $\therefore 2T_x - 40 = 30$

$T_x = 35°$ C

(26) Answer [B]

Solution : $v_{rms} = \sqrt{\frac{3kT}{m}}$ and temperature constant. So, v_{rms} is constant.

(27) Answer [C]

Solution : $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{80}{5 \times 10^{-2}}} = 40\ ms^{-1}$

Power $P = \frac{1}{2} \mu \omega^2 A^2 v$

$= \frac{1}{2} \times 5 \times 10^{-2} \times (2\pi \times 60)^2 \times (6 \times 10^{-2})^2 \times 40$

$= 511.12 \cong 512$ W

(28) Answer [A]

Solution : $W = MB(\cos 0 - \cos 60°) = \frac{MB}{2}$

$0.8 = \frac{MB}{2}$, $\therefore MB = 1.6$ Nm

$W' = MB(\cos 60° - \cos 90°)$

$= \frac{MB}{2} = \frac{1.6}{2} = 0.8 \times 10^7$ erg

(29) Answer [B]

Solution : Work function of A*l*, $\phi_o = 4.2\ eV$

$\Rightarrow \frac{\phi_o}{e} = 4.2$ V

$\lambda = 10\ \mathring{A} = 10 \times 10^{-10}$ m

Suppose, electrostatic potential of sphere is V. In this condition, maximum energy of photo electron is 4.2 eV. They leave sphere with zero velocity.

Now from, $eVo = \frac{hc}{\lambda} - \phi_o$

$V = \frac{hc}{\lambda e} - \frac{\phi_o}{e}$ (taking Vo = V)

$V = \frac{6.625 \times 10^{-34} \times 3 \times 10^8}{10 \times 10^{-10} \times 1.6 \times 10^{-19}} - 4.2$

$= 1242.18 - 4.2 = 1237.98$ V $\cong 1238$ V

(30) Answer [A]

Solution : $\frac{1}{\lambda} \propto (Z-1)^2 \Rightarrow \frac{\lambda_1}{\lambda_2} = \left(\frac{Z_2 - 1}{Z_1 - 1}\right)^2$

$\therefore \frac{\lambda}{4\lambda} = \frac{(Z_2-1)^2}{100}$

$\therefore [Z_2 - 1]^2 = 25 \Rightarrow Z_2 - 1 = 5 \Rightarrow Z_2 = 6$

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Question paper - 2

(1) Answer [A]

Solution : $A = B + \frac{C}{D+E}$ is dimensionally true.

$\therefore$ A = B, A = $[M^o L^1 T^{-1}]$, $\frac{C}{D+E}$ = B.

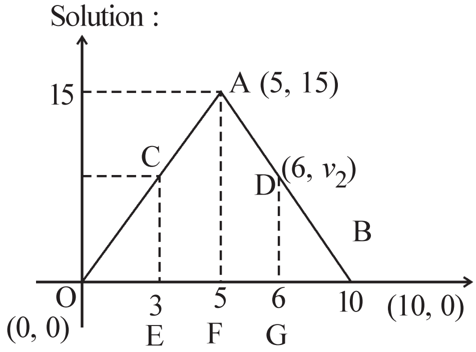
$D + E = \frac{C}{B}$ ($\because$ D = E)

$\therefore D = \frac{C}{B} = \frac{[M^o L^1 L^O]}{[M^o L^1 L^{-1}]}$

$\therefore D = [M^o L^o T^1]$, $\therefore D = [T^1]$

(2) Answer [C]

Solution :



Area of ΔOAB = $\frac{1}{2}$ × OB × AF

= $\frac{1}{2}$ × 10 × 15 = 75 m

for O – C – A line, $\frac{15-0}{5-0} = \frac{v_1 - 0}{3-0}$

$\therefore \frac{15}{5} \times 3 = v_1$, $\therefore v_1 = 9$ ms^{-1}

for A – D – B line, $\frac{15-0}{5-10} = \frac{v_2 - 0}{6-10}$

$\therefore v_2 = 12$ ms^{-1}

Area of ΔOEC = $\frac{1}{2}$ (OE) (CE)

= $\frac{1}{2}$ × 3 × 9 = 13.5 m

Area of ΔDGB = $\frac{1}{2}$ (GB) (GD)

= $\frac{1}{2}$ × 4 × 12 = 24 m

Now, distance travel during 3 to 6 s

= Area under the part ECADGE

= Area of ΔOAB

– (Area of ΔOEC + Area of ΔDGB)

= 75 – (13.5 + 24) = 37.5 m

(3) Answer [B]

Solution : acceleration $a = \frac{F}{m}$, $\therefore d = v_o t + \frac{1}{2} at^2$

$\therefore d = \frac{F}{2m} t^2$, $\therefore t = \sqrt{\frac{2md}{F}}$ ...(1)

and $v^2 - v_o^2 = 2ad$

$\therefore v^2 = \frac{2F}{m} d$ $\therefore v = \sqrt{\frac{2Fd}{m}}$ ...(2)

From (1) and (2)

$tv = \sqrt{\frac{2md}{F}} \cdot \sqrt{\frac{2Fd}{m}} = \sqrt{4d^2} = 1$

(4) Answer [A]

Solution : Tension force generated in string

T = Mg – Ma = Mg – Mg/3

$\therefore$ T = $\frac{2}{3}$ Mg (in normal direction)

displacement = d (in downward direction),

$\therefore \theta = \pi$

$\therefore$ Work W = Td cosθ

= $\frac{2}{3}$ Mg d cosπ = – $\frac{2}{3}$ Mgd

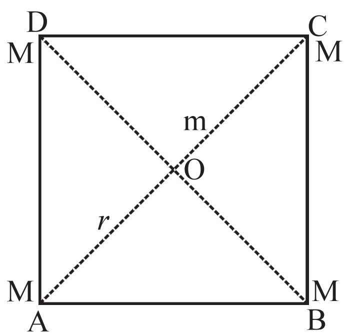
(5) Answer [B]

Solution : $I = I_1 + I_2 + I_3 = 2(\frac{3}{2} MR^2) + \frac{1}{2} MR^2$

= $\frac{7}{2}$ MR^2

(6) Answer [B]

Solution :



Here r = OA = OB = OC = OD = $\frac{b}{\sqrt{2}}$

Suppose, escape velocity of particle

having mass m is Ve. $\therefore$ Total energy at 'O' = total energy at infinite distance ($\because$ from energy conservation Potential energy at infinite distance is zero and particle need to free from binding so kinetic energy at infinite distance is also zero).

At 'O' potential energy + kinetic energy = At infinite distance (potential energy + kinetic energy)

$$\therefore \frac{1}{2} mv_e^2 - 4\left(\frac{GMm}{r}\right) = 0 + 0$$

$$\therefore v_e = \sqrt{\frac{8Gm}{r}} = \sqrt{\frac{8Gm}{b|\sqrt{2}}} = \sqrt{\frac{8\sqrt{2}Gm}{b}}$$

$$\therefore v_e = \sqrt{\frac{8 \times 1.4 \times 6.67 \times 10^{-11} \times 10^{30}}{4 \times 10^{12}}}$$

$= 1.37\ 10^4\ ms^{-1} = 13.7\ 10^3\ kms^{-1}$

(7) Answer [C]

Solution : $Y = 2n(1 + \mu)$ ...(1)

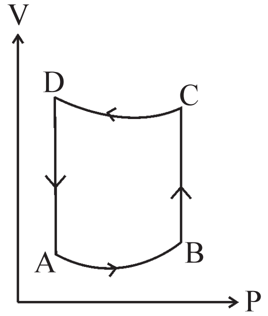
put $Y = 2.8\ n$ in equation (1)

$2.8n = 2n(1 + \mu)$, $1.4 = 1 + \mu$

$\therefore \mu = 0.4$

(8) Answer [D]

Solution :



Net work done during cyclic process is area enclosed by graph P – V. Above all process are cyclic process so diffenence of internal energy for each is $\Delta U = 0$.

(9) Answer [B]

Solution : $P_1 = h\rho g + P_0$

Where P_0 = Atmospheric pressure

$= 1.01 \times 10^6$ dyne cm^{-2}

From Boyle's law $P_1 V_1 = P_2 V_2$

$V_1 (h\rho g + P_0) = P_0 V_2$

$\therefore (490 \times 1 \times 1000 + 1.01 \times 10^6) V_1 = 1.01 \times 10^6 V_2$

$\therefore (0.49 \times 10^6 + 1.01 \times 10^6) V_1 = 1.01 \times 10^6 V_2$

$\therefore 1.50 \times 10^6 V_1 = 1.01 \times 10^6 V_2$

$\therefore V_2 = \frac{1.50}{1.01} \times V_1 = 1.5 \times 50$

= 75 cc

(10) Answer [A]

Solution : $Y = A \sin(\omega t + \phi)$

$y = 5$ cm

A = 10 cm અને $t = 2$s

$\Rightarrow \frac{1}{2} = \sin(2\omega + \phi) \Rightarrow \sin(2\omega + \phi) = \frac{\pi}{6}$

$\Rightarrow (12\omega + 6\phi) = \pi$ ...(1)

Now $t = 6 \Rightarrow$ kinetic energy $K = E/2 = \frac{1}{4} KA^2$

$\therefore t = 6 \Rightarrow y = \frac{A}{\sqrt{2}}$

$\frac{A}{\sqrt{2}} = A \sin(6\omega + \phi)$

$\Rightarrow \sin(6\omega + \phi) = \frac{\pi}{4}$

$\therefore (24\omega + 4\phi) = \pi$ ...(2)

for equation (1) and (2) $24\omega + 4\phi = 12\omega + 6\phi$

$\Rightarrow 12\omega = 2\phi$

$\Rightarrow 6\omega = \phi$ ...(3)

from (1), $12\omega + 36\omega = \pi$

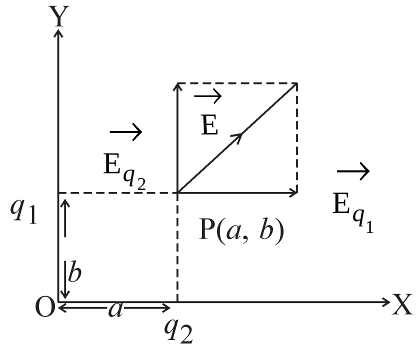
$\Rightarrow 48\omega = \pi$

$\Rightarrow \omega = \pi/48 = \frac{2\pi}{T}$ $\therefore$ T = 96s.

from equation (3) $\frac{6\pi}{48} = \phi \Rightarrow \phi = \pi/8$ rad

(11) Answer [B]

Solution :



Electric field by q_1 at P is

$$\vec{E}_1 = K\frac{q_1}{a^2} = \frac{K \times 2 \times 10^{-6}}{(2 \times 10^{-2})^2}$$

$$\vec{E}_1 = \frac{K}{2} \times 10^{-2}\ NC^{-1}$$

$\therefore$ Electric field by q_2 at P is

$$\vec{E}_2 = K\frac{q_2}{b^2} = \frac{K \times 1 \times 10^{-6}}{(1 \times 10^{-2})^2}$$

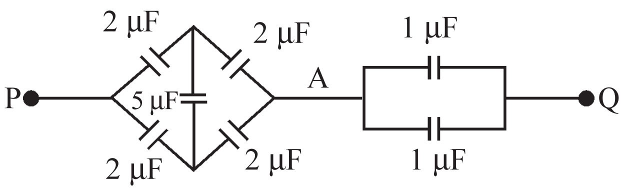
$$\therefore \vec{E}_2 = K \times 10^{-2}\ NC^{-1}$$

From figure, resultant vector $\vec{E}$ make an angle θ with X-axis then, $\tan\theta$

$$= \frac{Eq_2}{Eq_1} = \frac{K \times 10^{-2}}{\frac{K}{2} \times 10^{-2}}$$

$\therefore \tan\theta = 2$

(12) Answer [D]



Solution : The equivalent capacitance between point P and A is

$$C' = \frac{2 \times 2}{2+2} + \frac{2 \times 2}{2+2} = 1 + 1 = 2\ \mu F$$

The equivalent capacitance between point A and Q is

$$C'' = 1 + 1 = 2\ \mu F$$

$\therefore$ The equivalent capacitance between point P and Q is

$$C = \frac{C' \cdot C''}{C' + C''} = \frac{2 \times 2}{2+2} = 1\ \mu F$$

(13) Answer [D]

Solution : $\therefore E_{eq} = 2 \times 6 = 12$ V

$r_{eq} = 6 \times 0.015 = 0.09\ \Omega$

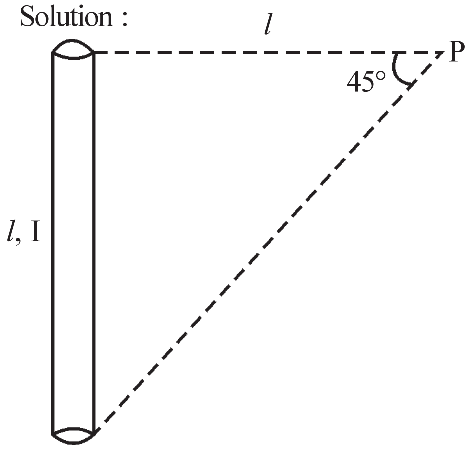
$$\therefore I = \frac{E}{R + r_{eq}} = \frac{12}{8.5 + 0.09}$$

$$\therefore V = E - Ir, = 12 - \left[\frac{12}{8.5 + 0.09}\right] \times 0.09$$

$= 11.9$ V

(14) Answer [C]

Solution :



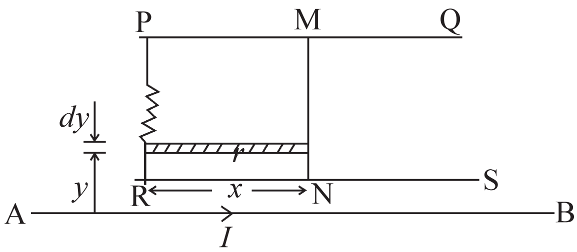
For electrical conducting wire of length l

$$B = \frac{\mu_0 I}{4\pi r}(\sin\theta_1 + \sin\theta_2)$$

$$B = \frac{\mu_0 I}{4\pi r}\left(0 + \frac{1}{\sqrt{2}}\right) = \frac{\mu_0 I}{4\pi\sqrt{2}l} = \frac{\sqrt{2}\mu_0 I}{8\pi l}$$

(15) Answer [C]

Solution :



Magnetic flux associated with surface having width dy and length x as seen in figure is,

$$d\phi = BdA = \frac{\mu_0 I}{2\pi y}xdy$$

$$\therefore \int d\phi = \int_a^{a+l}\frac{\mu_0 I}{2\pi y}xdy = \frac{\mu_0 Ix}{2\pi}\int_a^{a+l}\frac{dy}{y}$$

$$\therefore \phi = \frac{\mu_0 Ix}{2\pi}\ ln\left[\frac{a+l}{a}\right]$$

$\therefore$ Induced electromotive force

$$E = -\frac{d\phi}{dt} = \frac{\mu_0 I}{2\pi}\ ln\left[\frac{a+l}{a}\right]\frac{dx}{dt}$$

$$\therefore\ E = \frac{\mu_0 I v}{2\pi}\ ln\left[\frac{a+l}{a}\right]\left[\because \frac{dx}{dt} = v\right]$$

$\therefore$ Induced current $I = E/r$

Now, force dF on small segment having width dy is $dF = BI\,dy = \frac{\mu_0 I}{2\pi y}\ I dy$

$\therefore$ Force required to maintain constant velocity of rod MN is,

$$F = \int dF = \frac{\mu_0 I}{2\pi}\ I \int \frac{dy}{y}$$

Using equation

$$F = \frac{\mu_0 I}{2\pi} \times \frac{\mu_0 I v}{2\pi r}\ ln\left[\frac{a+l}{a}\right] \int_a^{a+l} \frac{dy}{y}\ I,$$

$$\Rightarrow F = \frac{v}{r}\left[\frac{\mu_0 I}{2\pi}\ ln\left(\frac{a+l}{a}\right)\right]^2$$

(16) Answer [D]

Solution : For L – R circuit $\tan 60° = \frac{\omega L}{R}$

$\Rightarrow \omega L = R \tan 60°$

for C – R circuit $\tan 60° = \frac{1}{\omega CR}$

$\Rightarrow \frac{1}{\omega C} = R \tan 60°$

Here $\omega_L = \frac{1}{\omega C} = R \tan 60°$ so, $|Z| = R$.

$$\therefore I_{rms} = \frac{V_{rms}}{|Z|} = \frac{200}{R} = \frac{200}{100} = 2A$$

(17) Answer [B]

Solution : First plane mirror is effective because light did not incident on second. Hence, final image forms at distance 6 *cm* from first plane mirror.

(18) Answer [A]

Solution : $A = r_1 + r_2$

$A = 2r_1$ [$r_1 = r_2$ parallel ray of base]

$r_1 = 30°$, $A = 60°$, $i = e$ then $\delta = \delta m$

$i + e = A + \delta$, $2i = A + \delta m$

$\therefore 90° = 60° + \delta m$, $\delta m = 30°$

$$n = \frac{\sin\frac{A+\delta m}{2}}{\sin A/2} = \frac{\sin\frac{60°+30°}{2}}{\sin\frac{60°}{2}}$$

$$= \frac{\sin 45°}{\sin 30°} = \frac{1}{\sqrt{2}} \times \frac{2}{1} = \sqrt{2}$$

(19) Answer [A]

Solution : from $\lambda_0 = \frac{12375}{\phi_0}\ \mathring{A}$

$$(\lambda_0)\ L_i = \frac{12375}{2.3} = 5380\ \mathring{A}$$

$$\text{and } (\lambda_0)_{Cu} = \frac{12375}{4} = 3094\ \mathring{A}$$

But, 5380 $\mathring{A}$ of wavelength is visible light range, while 3094 $\mathring{A}$ of wavelength is in ultraviolet (100 – 4000 $\mathring{A}$) range. $\therefore$ Lithium shows photoelectric effect.

(20) Answer [A]

Solution : $f = \frac{2Rc}{n^3} \Rightarrow f \propto \frac{1}{n^3}$

(21) Answer [B]

Solution : From $I = \frac{V}{R}$ $I = \frac{5}{10+20} = \frac{5}{30} = \frac{1}{6}$ A

(22) Answer [A]

Solution : From Newton's law of cooling,

$$\frac{dv(t)}{dt} = -K(\theta_t - \theta_s)$$

$$\therefore \frac{dv(t)}{\theta_t - \theta_s} = -k\ dt$$

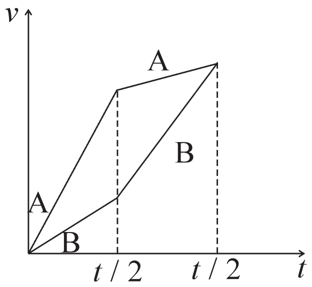
$\therefore$ By integration $\int\left(\frac{1}{\theta_t - \theta_s}\right) d\theta = \int -k\,dt$

$\therefore log_e(\theta_t - \theta_s) = -kt + C$, Where C is integrating constant.

This equation is for a straight line. So, option (A) is true.

(23) Answer [A]

Solution :



For both particle, it is seen from the graph of $v \rightarrow t$ that for particle A the area enclosed by graph $v \rightarrow t$ is large so distance travelled by particle A is large.

(25) Answer [D]

Solution : from $I = I_C + Md^2$, $I \propto d^2$ is parabolla

(26) Answer [A]

Solution : Weight of object at depth d from earth surface.

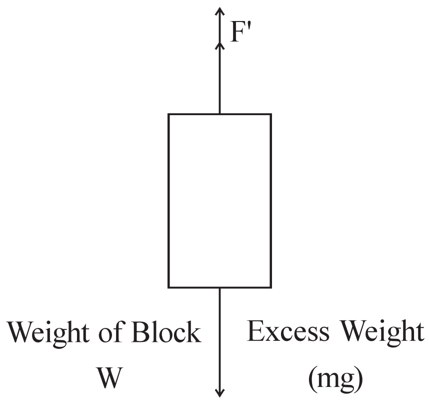
$mg' = mg\ (1 - d/R)$

$\therefore \frac{25}{36} W = W\ (1 - d/R)$, $\therefore 1 - \frac{d}{R} = \frac{25}{36}$

$\therefore \frac{d}{R} = 1 - \frac{25}{36} = \frac{11}{36}$ $\therefore d = \frac{11}{36} R$

(27) Answer [B]

Solution :



Suppose, the height of block outside the water is x. According to law of flotation, Weight of displaced water = Weight of block $(10 - x) \times 10^{-2} \times (10 \times 10^{-2}) \times 1000g$ $= (10 \times 10^{-2})^3 \times 800\ g$.

$\therefore x = 2$ cm

Now, putting mass of 325 g, block shifted downward by x.

$\therefore$ Compression in the spring is x cm.

$\therefore$ Restoring force generated in spring is,

$F = kx = (2 \times 10^{-2})$ k

Now, force in normal direction

$F' = (10 \times 10^{-2})^3 \times 1000 \times g = 10$ N

Now looking FBD for system, $W + mg = f + f'$

$\{(10 \times 10^{-2})^3 \times 800 \times 10) + 325 \times 10^{-3} \times 10$

$= (2 \times 10^{-2} \times k) + 10$

solving the above equation $k = \frac{125}{2}\ Nm^{-1}$

$\therefore k = 62.5\ Nm^{-1}$

(28) Answer [A]

Solution : $\lambda = \frac{v}{f} = \frac{700}{1000} = 0.7$ m

$\therefore A \sin(\pi/3 - \omega t) = A \sin(\frac{2\pi x}{0.7} - \omega t)$

$\Rightarrow -\omega t + \pi/3 + 2\pi n = \frac{2\pi x}{0.7} - \omega t$

$\Rightarrow x = (\frac{0.7}{8} + 0.7n)$ $\qquad n = 0, 1, 2, ...$

$\therefore x = 0.81, 1.51, 2.21, ...$

(29) Answer [A]

Solution :

$$\frac{M_1}{M_2} = \frac{v_S^2 + v_d^2}{v_S^2 - v_d^2},\ \therefore \frac{13}{5} = \frac{(15)^2 + v_d^2}{(15)^2 - v_d^2}$$

$\therefore v_d = 10$ oscillation/minute

(30) Answer [A]

Solution : de-Broglie wavelength of particle

$$\lambda_1 = \frac{h}{p_1} = \frac{h}{m_1 v_1}$$

de-Broglie wavelength of electron

$$\lambda_2 = \frac{h}{p_2} = \frac{h}{m_2 v_2}$$

$$\therefore \frac{\lambda_1}{\lambda_2} = \frac{m_2 v_2}{m_1 v_1} = \frac{m_2}{m_1}\left(\frac{1}{3}\right)$$

$$\therefore \quad m_1 = \frac{m_2}{3\left(\frac{\lambda_1}{\lambda_2}\right)} = \frac{9.11 \times 10^{-31}}{3 \times 1.813 \times 10^{-4}}$$

$= 1.675 \times 10^{-27}$ kg

•

Question paper - 3

(1) Answer [D]

Solution : Power = Work/time

$\therefore$ Unit of power = watt = Js^{-1}

But volt = JC^{-1}, $\therefore$ J = $\frac{V}{C^{-1}}$ (C = As)

$\therefore$ J = VAs (from W = V*It*)

watt = (VAs) s^{-1}, watt = AV

from V = *I*R, volt = A Ω

$\therefore$ watt = A (A *ohm*), $\therefore$ watt = $A^2\ \Omega$

$\therefore$ AV^{-1} does not show watt.

(2) Answer [B]

Solution : $R = \frac{V_0^2 \sin 2\theta}{g}$, $R_{max} = \frac{V_0^2}{g}$

$\therefore \frac{R_{max}}{R} = \frac{1}{\sin 2\theta} \therefore R_{max} = \frac{R}{\sin 2\theta}$

$= \frac{3}{\sin 60°} = \frac{3 \times 2}{\sqrt{3}}$ = 3.464 km

(3) Answer [B]

Solution : $t = 30 \times 60 = 1800$ s, m = 180 kg

$\therefore \frac{dm}{dt} = \frac{180}{1800} = \frac{1}{10}$

$\therefore F = v\frac{dm}{dt} = \frac{3 \times 10^3}{10}$ = 300 N

(4) Answer [C]

Solution : Work $W = \frac{Mgl^2}{2L}$

$\therefore l^2 = \frac{2WL}{Mg} = \frac{2 \times 160 \times 9}{8 \times 10} = 36$

$\therefore$ l = 6 m

(5) Answer [D]

Solution : Ring $I = \frac{1}{2} MR^2$ (With respect to diameter)

Half ring $I = \frac{1}{4} mR^2$ Here m = 2M

$= \frac{1}{4} \times \frac{2Ml^2}{\pi^2} = \frac{1}{2} \times \frac{Ml^2}{\pi^2}$

(6) Answer [C]

Solution : Gravitational potential at C_1 is,

$\phi_1 = \frac{-GM_1}{R} - \frac{GM_2}{\sqrt{2}R}$

Gravitational potential at C_2 is

$\phi_2 = \frac{-GM_2}{R} - \frac{GM_1}{\sqrt{2}R}$

$\therefore$ Work done for particle having mass m travel C_1 to C_2,

$W = m(\phi_2 - \phi_1)$

$$= m\left[\left(\frac{-GM_2}{R} - \frac{GM_1}{\sqrt{2}R}\right) - \left(\frac{-GM_1}{R} - \frac{GM_2}{\sqrt{2}R}\right)\right]$$

$$= \frac{Gm}{R}\left[-M_2 - \frac{M_1}{\sqrt{2}} + M_1 + \frac{M_2}{\sqrt{2}}\right]$$

$$= \frac{Gm}{R}\left[M_1\left(1 - \frac{1}{\sqrt{2}}\right) - M_2\left(1 - \frac{1}{\sqrt{2}}\right)\right]$$

$$= \frac{Gm}{R}\left[M_1\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right) - M_2\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)\right]$$

$$= \frac{Gm}{R}\ \frac{(M_1 - M_2)(\sqrt{2}-1)}{\sqrt{2}}$$

(7) Answer [A]

Solution : According to question figure in both branch A and B the mercury height is same. Now pressure generated by column of water and oil is $P_W = P_o$

$\therefore h_W \rho_W g = h_o \rho_o g$

Now relative density of oil is.

$\frac{\rho_o}{\rho_W} = \frac{h_w}{h_o} = \frac{5}{6.25} = 0.8$

(8) Answer [D]

Solution :

	p	*q*	*r*	*s*
a	O	O	O	●
b	●	O	●	O
c	O	O	O	●
d	O	●	O	●

(a) In $J \to K$ process, volume V constant and pressure P decreases.

$\therefore PV = \mu RT$, μR and V are constants

$\therefore P \propto T$

$\therefore$ With decreasing P, T also decreases and volume is constant so,

Work $W = P\Delta V = P \times 0 = 0$

$\therefore \Delta Q = \Delta U$ but $\Delta U \propto T$

$\therefore \Delta Q \propto T$ and T decreases and negative so, $Q < O$.

(b) In $K \to L$ process, pressure is constant and volume increases so, work $W > 0$ and in $PV = \mu RT$, μR and P are constants, $\therefore V \alpha T$

$\therefore$ With increasing volume, T increases and in isobaric difference. $Q = \mu C_V \Delta T$ where μC_V is constant.

$\therefore$ in $Q > \Delta T$, ΔT increases and so, Q increases. $\therefore Q > 0$

(c) process $L \to M$ is reverse process of $J \to K$ so, $Q < 0$

(d) In $M \to J$ process, volume decreases so work $W < O$ but $W = PV$ so,

$(PV)_J < (PV)_M$, $\therefore T_J < T_M \because (PV \propto T)$

$\therefore U_J < U_M \therefore (PV \propto T)$, $\therefore \Delta U < 0$

$\therefore Q > 0$

(9) Answer [C]

Solution : Degree of freedom for diatomic gas = 5

$\therefore$ Energy associated with thermal motion

$$= 5/2\ \mu RT = \frac{5}{2} \times \frac{M}{M_O}\ RT \left[\because \mu = \frac{M}{Mo}\right]$$

$$= \frac{5}{2} M \times \frac{P}{\rho} \qquad \left[\because \frac{RT}{Mo} = \frac{P}{\rho}\right]$$

$$= \frac{5}{2} \times 1 \times \frac{8 \times 10^4}{4}, \therefore \text{ Energy} = 5 \times 10^4 \text{ J}$$

(10) Answer [D]

Solution : $m = 150\ g$

$b = 100$ dyne-s/cm, $t = 6.909$ s

$$A(t) = A_0 e^{\frac{-bt}{2m}},\ \frac{bt}{2m} = \frac{100 \times 6.909}{300} = 2.303$$

$A(t) = A_0 e^{-2.303} = 0.1\ A_o$

$\therefore$ 90 % decreases in amplitude.

(11) Answer [C]

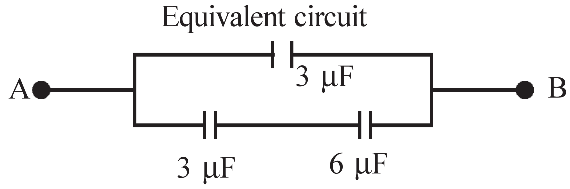
Solution : Due to the charge of A and B at O are equal in magnitude and in opposite direction to each other so its effect is zero. Now, magnitude of electric field at O due to the charge of C is,

$$E = \frac{K\left(\frac{2q}{3}\right)}{R^2} = \frac{2q}{4\pi\varepsilon_o \times 3 \times R^2}$$

$$\therefore E = \frac{q}{6\pi\varepsilon_o R^2}$$

(12) Answer [D]

Solution :



$$\text{Equivalent circuit } C = 3 + \frac{3 \times 6}{3 + 6}$$

$$C = 5\ \mu F$$

(13) Answer [A]

Solution : $L_1 = 2l$, $A_1 = A$,

resistance of first wire $R_1 = \frac{\rho l_1}{A_1} = \frac{\rho \times 2l}{A}$

electric current $I_1 = \frac{V}{R_1} = \frac{VA}{2\rho l}$

$L_2 = l$, $A_2 = 2A$, $\frac{J_1}{J_2} = ?$ Resistance of

second wire $R_2 = \frac{\rho l_2}{A_2} = \frac{\rho l}{2A}$

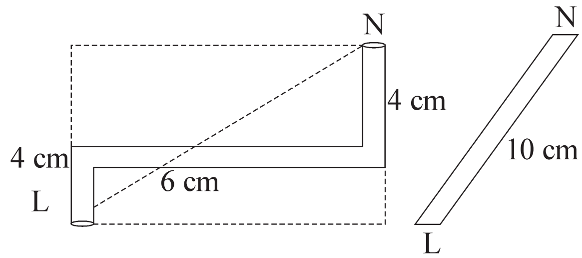
electric current $I_2 = \frac{V}{R_2} = \frac{2VA}{\rho l}$

So, ratio of current density $= \frac{J_1}{J_2} = \frac{I_1}{A_1} \times \frac{A_2}{I_2}$

$$= \frac{VA}{2\rho l A} \times \frac{2A\rho l}{2VA} = \frac{1}{2}$$

(14) Answer [B]

Solution :



$F = BIl \sin\theta$ Where $\theta = 90°$

$= 5 \times 10 \times 0.1 = 5$ N

(15) Answer [A]

Solution : $Q = \dfrac{|\Delta \phi|}{R}$

$= \dfrac{[NBA\cos(180) - NBA\cos(0)]}{R}$

$= \dfrac{2NBA}{R}$ but $A = \pi r^2$, $Q = \dfrac{2NB\pi r^2}{R}$

(16) Answer [D]

Solution : maximum power will exchange when frequency is resonance frequency.

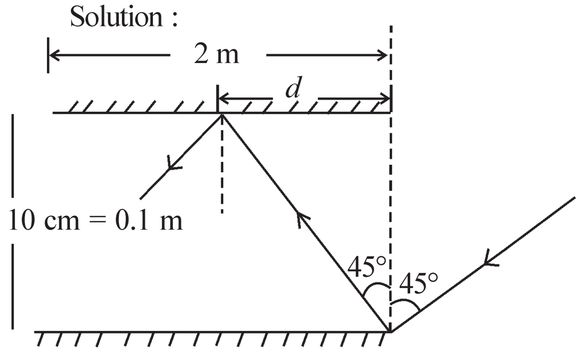
$\therefore f = \dfrac{1}{2\pi\sqrt{LC}}$, $\therefore f^2 = \dfrac{1}{4\pi^2 LC}$

$\therefore L = \dfrac{1}{4\pi^2 C f^2} = \dfrac{1}{4 \times 10 \times (50)^2 \times 10^{-6}}$

$= 10$ H

(17) Answer [B]

Solution :



Travelled distance d during one reflection

$\tan 45° = \dfrac{d}{0.1}$

$\therefore d = 0.1 \times 1 = 0.1$ m

during 0.1 m distance one reflection is happened.

$\therefore$ during distance of 2 m = (?)

$= \dfrac{2 \times 1}{0.1} = 20$ times

(18) Answer [C]

Solution : $n = \dfrac{n_V + n_R}{2} = 1.62$

$D = \dfrac{n_V - n_R}{(n-1)} = \dfrac{0.12}{1.62 - 1} = \dfrac{0.12}{0.62} = 0.194$

(19) Answer [C]

Solution : $I = \dfrac{E}{At} = \dfrac{nhf}{A}$ ($t = 1$ second)

$I = \dfrac{nhc}{A\lambda} \Rightarrow n = \dfrac{IA\lambda}{hc}$

$\therefore$ number of photo electron = 2 % n

$= \dfrac{2}{100} \times \dfrac{IA\lambda}{hc} = \dfrac{2 \times 1 \times 2 \times 10^{-4} \times 100 \times 10^{-9}}{100 \times 6.6 \times 10^{-34} \times 3 \times 10^{8}}$

$= 2.02 \times 10^{12}$ electron / second

(20) Answer [C]

According to $\dfrac{I}{I_0} = e^{-\lambda t}$, $\dfrac{2}{3} = e^{-\lambda t_1}$ ...(1)

and $\dfrac{1}{3} = e^{-\lambda t_2}$ ...(2)

(1) $\Rightarrow 2 = e^{-\lambda t_1 + \lambda t_2}$

(2) $\Rightarrow 2 = e^{\lambda(t_2 - t_1)} \Rightarrow ln_2 = \lambda (t_2 - t_1)$

$\Rightarrow 0.693 = \dfrac{0.693}{\tau_{\frac{1}{2}}} (t_2 - t_1)$

$\Rightarrow t_2 - t_1 = 20$ min

(21) Answer [C]

Solution : $\sigma = e(n_e\mu_e + n_h\mu_h)$ $\sigma = \dfrac{1}{\rho}$ taken

$\dfrac{1}{\rho} = 1.6 \times 10^{-19} (5 \times 10^{18} \times 2.3 + 8 \times 10^{19} \times 0.01)$

$= 1.968 \Rightarrow \rho = 0.508\ \Omega$ m

(22) Answer [A]

Solution : (i) $\dfrac{d\phi}{dt} = KA\dfrac{dT}{dx}$ (value)

$\therefore K = \dfrac{dQ/dt}{A \cdot dT/dx}$

$\therefore$ unit of $K = \dfrac{J/s}{m^2 \times K/m} = W\, m^{-1} K^{-1}$

(ii) $W = e\sigma AT^4 t$, $\therefore \sigma = \dfrac{E}{eAT^4 t}$

$\therefore$ unit of $\sigma = \dfrac{J}{m^2K^4 s} = \dfrac{W}{m^2K^4} = Wm^{-2}K^{-4}$

(iii) $\lambda m T = b$, $\therefore$ unit of b = meter $\times$ Kelvin

(iv) from $s = \frac{\Delta Q}{m\Delta T}$,

$\therefore$ Unit of specific heat $S = \frac{J}{Kg\ K} = J\ Kg^{-1}\ K^{-1}$

(23) Answer [B]

Solution :

$x_0 = 3m$, $y_0 = 0$ m, $v_{0x} = 7\ ms^{-1}$, $v_{0y} - 0\ ms^{-1}$

$a_x = 3\ ms^{-2}$, $a_y = 4\ ms^{-2}$, $y = 18$ m, $t = ?$,

According to $d = v_0 t + \frac{1}{2} at^2$

$y - y_0 = V_{0y}t + \frac{1}{2} a_y t^2$

$18 - 0 = 0 + \frac{1}{2} \times 4 \times t^2 \therefore t = 3$ s

$v_x = v_{0x} + a_x t = 7 + (3)(3) = 16\ ms^{-1}$

$v_y = v_{0y} + a_y t = 0 + (4)(3) = 12\ ms^{-1}$

$\therefore \vec{v} = v_x \hat{i} + v_y = \hat{j} = 16\hat{i} + 12\hat{j}\ ms^{-1}$

$\therefore |\vec{v}| = \sqrt{(16)^2 + (12)^2} = 20\ ms^{-1}$

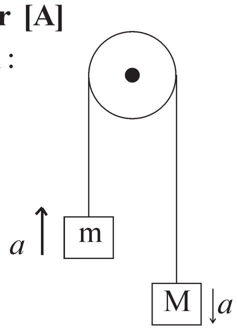
$v_x = 16\ ms^{-1}, \therefore \vec{v} = 16\hat{i} + 12\hat{j}$

$\therefore |\vec{v}| = \sqrt{(16)^2 + (12)^2} = \sqrt{256 + 144}$

$\therefore |\vec{v}| = 20\ ms^{-1}$

(25) Answer [A]

Solution :



Here, acceleration of each object is

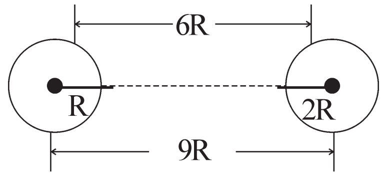
$$a = \left(\frac{M - m}{M + m}\right) g \quad ...(1)$$

$$\text{Now, } a_{cm} = \frac{M_1 a_1 + M_2 a_2}{M_1 + M_2} = \frac{Ma - ma}{M + m}$$

$$= \left(\frac{M - m}{M + m}\right) a = \left(\frac{M - m}{M + m}\right)^2 g$$

from equation (1)

(26) Answer [D]



Solution :

If the distance travel by two spheres to each other after time t and just before collision respectively x_1 and x_2 then, $x_1 + x_2 = 6R$ and $m_1x_1 = m_2x_2$

$\therefore (m)x_1 = (5m)\ x_2$, $x_1 = 5x_2$

$\therefore 5x_2 + x_2 = 6R \Rightarrow 6x_2 = 6R \Rightarrow x_2 = R$

$\therefore$ Sphere having mass 5m (large) travel distance is R.

(27) Answer [C]

Solution : According to equation of continuity

$A_1 v_1 = A_2 v_2$, $\therefore \frac{A_1}{A_2} = \frac{v_2}{v_1}$

$\therefore v_2 = v_1 + 1500\ \%\ v_1 = v_1 + 15\ v_1$

$v_2 = 16\ v_1$, $\therefore A_1 = 16\ A_2$, $\pi r_1^2 = 16\pi\ r_2^2$

$\therefore r_1 = 4r_2$, $\therefore \frac{r_1}{r_2} = 4 : 1$

(28) Answer [B]

Solution : $f_n = \frac{nv}{2L} = \frac{20 \times 1900}{200} = 190$ Hz

$\lambda = \frac{2L}{n} = \frac{2 \times 100}{20} = 10$ m

(29) Answer [C]

Solution : $L\rho = 10 \Rightarrow \rho = \frac{10}{L} = \frac{10}{10} = 1\Omega\ m^{-1}$

$\varepsilon = 2.1$ V, $r = 0.5\ \Omega$, L = 10 m,

V = 1.2 V, l = ?, R = 0, $l = 6\ m$,

$$V_e = \left[\frac{\varepsilon\rho}{R + L\rho + r}\right] \cdot l$$

$$\therefore l = v\left[\frac{R + L\rho + r}{\varepsilon\rho}\right]$$

$$\therefore l = 1.2\left[\frac{0 + 10 + 0.5}{2.1}\right] = 6m$$

●

Question paper - 4

(1) Answer [A]

Solution :

Volume of cube V = $L^3 = (1.2)^3$

$= 1.728\ cm^3$ Now $V = L^3$

$\therefore \frac{\Delta V}{V} = \frac{3\Delta L}{L} = 3 \times \frac{0.1}{1.2}, \therefore \frac{\Delta V}{V} = 0.25$

$\therefore \Delta V = 0.25 \times 10728 = 0.43\ cm^3$

$\therefore$ Volume of cube $= V \pm \Delta V = 1.728 \pm 0.43\ cm^3$

(2) Answer [C]

Solution :

$$R = \frac{V_0^2 \sin 2\theta}{g}, \therefore R_{max} = \frac{V_0^2}{g}$$

$$\therefore \frac{R_{max}}{R} = \frac{1}{\sin 2\theta}$$

$$\therefore R_{max} = \frac{1}{\sin 2\theta} = \frac{3}{\sin 60^\circ} = \frac{3 \times 2}{\sqrt{3}} = 3.464\ m$$

(3) Answer [C]

Solution :

momentum of gun = bullet gain momentum towards forward = $200 \times 10^{-3} \times 5 = 1$ Ns

(4) Answer [B]

Solution :

kinctic energy (K) = $\frac{3}{4}$ {potential energy (U)}

$$\therefore \frac{1}{2} mv^2 = \frac{3}{4} mgh, \therefore v = \sqrt{\frac{3}{4} gh}$$

$$\therefore \sqrt{2g\,(140 - h)} = \sqrt{\frac{3}{2} gh}$$

$$\therefore 2g\,(140 - h) = \frac{3}{2} gh, \therefore h = 80\ m$$

(5) Answer [C]

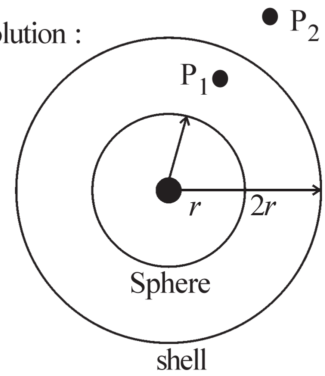
Solution :

If moment of inertia with respect to axis passing through O and perpendicular to plane is I then,

$I_{PR} = I_{QS} = I/2$ (Perpendicular axis theorem) similarly, $I_{AB} = I/2 \therefore I_{PR} = I_{AB}$

(6) Answer [D]

Solution :



Point P_1 and P_2 are at distance $\frac{3}{2} r$ and $\frac{5}{2} r$ from center respectively. P_1 is inside the shell. Due to the shell, the gravitational field inside the shell is zero.

$\therefore$ The gravitational field due to the sphere at point P_1 is,

$$I_1 = \frac{GM}{R^2} = \frac{GM}{(\frac{3}{2} r)^2} = \frac{4GM}{9r^2}$$

(Where R = distance from center) Point P_2 is outside the both sphere and shell.

$\therefore$ Considering mass of sphere and shell concentraded on its center, field in outer region should calculate. The gravitational field due to the each (due to the sphere and shell) at point P_2 is

$$I_2 = \frac{GM}{(\frac{5}{2} r)^2} = \frac{4GM}{25r^2}$$

($\because$ both mass are same)

$\therefore$ total gravitational field at point P_2 is

$$I = 2I_2 = \frac{8GM}{25r^2}$$

(7) Answer [A]

Solution : Slab (2) and (3) are in series connection

$$\therefore k_{23} = \frac{2k_2k_3}{k_2 + k_3} = \frac{2(2k)(3k)}{2k + 3k} = \frac{12}{5}$$

Now, the combine slab of slabs (1), (2) and (3) are in parallel connection to each other.

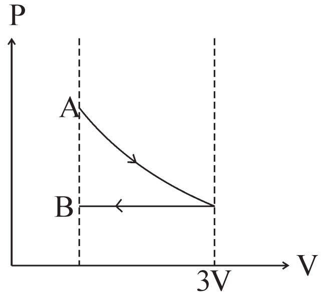
$$\therefore k' = \frac{k_1A_1 + k_{23}A_{23}}{A_1 + A_{23}}$$

$$= \frac{kx^2 + k_{23}(2x)^2}{x^2 + 2x^2} = \frac{k + 2\,k_{23}}{3}$$

$$k' = \frac{k + 2\left(\frac{12k}{5}\right)}{3} = \frac{29k}{15}$$

(8) Answer [D]

Solution :



In first method, due to the isothermal expansion of gas volume increases V to 3V and in second method, volume decreased by 3V to V at constant pressure. Which is shown in graph (D) of $P \rightarrow V$.

(9) Answer [A]

Solution :

$$PV = \mu RT, \therefore \frac{V}{T} = \frac{\mu R}{P}$$

$$\therefore \tan\theta \propto \frac{1}{P} \; [\because \frac{V}{T} = \tan\theta \text{ and } \mu R \text{ constant}]$$

$$\therefore \tan\theta_2 > \tan\theta_1 \Rightarrow \theta_2 > \theta_1$$

$$\therefore \frac{1}{P_2} > \frac{1}{P_1}, \therefore P_1 > P_2$$

(10) Answer [B]

Solution :

$\phi = \pi/2$, $T = 2\pi/\omega = 1 \Rightarrow \omega = 2\pi$ rads^{-1}, A = 5 cm

$v = A\omega \cos(\omega t + \phi)$

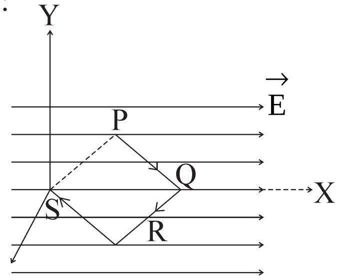
$5\pi = 10\pi \cos(2\pi t + \pi/2)$

$\Rightarrow \cos(2\pi t + \pi/2) = 1/2 \Rightarrow \sin 2\pi t = 1/2$

$\therefore 2\pi t = \pi/6 \Rightarrow t = 1/12$ s

(11) Answer [C]

Solution :



Work $W = \vec{F} \cdot \vec{PS}$

$= q\vec{E} \cdot [(0 - a)\hat{i} + (0 - b)\hat{j} + (0 - 0)\hat{k}]$

$= qE\hat{i} \cdot (-a\hat{i} - b\hat{j} + (0\hat{k}))$

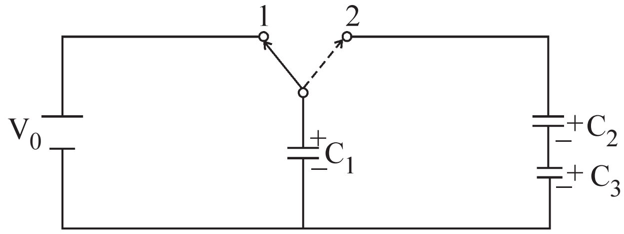
$= -qEa + 0 + 0$

$\therefore W = -qEa$

(12) Answer [C]

Solution :

When C_1 connected with switch '1' then charge on C_1 is $Q_o = C_1V_o$. When switch '2' connected then C_2 and C_3 are in series and C_1 with them parallel connected. In this condition, suppose Change Q_1 on C_1 and same charge Q_2 on C_2 and C_3.



$$\therefore -\frac{Q_2}{C_2} - \frac{Q_2}{C_3} + \frac{Q_1}{C_1} = 0$$

[$\because$ Net sum of potential in close loop is zero]

$$Q_2\left[\frac{1}{C_2} + \frac{1}{C_3}\right] = \frac{Q_1}{C_1}$$

$$\Rightarrow Q_1 = Q_2C_1\left[\frac{1}{C_2} + \frac{1}{C_3}\right]$$

But $Q_0 = Q_1 + Q_2$

$$\therefore Q_0 = Q_2C_1\left[\frac{1}{C_2} + \frac{1}{C_3}\right] + Q_2$$

$$= Q_2\left[C_1\left(\frac{C_2 + C_3}{C_2C_3}\right) + 1\right]$$

$$= Q_2\left[\frac{C_1C_2 + C_1C_3 + C_2C_3}{C_2C_3}\right]$$

$$\therefore Q_2 = Q_0\left[\frac{C_2C_3}{C_1C_2 + C_1C_3 + C_2C_3}\right]$$

But $Q_0 = C_1V_0$,

$$\therefore Q_2 = \frac{V_0 (C_1C_2C_3)}{C_2C_2 + C_2C_3 + C_3C_1}$$

and $Q_1 = Q_0 - Q_2$

$$= C_1 V_0 - \frac{V_0 (C_1C_2C_3)}{C_1C_2 + C_2C_3 + C_3C_1}$$

$$\therefore Q_1 = V_0 C_1 \left[\frac{C_1C_2 + C_3C_1}{C_1C_2 + C_2C_3 + C_3C_1}\right]$$

(13) Answer [B]

Solution :

$$\frac{dQ}{dt} = I = 3t^2 + 2t$$

$$\therefore dQ = (3t^2 + 2t)\, dt$$

$$\therefore Q = \int dQ = \int_{t_1=2sec}^{t_2=3sec} (3t^2 + 2t)\,dt$$

$$= \left[\frac{3t^3}{3}\right]_{t_1=2}^{t_2=3} + \left[\frac{2t^2}{2}\right]_{t_1=2}^{t_2=3} = 24 \text{ C}$$

(14) Answer [D]

Solution :

τ_{max} = NIAB, L = N $(2\pi r)$ = $NI\pi r^2B$

$$\therefore r = \frac{L}{2\pi N} = NI\pi \frac{\cdot L^2}{4\pi^2N^2}$$

$$B = \frac{BIL^2}{4\pi N} \quad \tau_{max} \propto \frac{1}{N_{min}} \quad \therefore N_{min} = 1$$

(15) Answer [D]

Solution :

$$I_P = \frac{Po}{n \cdot \varepsilon_P} = \frac{Por}{n\, \varepsilon_S} = \frac{12000 \times 5}{0.9 \times 1000} = 66.66$$

$$I_S = \frac{Po}{\varepsilon_S} = \frac{12000}{1000} = 12 \text{ A}$$

$$\therefore \frac{I_P^2 R_P}{I_S^2 R_S} = \frac{(66.66)^2 \times 0.9}{(12)^2 \times 5} = 5.55$$

(16) Answer [A]

Solution :

$$\frac{U_E}{E_B} = 1 \Rightarrow U_E = E_B$$

$$\therefore U = U_E + E_C = 2U_E \Rightarrow U_E = \frac{1}{2} U$$

$$\therefore \frac{1}{2} \frac{Q^2}{C} = \frac{1}{2} \times \left(\frac{1}{2} \frac{Q_0}{C}\right)$$

$$\therefore Q = \frac{Q_0}{\sqrt{2}}, \therefore Q_0 \cdot \cos \omega t = \frac{Q_0}{\sqrt{2}}$$

$$\therefore \cos\omega t = \frac{1}{\sqrt{2}}, \therefore \omega t = \frac{\pi}{4}$$

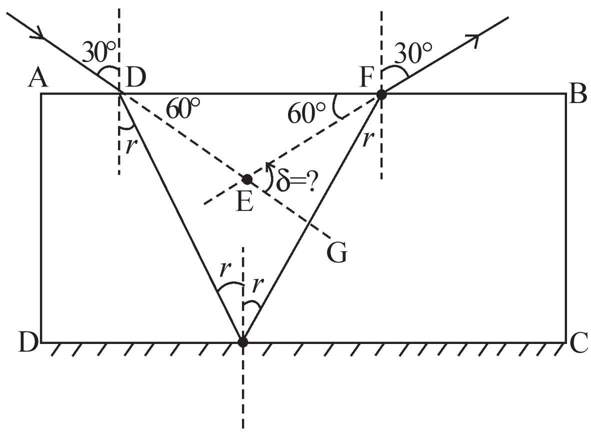
$$\therefore \frac{1}{\sqrt{LC}}\, t = \frac{\pi}{4}$$

$$\therefore t = \frac{\pi}{4} \times \sqrt{LC} = \frac{3.14}{4} \times \sqrt{100 \times 10^{-6}}$$

$$\therefore t = 0.785 \times 10^{-3} \text{ s} = 0.785\ ms$$

(17) Answer [C]

Solution :



Incident angle on AB surface = 30°.

Refraction angle = r

$\therefore$ ∠FDE = 60°, DC surface refracted incident angle = reflection angle = r

For AB surface, Incident angle = r

refraction angle = 30°.

$\therefore$ From ∠DFE = 60°, ∠DEF = 60°

$\therefore$ δ = ∠FEG = 120°

(18) Answer [B]

Solution :

$$\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

(1) $\frac{1}{15} = \frac{1.5-1}{1}\ x\ [\frac{1}{R_1} - \frac{1}{R_2} = x \text{ taken}]$

$\frac{1}{15} = 0.5\ x$ ...(i)

(2) $\frac{1}{f_w} = \frac{1.5 - \frac{4}{3}}{\frac{4}{3}}\ x = 0.125\ x$ ...(ii)

$$\frac{\text{equation (i)}}{\text{equation (ii)}} = \frac{f_w}{15} = \frac{0.5\ x}{0.125\ x}$$

$\therefore f_w = 60$ cm

(19) Answer [C]

Solution :

Parrcle having mass m moving with velocity v is,

$m = \frac{m_o}{\sqrt{1 - v^2/c^2}}$ Where, m_o = (rest mass)

$\therefore \frac{m}{m_o} = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$, $\therefore 3 = \frac{1}{\sqrt{1 - v^2/c^2}}$

$\therefore 9 = \frac{1}{1 - \frac{v^2}{c^2}} \Rightarrow \frac{1}{9} = 1 - \frac{v^2}{c^2}$

$\Rightarrow \frac{v^2}{c^2} = 1 - \frac{1}{9} = \frac{8}{9}$

$\therefore \frac{v}{c} = \frac{2\sqrt{2}}{3} \Rightarrow v = \frac{2\sqrt{2}}{3}$ c.

(20) Answer [C]

Solution :

Due to $3\alpha\ {}_{Z-6}X^{A-12}$, due to $2\beta^+$

Z – 6 – 2 so, final ${}_{Z-8}X'^{A-12}$, proton = Z – 8

neutron = A – 12 – Z + 8 $\Rightarrow$ A – Z – 4

(21) Answer [B]

Solution :

Volume V = $l \times b \times h$

$= 10^{-2} \times 10^{-2} \times 10^{-3} = 10^{-7}\ m^3$

$\therefore$ number of holes in given volume = number of holes in unit volume × volume

$= 6 \times 10^{19} \times 10^{-7} = 6 \times 10^{12}$

(22) Answer [B]

Solution :

Combined slab is in permanent thermal state and length of A and E is same so the heat passing through it is same.

Combined slab is in permanent thermal state so the temperature trend is similar in each component of slabs. The length of slabs A and E is lower by Δx so the tempereture difference (ΔT) is also minimum for this component of Slabs.

The height of slab C is summation of height of D and B, the heat passing through it in direction perpendicular to heat flow is as following :

$$\left(\frac{dQ}{dt}\right)_C = \left(\frac{dQ}{dt}\right)_B + \left(\frac{dQ}{dt}\right)_D$$

Due to the permanent termal state, heat passing through components of slub having same length is same. Thus, option (B) is wrong.

(23) **Answer [C]**

Solution :

According to conservation of angular momentum

$m\, v_{max}\, d_{min} = m\, v_{min}\, d_{max}$

$\therefore d_{min} = \dfrac{v_{min}\, d_{max}}{v_{max}}$

$= \dfrac{(2 \times 10^4)\,(3 \times 10^4 \times 10^3)}{4 \times 10^4} = 1.5 \times 10^7$ m

(24) **Answer [A]**

Solution :

$\alpha_1 = 9 \times 10^{-4}\ C^{-1}, \alpha_2 = -6 \times 10^{-4}\ C^{-1}$

$(\rho_{20})_1 = 3 \times 10^{-8}\ \Omega$ m, $(\rho_{20})_2 = ?$

$\rho_\theta = \rho_{20}\,[1 + \alpha\,(0 - 20)]$

differenciate with respect to temperature θ

$\dfrac{d\rho_\theta}{d\theta} = \rho_{20}\,\alpha$

For first matter $\left(\dfrac{d\rho}{d\theta}\right)_1 = (\rho_{20})_1\,\alpha_1$

For second matter $\left(\dfrac{d\rho}{d\theta}\right)_2 = (\rho_{20})_2\,\alpha_2$

Resistivity of mixture $\rho_\theta = (\rho_\theta)_1 + (\rho_\theta)_2$

$\therefore \dfrac{d\rho}{d\theta} = \left(\dfrac{d\rho}{d\theta}\right)_1 + \left(\dfrac{d\rho}{d\theta}\right)_2 = 0$

$\left(\dfrac{d\rho}{d\theta}\right)_1 = -\left(\dfrac{d\rho}{d\theta}\right)_2$

$(\rho_{20})_1\,\alpha_1 = -(\rho_{20})_2\,\alpha_2$

$(\rho_{20})_2 = -\dfrac{(\rho_{20})_1\,\alpha_1}{\alpha_2}$

$= \dfrac{-3 \times 10^{-8} \times 9 \times 10^{-4}}{-6 \times 10^{-6}} = 4.5 \times 10^{-8}\ \Omega$ m

(25) **Answer [B]**

Solution :

$\Delta f = 2v\dfrac{f}{C} = \dfrac{2v}{\lambda}$

$\therefore v = \dfrac{\Delta f \lambda}{2} = \dfrac{2000 \times 0.25}{2} = 250\ ms^{-1}$

$= 900\ kmh^{-1}\ (1ms^{-1} = 18/5\ kmh^{-1})$

(26) **Answer [C]**

Solution :

$\lambda o = \dfrac{hc}{\phi_o} = \dfrac{(6.6 \times 10^{-34})\,(3 \times 10^8)}{4 \times 1.6 \times 10^{-19}}$

$= 3.1 \times 10^{-7}$ m = 310 nm

(27) **Answer [A]**

Solution :

Population density = 1000 km^{-2}

$= 1000 \times (10^3)^{-2} = 10^{-3}\ m^{-2} =$

$\therefore$ Area $= \pi d_T^2 = \pi\left(\sqrt{2h_T R}\right)^2 = 2\pi h_T R$

$= 40.192 \times 10^8\ m^2$

$\therefore$ Number of peoples who can watch program.

$= 10^{-3} \times 40.192 \times 10^5 = 40.192$ Lakhs

(28) **Answer [C]**

Solution :

$8M = 9V \Rightarrow 9M - M = 9V$

$9(M - V) = M$ or $(M - V) = \dfrac{M}{9}$

$\Rightarrow \dfrac{M - V}{M} = \dfrac{1}{9}$ mm

(29) **Answer [D]**

Solution :

$\theta = \dfrac{l}{r} = \dfrac{4cm}{112cm} = \dfrac{1}{28}$ rad

$= 2.05° = 2°$

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Question paper - 5

(1) Answer [D]

Solution :

Possible maximum value calulated by series connection of two resistance.

For series connection = $R_S = R_1 + R_2 = 3.0 + 6.0 = 9.0\ \Omega$

$\Delta R_S = \Delta R_1 + \Delta R_2 = 0.2 + 0.1 = 0.3\ \Omega$

$\therefore R_S \pm \Delta R_S = (9.0 + 0.3)\ \Omega$

$\therefore$ maximum possible value = $(9.0 \pm 0.3)\ \Omega$.

Minimum value calculated by parallel connection of two resistance.

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_L}$$

$$\frac{R_1R_2}{R_1 + R_2} = \frac{3.0 \times 6.0}{3.0 + 6.0} = \frac{18}{9} = 2.0\ \Omega$$

Now $R_P = \dfrac{R_1R_2}{R_s}$, $\quad (\because R_S = R_1 + R_2)$

$$\therefore \frac{\Delta R_P}{R_P} = \frac{\Delta R_1}{R_1} + \frac{\Delta R_2}{R_2} + \frac{\Delta R_s}{R_S}$$

$$= \frac{0.1}{3.0} + \frac{0.2}{6.0} + \frac{0.3}{9.0} = 0.099,\ \frac{\Delta R_P}{R_P} = 0.1$$

$\therefore \Delta R_P = 0.1 \times 2 = 0.2\ \Omega$

minimum value = $R_P \pm \Delta R_P = (2.0 \pm 0.2)\ \Omega$

(2) Answer [B]

Solution :

Distance travelled for free falling object to reach plate is $d_1 = \frac{1}{2} gt^2$ and gained velocity $v_1 = gt$. Now due to the collision with plate, its velocity becomes halved.

So, $v_1' = \frac{1}{2} gt$

For distance from plate to land,

According to equation $d_2 = v_0 t + \frac{1}{2} at^2$

$$d_2 = v_1' \left(\frac{t}{2}\right) + \frac{1}{2} g \left(\frac{t}{2}\right)^2$$

$$\therefore 60 = \frac{1}{2} gt \frac{t}{2} + \frac{1}{2} g \frac{t^2}{4}$$

$$\therefore 60 = \frac{1}{4} gt^2 \left(1 + \frac{1}{2}\right) = \frac{1}{4} \times \frac{3}{2} \times 10t^2$$

$$\therefore t^2 = \frac{60 \times 4 \times 2}{3 \times 10},\ \therefore t = 4 \text{ s}$$

$\therefore d_1 = 80$ m, $d = 80 + 60 = 140$ m

(3) Answer [B]

Solution :

$$\mu = \frac{l}{L - l} = \frac{\frac{1}{3}}{1 - \frac{1}{3}} = \frac{\frac{1}{3}}{\frac{2}{3}} = \frac{1}{2}$$

(5) Answer [D]

Solution :

$$\frac{F_1}{F_2} = \frac{m v_1^2 R_2}{R_1 m v_2^2} = \frac{m\omega^2 R_1}{m\omega^2 R_2} = \frac{R_1}{R_2}$$

(6) Answer [C]

Solution :

Kinetic energy of particle = $\frac{1}{4}$ (Escape energy)

$$= \frac{1}{4}\left(\frac{GMm}{R}\right)$$

from energy conservation law, total energy on earth's surface = total energy (kinetic energy + potential energy) at maximum height H from earth's surface

$$\frac{GMm}{4R} - \frac{GMm}{R} = 0 - \frac{GMm}{R + H}$$

($\because$ Velocity at maximum height is zero $\Rightarrow$ Kinetic energy is zero.)

$$\therefore \frac{1}{4R} - \frac{1}{R} = \frac{-1}{R + H}$$

$\therefore \frac{1}{R+H} = \frac{1}{R} - \frac{1}{4R} = \frac{3}{4R}$

$\therefore 4R = 3R + 3H \Rightarrow 3H = R \Rightarrow H = \frac{R}{3}$

(7) Answer [B]

Solution : $t \propto (x_2^2 - x_1^2)$

$$\frac{t_1}{l_2} = \left(\frac{x_1^2 - x^2}{x_2^2 - x^2}\right) = \frac{9x^2 - x^2}{16x^2 - x^2} = \frac{8}{15}$$

(8) Answer [C]

Solution : Performance coefficient of Refridgerator

$$\frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2},\ \therefore \frac{Q_2}{W} = \frac{\frac{Q_2}{Q_1}}{1 - \frac{Q_2}{Q_1}}$$

$$\therefore \frac{Q_2}{W} = \frac{1-\eta}{\eta} \quad [\eta = 1 - \frac{Q_2}{Q_1} \Rightarrow \frac{Q_2}{Q_1} = 1 = \eta]$$

$$\therefore Q_2 = W \times \frac{1-\eta}{\eta},\ \therefore Q_2 = 10 \times \frac{1 - \frac{1}{10}}{\frac{1}{10}}$$

$\therefore Q_2 = 90$ J

(10) Answer [C]

Solution : Assume that due to the compression in spring A is y, the expansion in spring B and C is y'.

$\therefore y' = y \cos 45° = \frac{y}{\sqrt{2}}$ Now F = 2 ky

$\therefore$ Effective force constant k' = 2k

$\therefore T = 2\pi\sqrt{m/k'},\ \therefore T = 2\pi\sqrt{\frac{m}{2k}}$

(11) Answer [A]

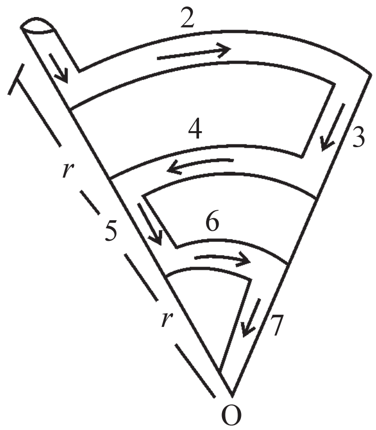
Solution :

$$f^2 = \frac{p^2}{4l^2} \cdot \frac{F}{m}\ \therefore, m = \frac{p^2 F}{4l^2 f^2}$$

Writing the dimensional formula for each one. $m = M^1L^{-1}T^0$

(14) Answer [A]

Solution :



$B_1 = B_3 = B_5 = B_7 = 0$

$B_2 = \frac{\mu_0}{4\pi} \frac{I\theta}{3r} \otimes$

$B_4 = \frac{\mu_0}{4\pi} \frac{I\theta}{2r} \odot,\quad B_6 = \frac{\mu_0}{4\pi} \frac{I\theta}{r} \otimes$

Resultant magnetic field at point O is

$$B = B_2 - B_4 + B_6 = \frac{\mu_0 I\theta}{4\pi r}\left(\frac{1}{3} - \frac{1}{2} + 1\right)$$

$$= \frac{5\mu_0 I\theta}{24\pi r}$$

(15) Answer [B]

Solution :

$\vec{\tau} = \vec{m} \times \vec{B}$, but magnetic moment

$m = I\pi R^2 = Qf\pi R^2,\ \therefore \vec{m} = Qf\pi R^2 \hat{i}$

$\vec{B} = B\hat{j},\ \vec{\tau} = BQf\pi R^2 (\hat{i} \times \hat{j})$

$\therefore \tau = (2 \times 0.6 \times 10 \times 25 \times 10^{-2}) = 3\ \hat{k}$

(17) Answer [A]

Solution :

$f = -15$ cm $\qquad m = 2$

$-\frac{v}{u} = 2 \therefore v = -2u,\ \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$$\therefore \frac{-1}{15} = \frac{1}{u} - \frac{1}{2u}$$

$$\therefore \frac{-1}{15} = \frac{1}{2u} \quad \therefore 2u = -15, \ u = -7.5 \text{ cm}$$

(18) Answer [D]

Solution :

$m = v/u$, $\therefore v = mu$

$\therefore |u| + v = D$, $|u| + m|u| = D$

$|u|(1 + m) = D$

$$\therefore |u| = \frac{D}{m+1}, \ \therefore v = \frac{mD}{m+1}$$

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} = \frac{m+1}{mD} + \frac{m+1}{D} \text{ (taking } u \text{ negative)}$$

$$= \frac{m+1+m^2+m}{mD} = \frac{m^2+2m+1}{mD}$$

$$= \frac{(m+1)^2}{mD}, f = \frac{mD}{(m+1)^2}$$

(19) Answer [D]

Solution :

Energy of one photon of X - ray is

$$E_P = \frac{hc}{\lambda} = \frac{6.6\times10^{-34}\times3\times10^{8}}{3\times10^{-10}}$$

$= 6.6 \times 10^{-16}$ J ...(1)

Now electron energy means kinetic energy,

$$E_e = \frac{1}{2} m_e v^2 \Rightarrow E_e = \frac{P_e^{\,2}}{2m_e} \text{ But } P_e = \frac{h}{\lambda}$$

$$\therefore E_e = \frac{h^2}{2m_e\lambda^2}$$

$$= \frac{(6.6\times10^{-34})^2}{(2)\,(9.1\times10^{-31})\times(3\times10^{-10})^2}$$

$= 2.65 \times 10^{-18}$ J ...(2)

taking ratio of equation (1) and (2)

$$\frac{E_P}{E_e} = \frac{6.6\times10^{-16}}{2.65\times10^{-18}} = 249$$

(20) Answer [B]

Solution :

Total binding energy of X = 1480 MeV

Total binding energy of A = 902 MeV

Total binding energy of B = 738 MeV

Thus, emitted energy = (902 + 738) – 1480

= 1640 – 1480 = 160 MeV

(21) Answer [A]

Solution :

$$\beta = \frac{I_C}{I_B}, \ \beta = \frac{I_E - I_B}{I_B}$$

$$\therefore I_B = \frac{I_E}{1+\beta} = \frac{60}{1+59} = 0.1 \ mA$$

$I_C = I_E - I_B = 6.0 - 0.1 = 5.9 \ mA$

(22) Answer [A]

Solution :

According to arrangement of figure (*a*), the equivalent thermal resistance is $R_S = R + R = 2R$

$$\therefore \text{Rate of heat conduction is } \frac{d\theta}{dt} = \frac{\Delta\theta}{R_S}$$

$$\therefore \frac{10}{2} = \frac{(100-0)}{2R} \quad ...(1)$$

According to arrangement of figure (*b*),

$$R_P = \frac{R^2}{R+R} = \frac{R}{2}$$

$$\therefore \text{Rate of heat conduction is } \left(\frac{d\theta}{dt}\right) = \frac{\Delta\theta}{R_P}$$

$$\therefore \frac{30}{t} = \frac{(100-0)}{R/2} \quad ...(2)$$

from equation (1) putting R = 10 in equation (2), t = 1.5 min

(23) Answer [D]

Solution :

Second order diffraction $sin\theta_2 = \frac{2\lambda}{d}$

$= 2\ sin\ 32° > 1$ Which is not possible.

(24) Answer [D]

Solution :

In β – decay atomic number increase by 1.

atomic mass does not change.

$_{29}Cu^{64} \rightarrow {}_{30}Zn^{64} + {}_{-1}e^{0}$

(26) Answer [B]

Solution :

$A_v = \frac{Vo}{V_i} = \beta\ \frac{Ro}{R_i}$

$V_o = \beta\ \frac{Ro}{R_i}\ V_i = \frac{50 \times 5 \times 10^3 \times 0.01}{10^3}$

$\therefore$ Vo = 2.5 V

(28) Answer [D]

Solution :

Value of one division on main scale 1 MsD = 1 *m*m, 9 MsD = 10 divigon on vernier scale

$\therefore$ L. C. M. L C = 1 MsD – 1 VsD

$= 1\ mm - \frac{9}{10}\ mm = \frac{1}{10}\ mm = 0.1\ mm$

observed measurement or sides

= (observation of main scale) + (Adjacent division of vernier scale × L C M)

$= (10) + \left(1 \times \frac{1}{10}\right) = 10.1$ mm

Volume of cube V = $(1.01)^3\ cm^3 = 1.03\ cm^3$

(round-off upto three significant digits of observation of length)

Density of cube = $\frac{2.736}{1.03} = 2.6563\ gcm^{-3}$

Round-off upto three significant digits to last observation density is 2.66 gcm^{-3}

(30) Answer : (A)

Solution :

When mixing of liquid *x* and *y* then heat loss by *y* = heat gain by *x*.

$ms_y\ (19° - 16°) = ms_x\ (16° - 12°)$

$\Rightarrow 3S_y = 4S_x$ ...(1)

Simllarly mixing of *y* and then

$ms_y\ (23° - 19°) = ms_z\ (28° - 23°)$

$\Rightarrow 4S_y = 5S_z$ ...(2)

mixing of *x* and *z*,

$ms_x\ (T - 12°) = ms_z\ (28° - T)$

$\Rightarrow (T - 12°)S_x = (28° - T)S_z$ ...(3)

from equation (2) and (3)

$(T - 12°)S_x = (28 - T)4/5\ S_y$

$\therefore (T - 12)S_x = (28 - T)\frac{4}{5} \times \frac{4}{3}\ S_x$

$\therefore T - 12 = (28 - T)\ \frac{16}{15}$

$\Rightarrow 15\ T - 180 = 448 - 16\ T \Rightarrow 31\ T = 628$

$\therefore$ T = 20° C

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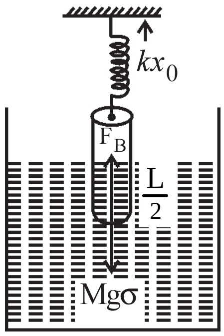
(1) Answer [C]

Solution :

Mass of $\frac{L}{2}$ length and A cross - section is $m = \frac{AL}{2}$

$\therefore$Buoyant force in liquid having density σ is $F_B = \sigma\, Mg = \sigma \frac{ALg}{2}$



Suppose, increase in length of spring is x_0

$\therefore$ Restoring force in spring towards upward is $= kx_0$. Where k = spring's force constant and weightage on cylinder in downward direction = Mg weight force.

$\therefore$ For equilibrium cylinder, weight force = buoyant force + Restoring force

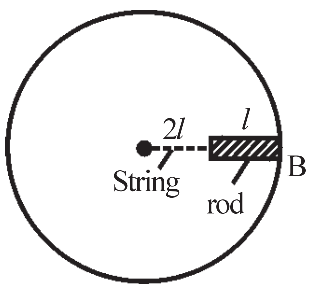
$Mg = \frac{\sigma ALg}{2} + kx_0$, $\therefore kx_0 = Mg - \frac{\sigma ALg}{2}$

$\therefore x_0 = \frac{Mg}{k}\left[1 - \frac{\sigma AL}{2M}\right]$

(2) Answer [D]

Solution : Velocity of rod's A end $v_1 = r\omega = 2l\omega$

Velocity of rod's B end $v_2 = r\omega = 3l\omega$



$\therefore$ Average velocity $v = \frac{v_1 + v_2}{2}$

$= \frac{2l\omega + 3l\omega}{2}$, $\therefore v = \frac{5l\omega}{2}$

$\therefore$ Induced *emf* between two ends of rod is $E = Bvl$

$= B \times \frac{5l\omega}{2} \times l \quad [\because v = \frac{5l\omega}{2}] = \frac{5B\omega l^2}{2}$

(3) Answer [D]

Solution :

Kinetic energy before collision - kinetic energy after collision = energy loss

$\frac{1}{2}mv^2 + \frac{1}{2}M(0)^2 - \frac{1}{2}(m + M)(v')^2$

= energy loss where, $v' = \frac{mv + M \times 0}{m + M}$

$\therefore v' = \frac{m}{m + M} \cdot v$

$\frac{1}{2}mv^2 - \frac{1}{2}(m + M)\left(\frac{mv}{m + M}\right)^2$ = energy loss

$\frac{1}{2}mv^2 - \frac{1}{2}mv^2 \times \left(\frac{m}{m + M}\right)$ = energy loss

$\frac{1}{2}mv^2\left[1 - \frac{m}{m + M}\right]$ = energy loss

$\frac{1}{2}mv^2\left[\frac{M}{m + M}\right]$ = energy loss compare with $\left(\frac{1}{2}mv^2\right) f$

$f = \frac{M}{m + M}$

While $\frac{m}{m + M}$ is given in statement, So statement I is wrong and energy loss is positive so, maximum energy loss happened. So, statement II is true.

(4) Answer [B]

Solution :

$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2} \Rightarrow \varepsilon_0 = \frac{q_1 q_2}{4\pi F r^2}$

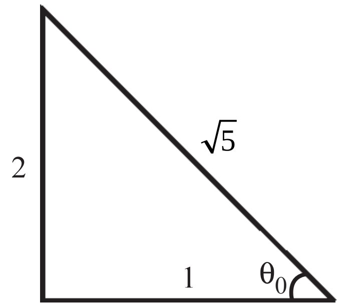
$\therefore [\varepsilon_0] = \frac{[q_1][q_2]}{[F][r^2]}$ [$\because 4\pi$ is dimensionless]

$= \frac{(AT)(AT)}{(M^1 L^1 T^{-2})(L^2)} = M^{-1} L^{-3} T^4 A^2$

(5) Answer [B]

Solution : $\vec{v_0} = (\hat{i} + 2\hat{j})\ \text{ms}^{-1}$

$\therefore v_{0x} = 1\ \text{ms}^{-1}$, $v_{0y} = 2\ \text{ms}^{-1}$



$$\therefore \tan\theta_0 = \frac{v_{0y}}{v_{0x}} = \frac{2}{1} = 2$$

$\therefore \cos\theta_0 = \frac{1}{\sqrt{5}}$ and value of $v_0 = \sqrt{(1)^2 + (2)^2}$

$v_0 = \sqrt{5}$ m/s. Now, equation of projectile motion,

$$y = \tan\theta_0 x - \frac{g}{2(v_0\cos\theta_0)^2} \cdot x^2$$

substituting values

$$y = 2x - \frac{10x^2}{2\left((\sqrt{5}) \times \frac{1}{\sqrt{5}}\right)^2}, \therefore y = 2x - 5x^2$$

(6) Answer [C]

Solution :

Amplitude of damped oscillation at time t is

$$A_t = A_0 e^{\frac{-bt}{2m}}$$

At time $t = 5$ s, amplitude is $0.9\ A_0$.

$$\therefore 0.9\ A_0 = A_0 e^{\frac{-5b}{2m}},$$

$$\therefore 0.9 = e^{\frac{-5b}{2m}} \quad ...(1)$$

and $t = (5 + 10)$, amplitude is αA_0.

$$\therefore \alpha A_0 = A_0 e^{\frac{-5b}{2m}}, \therefore \alpha A_0 = A_0 e^{3\left(\frac{-5b}{2m}\right)}$$

$$\therefore \alpha = e^{3\left(\frac{-5b}{2m}\right)} \quad ...(2)$$

From equation (1) $\alpha = e^{3 \times 0.9} = e^{2.7}$

$= 2.7 \times loge = 2.7 \times 0.27$, $\therefore \alpha = 0.729$

(7) Answer [B]

Solution : Charge on first capacitor,

$Q_1 = C_1 V_1 = 120\ C_1$

Charge on second capacitor

$Q_2 = C_2 V_2 = 200\ C_2$

Both are connected to each other so, difference on both becomes zero then,

$Q_1 = Q_2$

$120C_1 = 200C_2 \therefore 3C_1 = 5C_2$

(8) Answer [B]

Solution :

$f_1 = \frac{v}{2L}$ fundamental frequency in wire or first harmonic

$$\text{But, } v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{T}{A}} \quad ...(1)$$

Now Young Modulus $Y = \frac{T}{A} \times \frac{L}{\Delta L}$

$\therefore \frac{T}{A} = Y \times \frac{\Delta L}{L}$ but $\frac{\Delta L}{L} = 1\ \% = 0.01$

$$\therefore \frac{T}{A} = 0.01\ Y \quad ...(2)$$

substiluting value of equation (2) in equation (1),

$$v = \sqrt{\frac{0.01Y}{\rho}} \quad ...(3)$$

$\therefore$ Fundamental frequency $f_1 = \frac{v}{2L} = \frac{1}{2L}\sqrt{\frac{0.01Y}{\rho}}$

$$= \frac{1}{2 \times 1.5}\sqrt{\frac{2.2 \times 10^{11}}{7.7 \times 10^3} \times 0.01}$$

$$= \frac{1}{3}\sqrt{\frac{2}{7} \times 10^6} = \frac{10^3}{3} \times 0.5345$$

$= 0.17817 \times 10^3$, $\therefore f_1 = 178.2$ Hz

(9) Answer [A]

Solution :

Flux associated with large ring $\phi = AB$

$$= \pi R^2 \times \frac{\mu_0 I a^2}{2(a^2 + x^2)^{\frac{3}{2}}}$$

$$= \frac{3.14 \times 9 \times 10^{-8} \times 4 \times 3.14 \times 10^{-7} \times 2 \times 0.04}{2(0.04 + 0.0225)^{\frac{3}{2}}}$$

$$= \frac{72 \times 0.04 \times (3.14)^2 \times 10^{-13}}{2 \times (0.0625)^{\frac{3}{2}}}$$

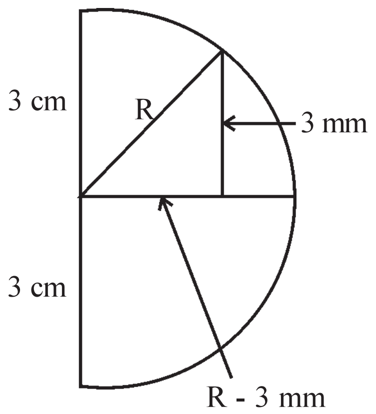
$= \dfrac{36 \times 0.04 \times (3.14)^2 \times 10^{-13}}{(0.25)^3}$

$= \dfrac{14.1978 \times 10^{-13}}{1.5625 \times 10^{-2}} = 9.08 \times 10^{-11}$

$\therefore \phi = 9.1 \times 10^{-11}$ W

(10) Answer [C]

Solution :



$n = \dfrac{c}{v} = \dfrac{3 \times 10^8}{2 \times 10^8} = \dfrac{3}{2}$

$n = 1.5$ from figure,

$R^2 = (R - 3)^2 + (3)^2$

$\therefore R^2 = R^2 - 2R(3) + (3)^2 + (3)^2$

$\therefore$ from $2R(3) = (3)^2 + (3)^2$ R = 15 cm

Now, $\dfrac{1}{f} = \dfrac{(n-1)}{R} = \dfrac{1.5-1}{15} = \dfrac{0.5}{15} = \dfrac{1}{30}$

$\therefore f = 30$ cm

(11) Answer [A]

Solution :

total energy on surface of planet is E_1 = potential energy + kinetic energy

$E_1 = -\dfrac{GMm}{R}$ + kinetic energy ...(1)

total energy at height 2R of planet from surface

$E_2 = -\dfrac{GMm}{3R} + \dfrac{1}{2} m v_0^2$ where E_2 = orbital energy

At 2R height from surface of planet $r = 3R$.

and orbital velocity $v_0 = \sqrt{\dfrac{GM}{r}} = \sqrt{\dfrac{GM}{3R}}$

$\therefore E_2 = -\dfrac{GMm}{3R} + \dfrac{1}{2}\dfrac{GMm}{3R}$

$\therefore E_2 = -\dfrac{GmM}{6R}$ But from law of energy conservation, total energy is constant.

$\therefore E_1 = E_2,\ -\dfrac{GMm}{R} + K.E. = -\dfrac{GmM}{6R}$

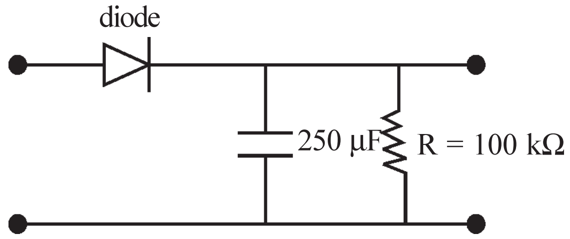
$\therefore$ Kinetic energy $= -\dfrac{GmM}{6R} + \dfrac{GMm}{R}$

$= \dfrac{-GmM + 6GMm}{6R}$

$\therefore$ Kinetic energy $= \dfrac{5GmM}{6R}$

(12) Answer [B]

Solution :



$RC = 100 \times 10^3 \times 250 \times 10^{-12}$

$T = 25\ \mu s$ [$\because$ RC = time T] High frequency with negligible resistor is

$f = \dfrac{1}{2\pi m_a T} = \dfrac{1}{2 \times 3.14 \times 0.6 \times 25 \times 10^{-6}}$

$= 0.010615 \times 10^6 = 10.62 \times 10^3$ Hz

$= 10.62$ kHz

(13) Answer [C]

Solution : light emmited from first poleroid,

$I = I_0 \cos^2\theta = I_0 \cos^2 45° = I_0 \times \left(\dfrac{1}{\sqrt{2}}\right)^2$

$\therefore I = \dfrac{I_0}{2}$

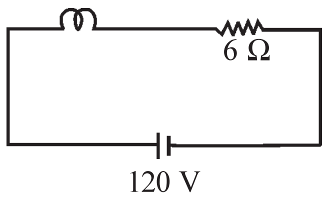
light emttied from second poleroid,

$I' = I_0 \cos^2\theta = \dfrac{I_0}{2} \cos^2 45° = \dfrac{I_0}{2} \times \dfrac{1}{2}$

$\therefore I' = \dfrac{I_0}{4}$

(14) **Answer** [D]

Solution :



Power $P = \dfrac{V^2}{R}$

$\therefore\ R = \frac{V^2}{P} = \frac{120 \times 120}{60} = 240\ \Omega$

$\therefore$ Resistance of circuit $R_1 = R + 6$
$= 240 + 6 = 246\ \Omega$

Now $V_1R_1 = VR \therefore V_1 = V \times \frac{R}{R_1} = 120 \times \frac{240}{246}$

$\therefore\ V_1 = 117.073\ V$ ...(1)

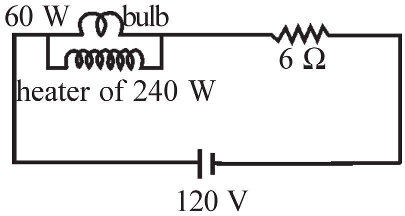
Now connect bulb parallel to heater, resistance of heater is

$R' = \frac{V^2}{P^1} = \frac{120 \times 120}{240} = \frac{14400}{24} = 60\ \Omega$

$\therefore$ Resistance of bulb and heater

$R'' = \frac{240 \times 60}{240 + 60} = \frac{14400}{300}\ \therefore\ R'' = 48\ \Omega$

Now resistance of circuit $R_2 = R'' + 6$
$= 48 + 6 = 54\ \Omega$, Now $V_2R_2 = VR''$



$\therefore\ V_2 = V \times \frac{R''}{R_2} = 120 \times \frac{48}{54}$

$\therefore\ V_2 = 106.66\ V$ ...(2)

$\therefore$ decrease in bulb voltage

$V_1 - V_2 = 117.073 - 106.66 = 10.04\ V$

(15) Answer [A]

Solution :

Area enclosed by P $\rightarrow$ V graph is defines energy from heat source during one cycle. Area enclosed by P – V graph means energy.

energy $= (2P_0 - P_0)(2V_0 - V_0) = P_0V_0$

(16) Answer [C]

Solution :

Here when ring is stationary then initial velocity $v_0 = 0$. When ring has angular frequency of ω then its velocity $v = r\,\omega_0$.

$\therefore$ Average velocity of ring's center $v = \frac{v_0 + v}{2}$

$\therefore\ v = \frac{0 + r\omega_0}{2},\ \therefore\ v = \frac{r\omega_0}{2}$

(17) Answer [C]

Solution :

Suppose, initial pressure P and volume V of cylinder. Due to small displacement of x on piston, Pressure is P_0 and volume is V_0. considering adiabatic process,

$P_0V_0^{\gamma} = PV^{\gamma}$

$P_0A^{\gamma}x_0^{\gamma} = PA^{\gamma}(x_0 - x)^{\gamma}$ [$\because$ V = Ax]

$\therefore\ P = \frac{P_0x_0^{\gamma}}{(x_0 - x)^{\gamma}}$ ...(1)

Restoring force = Mg – PA

$= Mg - \frac{P_0x_0^{\gamma}A}{(x_0 - x)^{\gamma}}$

$\therefore$ Resultanrt force $F_R = P_0A - PA$

$= P_0A - \frac{P_0x_0^{\gamma}A}{(x_0 - x)^{\gamma}} = P_0A\left[1 - \frac{x_0^{\gamma}}{(x_0 - x)^{\gamma}}\right]$

$= P_0A\left[\frac{(x_0 - x)^{\gamma} - x_0^{\gamma}}{(x_0 - x)^{\gamma}}\right]$

Simpliflying with binomial expension of $(x_0 - x)^{\gamma}$ in numerator and neglet x^{γ}

$F_R = -P_0A\left[\frac{\gamma x}{x_0}\right]$ Assume that $x_0 - x = x_0$

$F_R = -\frac{P_0A\gamma x}{x_0}$. Assume $\frac{P_0A\gamma}{x_0} = k$

$F_R = -kx$ Which is condition of simple harmonic motion.

$\therefore$ frequency $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\sqrt{\frac{P_0A\gamma}{x_0M}}$

But $V_0 = Ax_0$, $\therefore\ x_0 = \frac{V_0}{A}$

$\therefore\ f = \frac{1}{2\pi}\sqrt{\frac{P_0\gamma A^2}{V_0M}}$

(18) Answer [C]

Solution : From the Newton's cooling law

$\frac{dT}{dt} = -k'\,[T - T_s]$

(19) Answer [D]

Solution :

Range of ameter (current efficiency) is inversely proportional to shunt. To increase the range, large value of shunt required and if value of shunt is large then resistance of ameter is small so, given statement I is wrong, statement II is true.

(20) Answer [C]

Solution :

$q = q_0\left(1 - e^{-\frac{t}{\tau}}\right)$, $q_0 = CV$ and putting $t = 2\tau$,

$q = CV\left(1 - e^{-\frac{2\tau}{\tau}}\right)$, $q = CV\ (1 - e^{-2})$

(23) Answer [D]

Solution :

$\lambda \propto \frac{1}{f}$ means wavelength $\propto \frac{1}{\text{frequency}}$.

photoelectrons are not emitted for λ_0 so photoelectrons are not emitted for f_0 and for wavelength more than λ_0 and frequency less then f_0, photoelectrons are not emitted. So, emission of photoelectrons increases for decrease in wavelength less than λ_0. So, current is larg for smallwavelength. λ_0 = threshold wavelength and f_0 = threshold frequency.

(24) Answer [A]

Solution :

For lead $E_g = hf$

$\therefore E_g \propto f$ and $E_g = qV$, $\therefore qV \propto f$

$\therefore V \propto f$

Energy means gain current $\propto f$. The large value of voltage required for waves having high frequency and for equal current.

(25) Answer [D]

Solution :

decrease in surface energy due to evaporation of drop = necessary heat for evaporation

$2T\Delta A = mL$

$\therefore 2T \times 4\pi r\, dr = 4\pi r^2 dr \rho L$

$[\because \Delta A = 4\pi r\, dr]$

$\therefore 2T = r\rho L$, $\therefore r = \frac{2T}{\rho L}$

(26) Answer [D]

Solution :

Frequency of emited radiation due to the transition of electron from one orbit to second orbit is,

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

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

$$\therefore f \propto \frac{1}{n^3}$$

(27) Answer [C]

Solution :

Initially, with increasing incident angle the angle of deviation decreases. When $i = e$ becomes minimum angle of deviation and then with increasing incident angle i, the angle of deviation δ also increases.

(28) Answer [A]

Solution :

Same electric charge on both point $x = a$ and $x = -a$ and the force due to the both on q_0 is equal.

$$\text{This force } F = \frac{kq\left(\frac{q}{2}\right)}{\left(\sqrt{a^2 + y^2}\right)^2} \qquad ...(1)$$

Taking component on X-axis and Y-axis of this force, the components on X-axis are equal in magnitude and opposite in direction to each other so its resultant force becomes zero.

$\therefore$ The components of Y-axis on given particle should added.

$\therefore$ Resultant force on particle is

$F' = 2F\cos\theta$ ...(2)

$$\text{From figure } \cos\theta = \frac{y}{\sqrt{a^2 + y^2}} \qquad ...(3)$$

putting values of result (1) and (3) in result (2)

$$F' = \frac{\frac{2kq^2}{2}}{(a^2 + y^2)} \times \frac{y}{\sqrt{a^2 + y^2}}$$

$\therefore$ F' = $\dfrac{kq^2}{(a^2+y^2)^{\frac{3}{2}}} \cdot y$ If $y << a$ then

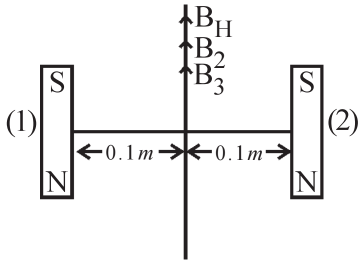
putting $y = 0$ in denominator,

F' = $\dfrac{kq^2}{a^3} \times y$, $\therefore$ F' = y

(29) Answer [B]

Solution :

From middle point O, distance of both magnet r = 10 cm = 0.1 m. Magnetic moment of both magnet are m_1 = 1.2 Am^2, m_2 = 1.00 Am^2 respectively and its direction is south - facing,



Magnetic field at O due to first magnet

$B_1 = \dfrac{\mu_0}{4\pi} \cdot \dfrac{m_1}{r^3}$ towards north direction

$\therefore B_1 = 10^{-7} \times \dfrac{m_1}{r^3}$

Magnetic field at O due to second magnet,

$B_2 = \dfrac{\mu_0}{4\pi} \cdot \dfrac{m_2}{r^3}$ towards north direction

$\therefore B_2 = 10^{-7} \times \dfrac{m_2}{r^3}$

Horizontal component of earth is north to south.

$\therefore B_H = 3.6 \times 10^{-5}$ Wbm^{-2}

$\therefore$ Magnetic field at O is, $B = B_1 + B_2 + B_H$

$= 10^{-7} \dfrac{m_1}{r^3} + 10^{-7} \dfrac{m_2}{r^3} + 3.6 \times 10^{-5}$

$= \dfrac{10^{-7}}{r^3}(m_1 + m_2) + 3.6 \times 10^{-5}$

$= \dfrac{10^{-7}(1.2+1.0)}{(0.1)^3} + 3.6 \times 10^{-5}$

$= 2.2 \times 10^{-4} + 0.36 \times 10^{-4}$

$= 2.56 \times 10^{-4}$ Wbm^{-2}

(30) Answer [D]

Solution :

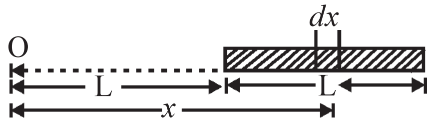
Electric charge Q on rod having length L.

$\therefore$ Electric charge per unit length is $\lambda = \dfrac{Q}{L}$

$\therefore$ Electric charge of dx segment of rod is

$dQ = \dfrac{Q}{L} dx$

Potential difference at point O which is at



distance x from dQ charge is, $dV = \dfrac{kdQ}{x}$

$\therefore$ Potential difference at point O due to charge on whole AB rod is,

$$V = \int_L^{2L} dV = \int_L^{2L} \frac{kdQ}{x} = \int_L^{2L} \frac{k \times Q}{L} \cdot \frac{dx}{x}$$

$$= \frac{kQ}{L}\int_L^{2L} \frac{dx}{x} = \frac{Q}{4\pi\varepsilon_0 L}[\ln x]_L^{2L}$$

$$= \frac{Q}{4\pi\varepsilon_0 L}[\ln 2L - \ln L]$$

$$= \frac{Q}{4\pi\varepsilon_0 L}\left[\ln\frac{2L}{L}\right], \therefore V = \frac{Q}{4\pi\varepsilon_0 L}\ln 2$$

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(1) Answer [D]

Solution :

(i) In present case, due to thermal expansion the increase in length of wire is,

$$\Delta l = \alpha l \Delta T \Rightarrow \frac{\Delta l}{l} = \alpha \Delta T$$

(ii) Here, excess increment in length should cancel for length of wire remains constant. For this pressure requires equal to tensile stress on both ends of wire so,

$$P = \sigma_1 = Y\varepsilon_1 \left(\because\ y = \frac{\sigma_1}{\varepsilon_1}\right)$$

$$= Y\frac{\Delta l}{l} = Y \times \alpha\,\Delta T$$

$$= 2 \times 10^{11} \times 1.1 \times 10^{-5} \times 100$$

$P = 2.2 \times 10^8$ Pa

(2) Answer [B]

Solution :

Here, disconnecting the point C with point A and connecting point C with point B then there is no battery in formed closed-loop. So, applied total voltage should zero. Thus, now at any time,

$$V_R + V_L = 0,\ V_R = -V_L,\ \therefore\ \frac{V_R}{V_L} = -1$$

(3) Answer [A]

Solution :

Energy level diagram for Hydrogen atom

$n = 3$ ________________ $E_3 = -1.51$ eV

$n = 2$ ________________ $E_2 = -3.4$ eV

$n = 1$ ________________ $E_1 = -13.6$ eV

Here, energy of emitted photon during electron transition from $3 \to 2$.

$hf = E_3 - E_2 = -1.51 - (-3.4) = 3.4 - 1.51$ $= 1.89$ eV

When photon incident on given metal surface then maximum kinetic energy of emitted photo electron is,

$$K_{max} = \frac{p_{max}^2}{2m} = \frac{(Bq \times r_{max})^2}{2m}$$

$$\left(\because\ r = \frac{mv}{Bq} = \frac{p}{Bq} \Rightarrow P\right.$$

$$\left. = Bqr \Rightarrow p_{max} = Bqr_{max}\right)$$

$$\therefore\ K_{max} = \frac{(3 \times 10^{-4} \times 1.6 \times 10^{-19} \times 10 \times 10^{-3})^2}{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19}}$$

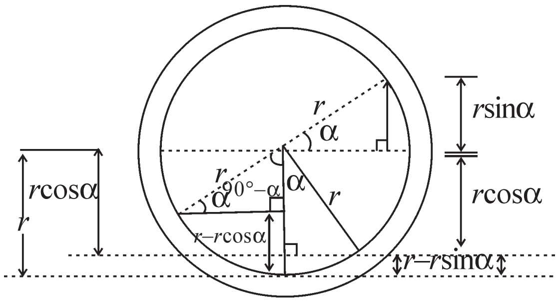
$= 0.791$ V

Now, according to Eienstein's photo electric equation, $hf = \phi + K_{max}$,

$1.89 = \phi + 0.791$

$\phi = 1.099$ eV, $\phi \approx 1.1$ eV

(4) Answer [B]



Solution :

Here in equilibrium condition of different liquids in circular pipe placed in vertical plane, at lowest position θ in pipe, the applied pressure by liquid column of left and right side should equal. You remember that the pressure on base of column by liquid column having vertical height h and density ρ is equal to ρgh. This truth is used in present answer) Now, compare the pressure applied on both sides at point θ then.

$$\rho_1 g(r - r\sin\alpha) = \rho_2 g(r\sin\alpha)$$

$$+ \rho_2 g(r\cos\alpha) + \rho_1 g(r - r\cos\alpha)$$

$$\rho_1 (1 - \sin\alpha) = \rho_2 \sin\alpha$$

$$+ \rho_2 \cos\alpha + \rho_1 (1 - \cos\alpha)$$

$$\therefore\ \rho_1 (1 - \sin\alpha - 1 + \cos\alpha) = \rho_2 (\cos\alpha + \sin\alpha)$$

$$\therefore\ \rho_1 (\cos\alpha - \sin\alpha) = \rho_2 (\cos\alpha + \sin\alpha)$$

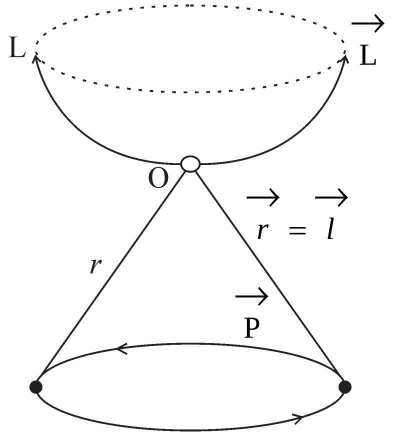
$$\therefore \frac{\rho_1}{\rho_2} = \frac{\cos\alpha + \sin\alpha}{\cos\alpha - \sin\alpha}$$

divide by *cos*α to numerator and denominator of right side

$$\therefore \frac{\rho_1}{\rho_2} = \frac{1+\tan\alpha}{1-\tan\alpha}, \therefore \frac{d_1}{d_2} = \frac{1+\tan\alpha}{1-\tan\alpha}$$

(5) Answer [B]

Solution :



Here, sphere having mass m is in regular circular motion in horizontal plane. The value of angular momentum with respect to base point is L = rPsinθ = (l) (mv) sin90° = mvl remains constant. But its direction varies continuously. Here, if find the direction of $\vec{L} = \vec{l} \times \vec{P}$ using right hand screw law then this direction continuously changes from point O in figure to wall of cone towards upward.

(6) Answer [A]

Solution :

According to Lens maker equation

$$\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$ Here for given lens, the value of term $\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ is positive and it remain constant. It's indicate by sign, $\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1}\right)(x)$ ...(1)

It is defined by sign x and focal length f of given lens in air so from equation (1).

$$\frac{1}{f} = \frac{1.5-1}{1}(x) = 0.5\,x$$

$$\therefore \Rightarrow f = \frac{1}{0.5\,x} \quad ...(2)$$

The focal length is f_1 of given lens in first liquid. so, from equation (1),

$$\frac{1}{f_1} = \left(\frac{1.5 - 4/3}{4/3}\right)(x) = 0.125x$$

$$\Rightarrow f_1 = \frac{1}{0.125}\,x \quad ...(3)$$

The focal length is f_2 of given lense in second liquid. so, from equation (1),

$$\frac{1}{f_2} = \frac{1.5 - 5/3}{5/3}(x) = -\,0.1\,x$$

$$f_2 = \frac{1}{0.1\,x} \quad ...(4)$$

From equation (2) and (3) $f_1 > f$

From equation (4) $f_2 = (-)$

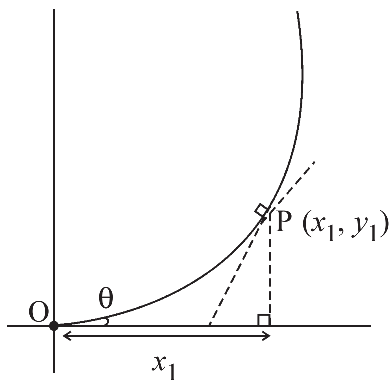
(7) Answer [A]

Solution :

In case of refraction as frequency of incident light is small, the refraction constant is small. so, according to equation sinc = $1/n$, as n decreases then *sin*c increases then c increases and becomes c > i so i < c. so, this light does not total internal reflected so it emits in air.

(8) Answer [D]

Solution :



In present case, according to $y = x^3/6$ equation, surface of slope is curve. Which is shown in above figure. Suppose, maximum height for piece having mass m on surface and remains steady without sliding is equal to y_1 and respective position point is P(x_1, y_1). Now drawing tangent at point P to the curve surface of slope, the respective slope angle as seen in figure is equal to θ.

Here, $y = x^3/6$

$$\therefore \frac{dy}{dx} = \frac{1}{6}\frac{d}{dx}(x^3) = \frac{1}{6}(3x^2) = \frac{x^2}{2}$$

At point P, $x = x_1$ so, $\frac{dy}{dx} = \frac{x_1^2}{2}$

Here, if μ_S is static friction co-efficient then from instruction, $\tan\theta = \mu_S$

$$\frac{dy}{dx} = 0.5 \qquad (\therefore \mu_S = 0.5)$$

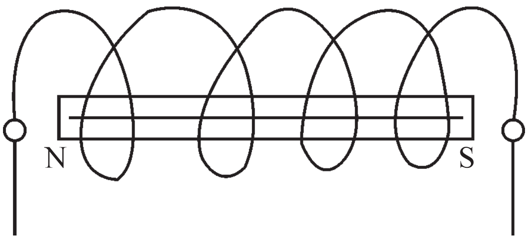
$$\frac{x_1^2}{2} = 0.5 \therefore x_1^2 = 1, \therefore x_1 = 1 \text{ m}$$

At point P, $y_1 = \frac{x_1^3}{6} = \frac{(1)^3}{6} = \frac{1}{6}$ m

(9) Answer [B]

Solution :

The magnetic field is $B_b = \mu_0 n I_b = \mu_0 M$ in bar magnet which is inside the solenoid is due to the conditioned current. Now to make temporiarily magnetic free, we have to apply magnetic field $\vec{B_b}$ same value in opposite direction. For this, magnetizing current, it should pass in opposite direction of I_b from each turns of solenoid winding. Due to this, total induced magnetization temporiarily becomes zero.



Now, $B = B_b + B_f$, $0 = \mu_0 M + \mu_0 H$

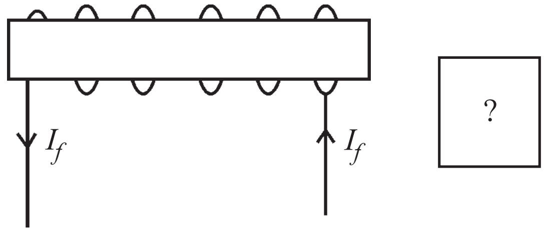
$\therefore \mu_0 M = -\mu_0 H$, $H = -M$

$H = -i_b$ ($\therefore M = i_b$)

$= i_f$ ($\because$ Here $i_f = -i_b$) $= nI_f$

$\therefore H = \frac{N}{l} \times I_f$ ($\because n = \frac{N}{l}$)

Here, for above value of H, total induced magnetization B = 0. Thus, it shown the coercivity.



$3 \times 10 = \frac{100}{0.1} \times I_f$, $I_f = 3$A

(10) Answer [A]

Solution :

(i) Here length of condicting rod having electric current is $\vec{l} = (0, 0, -1.5) - (0, 0, 1.5) = 3(-\hat{k})$ $l = 3$m

(ii) Here, according to Ampere's law $\vec{F} = I(\vec{l} \times \vec{B})$ the magnetic force of value $I\,l\,B$ acted in +X direction on rod such arrangement shown in figure. Rod accelerates in +X direction under its effect. In this condition, to keep rod moving with constant velocity, the external force of value $I\,l\,B$ continuously requires at each time in –X direction. Here value of B decreases with increasing distance x according to equation $B = 3 \times 10^{-4} e^{-0.2x}$. Total mechanical work from $x = 0$ or $x = 2$m under this variable force is, $W = \int_0^2 F\,dx = \int_0^2 IlB\,dx$

$$= \int_0^2 10 \times 3 \times 3 \times 10^{-4} \times e^{-0.2x}\,dx$$

$$= 9 \times 10^{-3} \times \left[\frac{e^{-0.2x}}{-0.2}\right]_0^2$$

$$= -4.5 \times 10^{-2} \times \left[e^{-0.2x}\right] = -0.045\left[\frac{1}{e^{0.4}} - 1\right]$$

$$= -0.045\left[\frac{1}{(2.718)^{0.4}} - 1\right]$$

$$= -0.045\left[\frac{1}{1.492} - 1\right] = -0.045\,[0.6702 - 1]$$

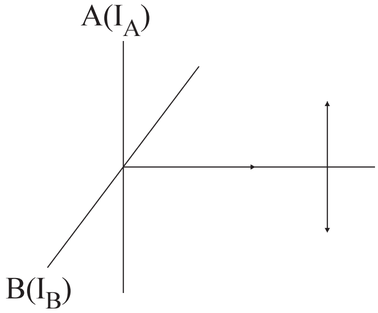
$= -0.045\ [-0.3298]$, $W = 0.014841$ J

Now, time rate of Energy

$$P = \frac{W}{t} = \frac{0.02214}{5\times10^{-3}} = 2.9682\ \text{W},\ P \approx 2.97\ \text{W}$$

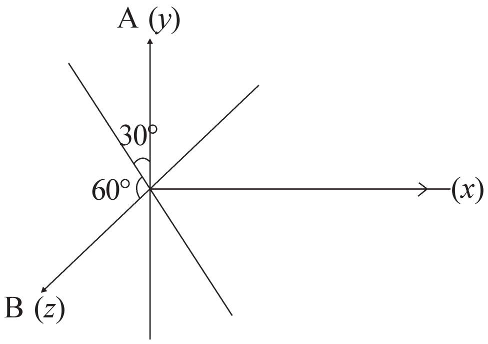
(11) Answer [C]

Solution : Initial condition



Intensity $= I_A + I_B = I_A\ (\because\ I_B = 0)$

final condition



Intensity $= I_A \cos^2 30° + I_B \cos^2 60°$

$\rightarrow$ Here from statement $I'_A = I'_B$

$\therefore\ I_A \cos^2 30° = I_B \cos^2 60°$

$$I_A \times \frac{3}{4} = I_B \times \frac{1}{4}$$

$$\frac{I_A}{I_B} = \frac{1}{3}$$

(12) Answer [D]

Solution :

Here, electric potential of anode is $V_A = 2V$

Electric potential of cathode $V_K = -2V$

$\therefore\ V_A > V_K$

present diode is in forward bias condition.

(13) Answer [B]

Solution :

According to equation $V_A - V_o = -\int_0^A \vec{E}\cdot d\vec{x}$

$$= -\int_0^2 30x^2\,\hat{i}\cdot dx\,\hat{i} = -30\int_0^2 x^2\,dx$$

$$= -30\left\{\frac{x^3}{3}\right\}_0^2 = -30\left\{\frac{8}{3} - 0\right\}$$

$V_A - V_o = -80$ V

(15) Answer [D]

Here, $I = e^{\left(\frac{1000V}{T}\right)} - 1\ mA$ ...(1)

$\therefore\ 5 = e^{\left(\frac{1000V}{T}\right)} - 1,\ \therefore\ e^{\left(\frac{1000V}{T}\right)} = 6\ mA$

Form equation (1)

$$\frac{dI}{dV} = \frac{d}{dV}\left(e^{\frac{1000V}{T}}\right) - \frac{d(1)}{dV}$$

$$\therefore\ \frac{dI}{dV} = e^{\left(\frac{1000V}{T}\right)} \times \frac{1000}{T} - 0$$

$$\therefore\ \frac{dI}{0.01} = 6 \times \frac{1000}{300},\ \therefore\ dI = \frac{0.6}{3}$$

$\therefore\ dI = 0.2\ mA$

(16) Answer [C]

Solution :

According to equation, the difference in internal energy of thermodynone gas system $\Delta E_{int} = \Delta U = \mu C_V \Delta T$,

(i) for process of $A \rightarrow B$:

$\Delta U_{AB} = \mu C_V (T_B - T_A)$

$$= 1 \times \frac{5R}{2}(800 - 400) = 1000\ R$$

(ii) For process of $B \rightarrow C$:

$\Delta U_{BC} = \mu C_V (T_C - T_B)$

$$= 1 \times \frac{5R}{2}(600 - 800) = -500\ R$$

(ii) For process of $C \rightarrow A$:

$\Delta U_{CA} = \mu C_V (T_A - T_C)$

$$= 1 \times \frac{5R}{2}(400 - 600) = -500\ R$$

(iv) For whole cyclic process of $A \rightarrow B \rightarrow C \rightarrow A$:

$\Delta U_{total} = 0$ For cyclic process, initial and final phase is same.

(17) Answer [B]

Solution :

In present case for close pipe, the first harmonic is $f_1 = \frac{V}{4L} = \frac{340}{4 \times 0.85} = 100$ Hz

Now, for close pipe, possible harmonic $f_n = (2n - 1) f_1$ (Where $n = 1, 2, 3...$)

$\therefore \; f_n = f_1, 3f_1, 5f_1, 7f_1, 9f_1 ...$

f_n = 100 Hz, 300Hz, 500Hz, 700Hz, 900Hz, 1100Hz,

$\because$ here $f_n < 1250$ Hz is required.)

demanded number of harmonic = 6

(18) Answer [B]

Solution :

(i) electric power required to on 15 bulb of 40 watt = $15 \times 40 = 600$ W

(ii) electric power required to on 5 bulb of 100 W = $5 \times 100 = 500$ W

(iii) electric power required to on 5 fan of 80 W = $5 \times 80 = 400$ W

(iv) electric power required to on 1 heater of 1kW = $1 \times 1000 = 1000$ W

total electric power P = 600 + 500 + 400 + 1000

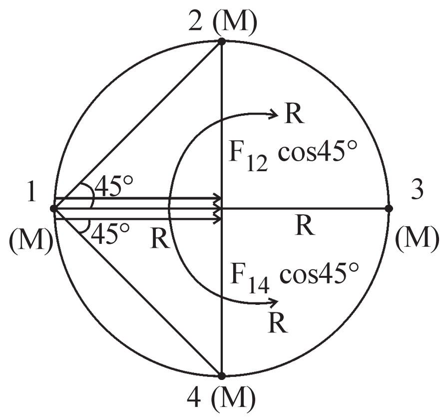
$\therefore$ VI = 2500, $\quad 220 \times I = 2500$

$I = 11.3636$ A $\Rightarrow I = 12$ A

(19) Answer [C]

Solution :

Here, the resultant force generated from gravitational force acted on each particle by other particles from given four particles and its direction is towards center of the circular motion. From figure, if resultant gravitational force on particle 1 is F then,



$$F = F_{12} \cos 45° + F_{13} + F_{14} \cos 45°$$

$$= \frac{GM^2}{(\sqrt{2}R)^2} \times \frac{1}{\sqrt{2}} + \frac{GM^2}{(2R)^2} + \frac{GM^2}{(2R)^2} \times \frac{1}{\sqrt{2}}$$

$$= 2 \times \frac{GM^2}{2R^2} \times \frac{1}{\sqrt{2}} + \frac{GM^2}{4R^2}$$

$$= \frac{GM^2}{R^2}\left(\frac{1}{\sqrt{2}} + \frac{1}{4}\right)$$

$$\therefore \frac{Mv^2}{R} = \frac{GM^2}{R^2}\left(\frac{4+\sqrt{2}}{4\sqrt{2}}\right)$$

$$v^2 = \frac{GM}{R}\left(\frac{4+\sqrt{2}}{4\sqrt{2}}\right)$$

$$v = \frac{1}{2}\sqrt{\frac{GM}{R}}\sqrt{2\sqrt{2}+1}$$

$$v = \frac{1}{2}\sqrt{\frac{GM}{R}(1+2\sqrt{2})}$$

(20) Answer [B]

(i) According to equation $v = v_0 + at$, if time t_1 to achieve maximum height then according to symbolic conventions,

$0 = u + gt_1, t_1 = \frac{u}{g}$ ...(1)

(ii) According to equation

$d = v_0 t + \frac{1}{2} at^2$, time t_2 to reach on land then according to symbolic conventions,

$- H = ut_2 - \frac{1}{2} g t_2^2$

$H = \frac{1}{2} g t_2^2 - u t_2$

$H = \frac{1}{2} g (n^2 t_1^2) - u(nt_1)$ ($\because t_2 = nt_1$)

$$H = \frac{1}{2}\, gn^2 \times \frac{u^2}{g^2} - u\left(n \times \frac{u}{g}\right)$$

$$H = \frac{1}{2}\, n^2 \cdot \frac{u^2}{g} - n \times \frac{u^2}{g}$$

$$H = n\,\frac{u^2}{g}\left(\frac{n}{2} - 1\right),\ H = n\,\frac{u^2}{g}\left(\frac{n-2}{2}\right)$$

$2gH = nu^2\,(n - 2)$

(21) **Answer [A]**

Solution :

Here, given instrument should vernier calliperse.

(i) Least count measurement = 1 MSD – 1 VSD

$$= 1\text{ MSD} - g\,\frac{\text{MSD}}{10} \quad (\because 10\text{VSD} = 9\text{MSD})$$

$$= 1\,\frac{\text{MSD}}{10} = \frac{0.1\,\text{cm}}{10} = 0.01\text{ cm}$$

(ii) Total count = MSR + VSR + zero correction

$= 3.50 + 0 \times 0.01 + 0 = 3.50$ cm

(22) **Answer [D]**

Solution :

$$E = \frac{E_0}{K} = \frac{\sigma_f/\varepsilon_o}{K} = \frac{\sigma_f}{\varepsilon_0 K}$$

$\sigma_f = \varepsilon_0 KE$

$\sigma_f = 8.85 \times 10^{-12} \times 2.2 \times 3 \times 10^4$

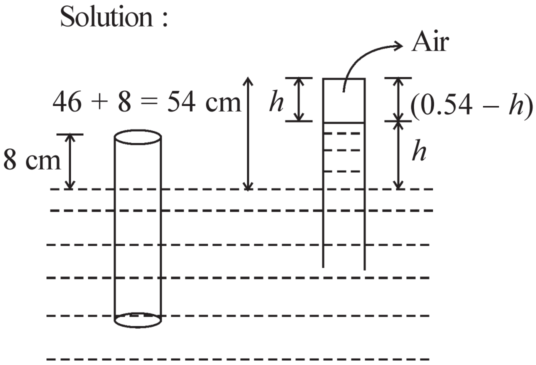
$= 58.41 \times 10^{-8} = 5.84 \times 10^{-7}$

$\sigma_f \approx 6 \times 10^{-7}\ \text{Cm}^{-2}$

(σ_f = density of free electric charge on plate of dielectric capacitor)

(23) **Answer [D]**

Solution :



Here, if ρ is density of mercury then pressure of atmosphere, According to equation. $P_a = \rho g \times 0.76$

(i) Pressure of air inside the pipe in initial condition is = P_1

Volume of air = $V_1 = A \times 0.08$

(ii) Pressure of air inside the pipe in final condition is = P_2

Volume of air = Ah

In equilibrium condition, the pressure at point x and y on water surface is same. So, $P_x = P_y$

$\therefore\ P_1 = P_2 + \rho g\,(0.54 - h)$

$\rho g\,(0.76) = P_2 + \rho g\,(0.54 - h)$

$P_2 = \rho g\,(0.76 - 0.54 + h),\ P_2 = \rho g\,(0.22 + h)$

Now temperature of air inside pipe is constant, So, $P_1 V_1 = P_2 V_2$

$\rho g \times 0.76 \times A \times 0.08 = \rho g\,(0.22 + h) \times Ah$

$0.76 \times 0.08 = (0.22 + h)\,h$

$0.0608 = 0.22h + h^2$

$h^2 + 0.22h - 0.0608 = 0$ this equation compare with $ax^2 + bx + c = 0$

$a = 1,\ b = 0.22,\ c = -0.0608$

Now, $\Delta = b^2 - 4ac$

$= (0.22)^2 - 4(1)(-0.0608)$

$= 0.0484 + 0.2432$

$\Delta = 0.2916 \Rightarrow \sqrt{\Delta} = 0.54$

Now, from $h = \dfrac{-b \pm \sqrt{A}}{2a}$ value of h is positive,

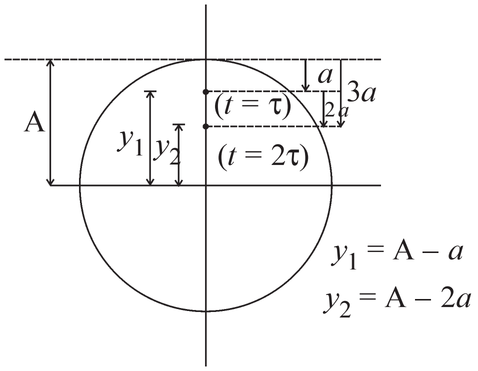
$$h = \frac{-0.22 + 0.54}{2(1)} = \frac{0.32}{2} = 0.16\text{ m}$$

$h = 16$ cm

(24) **Answer [B]**

Solution :

Here, travelled distance increases from a to $2a$ in equal time period of t. So, particle in simple harmonic motion (SHO), Mean of end points of motion path shold towards position. So, starting of SHO, taking from positive end of motion path, $\phi = \pi/2$ *rad*. Now according to equation,



$y = A \sin(\omega t + \phi)$, $\therefore y = \ \sin(\omega t + \frac{\pi}{2})$

(i) At $t = t$ time, $y_1 = A \sin(\omega t + \frac{\pi}{2})$

$\therefore A - a = A \cos(\omega t)$ ...(1)

(ii) At $t = 2t$ time, $y_2 = A \sin(\omega \times 2t + \frac{\pi}{2})$

$\therefore A - 3a = A \cos(2\omega t)$ ...(2)

from equation (1), $\cos(\omega t) = \frac{A - a}{A}$ ...(3)

from equation (2), $\cos(2\omega t) = \frac{A - 3a}{A}$ ...(4)

Now, according to formulla $\cos^2\theta = \frac{1 + \cos(2\theta)}{2}$

simillarly, $cos^2(\omega t) = \frac{1 + \cos(2\omega t)}{2}$

$2cos^2(\omega t) = 1 + \cos(2\omega t)$

$$2\left(\frac{A - a}{A}\right)^2 = 1 + \frac{A - 3a}{A}$$

$$\therefore 2\left(\frac{A^2 - 2Aa + a^2}{A^2}\right) = \frac{2A - 3a}{A}$$

$2A^2 - 4Aa + 2a^2 = 2A^2 - 3Aa$, $2a^2 = Aa$

$A = 2a$ ...(5)

Now from equation (3)

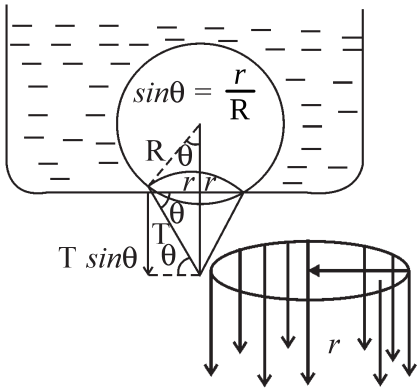
$$\cos(\omega t) = \frac{2a - a}{A} = \frac{a}{A} = \frac{1}{2}$$

(From equation (5)), $\therefore \omega t = \frac{\pi}{3}$, $\frac{2\pi}{T} t = \frac{\pi}{3}$

$T = 6t$

(25) **Answer [D]**

Solution :



In the present case, water at bottom of vessel first boiled and due to steam get started to form from bottom. Quantity of steam in these bubbles get increases with time and due to its dildtion its radius increases. Thus, buoyant force in upward direction is increased by the nearby liquid due to increase in size of bubbles.

Here, area of its surface is increases consequently due to enlarge bubbles. Hence, tension force of surface tension is produced parallel to the surface as the area of surface of the wall. (Also, called as free surface of liquid which is in contact.)

Here, as the radius of bubble increases, radius of circular edge contacted with bottom is also increases and hence tension force is also increases. Atlast radius of bubble is R when bubble is almost near to leave from bottom and radius of circular edge is r for which it is in contact with the bottom. For this stage on bubbles, buoyant force in upward direction = buoyant force tension force of surface tension in downward direction.

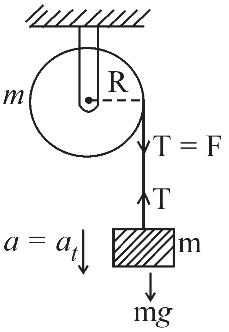
$$\frac{4}{3}\pi R^3 \rho_w g = 2\pi r \times T\ sin\theta$$

$$\frac{4}{3}\pi R^3 \rho_w g = 2\pi r \times T \times \frac{r}{R}$$

$$r^2 = R^4 \times \frac{2}{3} \times \frac{\rho_w g}{T},\ r = R^2\sqrt{\frac{2\rho_w g}{3T}}$$

Above answer is true which is not given in options.

(26) Answer [A]



(i) For moment of disc $T = I\alpha$

$\therefore RT \sin 90° = mR^2 \times \frac{a_t}{R}$

$\therefore T = ma_t = ma$

(ii) For acceleracted motion of object in downward direction :

$mg - T = ma$, $mg - ma = ma$

$2ma = mg$, $a = \frac{g}{2}$

(27) Answer [B]

Solution :

(i) $\rho_E = \frac{1}{2}\ \varepsilon_0\ E^2_{rms}$

(ii) $\rho_B = \frac{1}{2}\ \frac{B^2_{rms}}{\mu_0}$

$\because \frac{\rho_E}{\rho_B} \varepsilon_0\ \mu_0 \times \frac{E^2_{rms}}{B^2_{rms}} = \frac{1}{c^2} \times c^2 = 1$

$(\therefore \frac{E_{rms}}{B_{rms}} = c$ and $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}})$

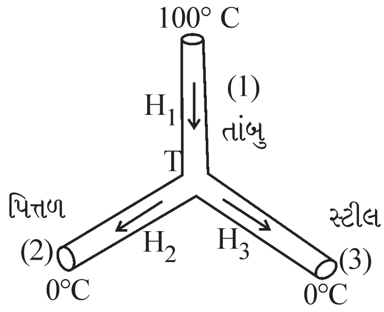
$\frac{\rho_E}{\rho_B} = 1$, $\therefore \rho_E = \rho_B$

(28) Answer [B]

Solution :

In permanent thermal state $H_1 = H_2 + H_3$

$k_1 A \left(\frac{100 - T}{46}\right) = k_2 A \left(\frac{T - 0}{13}\right) + k_3 A \left(\frac{T - 0}{12}\right)$



$\frac{0.92\,(100 - T)}{46} = \frac{0.26\,(T - 0)}{13} + \frac{0.12\,(T - 0)}{12}$

$T = 40°$ C, Now, $H_1 = k_1 A \left(\frac{100 - T}{46}\right)$

$H_2 = 0.92 \times 4 \times \left(\frac{100 - 40}{46}\right)$, $H_1 = 4.8\ \text{cals}^{-1}$

(29) Answer [B]

Solution :

According to equation $\frac{1}{\lambda_{ik}} = RZ^2 \left(\frac{1}{n_k^2} - \frac{1}{n_i^2}\right)$

$\Rightarrow \frac{1}{\lambda_{ik}} \propto Z^2$, $\therefore \lambda_{ik} \propto \frac{1}{Z^2}$

$\Rightarrow \lambda_1 : \lambda_2 : \lambda_3 : \lambda_4 = \frac{1}{(1)^2} : \frac{1}{(1)^2} : \frac{1}{(2)^2} : \frac{1}{(3)^2}$

$= 1 : 1 : \frac{1}{4} : \frac{1}{9}$, $\Rightarrow \lambda_1 = \lambda_2$

However, $\frac{\lambda_1}{\lambda_3} = \frac{1}{1/4} = 4 \Rightarrow \lambda_1 = 4\ \lambda_3$

However, $\frac{\lambda_1}{\lambda_4} = \frac{1}{1/9} = 9 \Rightarrow \lambda_1 = 9\ \lambda_4$

final answer $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$

(30) Answer [B]

Solution :

According to equation work done by variable force in one dimension,

$W = \int_{x_1}^{x_2} F dx = \int_{O}^{L} (ax + bx^2)\ dx$

$= a \int_0^L x dx + b \int_0^L x^2\, dx = a\left[\frac{x^2}{2}\right]_0^L + b\left[\frac{x^3}{3}\right]_0^L$

$= a\left[\frac{L^2}{2} - 0\right] + b\left[\frac{L^3}{3} - 0\right]$

$W = \frac{aL^2}{2} + \frac{bL^3}{3}$

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(1) Answer [D]

Solution :

Centripetal force for circular motion of electron, $\frac{mv^2}{r} = \frac{ke^2}{r^2}$, $\therefore mv^2 = \frac{ke^2}{r}$

$\therefore \frac{1}{2}mv^2 = \frac{ke^2}{2r} = \frac{1}{8\pi\varepsilon_0}\frac{e^2}{r}$

$\therefore$ potential energy $U = -\frac{1}{4\pi\epsilon_0}\frac{e^2}{r}$ and

total energy $\varepsilon = -\frac{1}{8\pi\epsilon_0}\frac{e^2}{r}$

kinetic energy $\propto \frac{1}{r}$, potential energy $\propto -\frac{1}{r}$, and total energy $\propto -\frac{1}{r}$ So, its kinetic energy increases but potential energy and total energy decreases.

(2) Answer [A]

Solution :

$T^2 = \frac{4\pi^2 L}{g} \quad \therefore g = \frac{4\pi^2 L}{T^2}$

$\frac{\Delta g}{g} \times 100\ \%$

$= \left(\frac{\Delta L}{L} \times 100\ \%\right) + 2\left(\frac{\Delta T}{T} \times 100\ \%\right)$

$= \frac{0.1}{20} \times 100\ \% + 2\left(\frac{1}{90} \times 100\ \%\right)$

$= 0.5 + 2.2 = 2.7 = 3\ \%$

(4) Answer [B]

Solution :

AC signal having frequency 5 kHz is amplitude modutation by signal having frequency 2 MHz, the frequency of resultant AC signal 2005 kHz, 2000 kHz, 1995 kHz.

(5) Answer [B]

$P = \frac{1}{3}\left(\frac{U}{V}\right) \propto T^4$. For ideal gas $PV = \mu RT$

$\therefore P = \frac{\mu RT}{V} \quad \therefore \frac{\mu RT}{V} \propto T^4$

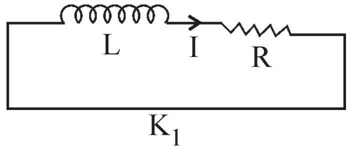
$\therefore \frac{\mu R}{V} \propto T^3, \therefore \frac{1}{4\pi R^3} \propto T^3$

$\therefore T^3 \propto \frac{1}{R^3} \rightarrow T \propto \frac{1}{R}$

(6) Answer [C]

Solution :

When switch K_1 is switch off for a long time then current flows from inductor is $I_0 = \frac{E}{R} = \frac{15}{0.15 \times 10^3} = 0.1$ A. When K_1 is open and K_2 is closed then, $I = I_0 e^{-t/\tau}$ $\quad t = 1 \times 10^{-3}$ s



$\tau = \frac{L}{R} = \frac{0.03}{0.15 \times 10^3} = 10^{+3}/5$

$I = e^{-1 \times 10^{-3} / 10^{-3} / 5} = 0.1\ e^{-5}$

$= 0.1/e^5 = \frac{0.1}{150} = \frac{1}{15} \times 10^{-2} \times 10^3$

$= 0.67\ mA$

(7) Answer [D]

Solution : $T = 2\pi\sqrt{\frac{l_1}{g}}$, $T_M = 2\pi\sqrt{\frac{l_2}{g}}$

$T^2 = \frac{4\pi^2 l_1}{g}$, $T_M^2 = 4\pi^2 l_2/g$

$\frac{T_M^2}{T^2} = \frac{l_2}{l_1}$, $\frac{T_M^2}{T^2} - 1 = \frac{l_2}{l_1} - 1 = \frac{l_2 - l_1}{l_1}$

$Y = \frac{Mg}{A}\frac{l_1}{l_2 - l_1}$, $\therefore \frac{1}{Y} = \frac{A}{Mg}\frac{l_2 - l_1}{l_1}$

$= \frac{A}{Mg}\left[\left(\frac{T_M}{T}\right)^2 - 1\right]$

(8) Answer [A]

Solution : $I = \frac{P}{4\pi r^2} = \frac{1}{2}\varepsilon_0 E_0^2 c = \frac{P}{4\pi r^2}$

$E_0 = \sqrt{\frac{2P}{4\pi\varepsilon_0 c r^2}}$

$= \sqrt{\frac{2 \times 0.1}{8.85 \times 10^{-12} \times 3 \times 10^8 \times 4\pi \times (1)^2}}$

$= 2.45\ Vm^{-1}$

(9) **Answer [D]**

Solution :

Solenoid is made from circular loop having electric current. The force acts on both solenoid in equal magnetic field is $F_1 = F_2 = 0$.

(10) **Answer [B]**

Average time for collisions $t = \frac{\lambda}{v}$

$$\therefore\ t = \frac{\frac{1}{\sqrt{2}\frac{N}{V}\pi d^2}}{\sqrt{\frac{3RT}{M}}} = \frac{\sqrt{M}\,V}{\sqrt{2}N\pi d^2\sqrt{3R}\sqrt{T}}$$

$$\therefore\ t = \frac{KV}{\sqrt{T}} \quad \text{Where } K = \frac{\sqrt{M}}{\sqrt{2}N\pi d^2\sqrt{3R}}$$

$$\therefore\ T \propto \frac{V^2}{t^2} \quad \text{For adiabatic process } TV^{\gamma-1} = \text{constant}$$

$$\therefore\ \frac{V^2}{t^2} V^{\gamma-1} = \text{constant} \quad \therefore\ \frac{V^{\gamma+1}}{t^2} = \text{constant}$$

$$\therefore\ t \propto V^{\frac{\gamma+1}{2}} \quad \therefore\ q = \frac{\gamma+1}{2}$$

(11) **Answer [D]**

Solution :

For damped oscillations $A = A_0\, e^{-bt/2m}$

$$\therefore\ A = A_0\, e^{-\left(\frac{R}{2L}\right)t}$$

L and m have same duty so,

$L_1 > L_2$

(12) **Answer [A]**

Solution :

gravitational potential at distance r inside the solid sphere,

$$V = -\frac{GM}{R}\left[\frac{3}{2} - \frac{r^2}{2R^2}\right]$$

at $r = R/2$,

$$V_1 = -\frac{GM}{R}\left[\frac{3}{2} - \frac{R^2}{8R^2}\right] = -\frac{11}{8}\frac{GM}{R}$$

By removing the sphere,

$$V_2 = \frac{3}{2}\,\frac{\frac{GM}{8}}{R/2} = \frac{3}{8}\,\frac{GM}{R}$$

$\therefore$ total gravitational potential

$$V = V_1 + V_2 = -\frac{11}{8}\frac{GM}{R} + \frac{3}{8}\frac{GM}{R}$$

$$= -\frac{GM}{R}$$

(13) **Answer [A]**

Solution : $v_S = 20\ ms^{-1}$ train comes near then,

$$f_L = f_S \cdot \left(\frac{v}{v - v_S}\right),\ f_S = 1000\ \text{Hz}$$

$$f_L = 1000 \times \left(\frac{320}{320 - 20}\right),\ f_L = 1066.67\ \text{Hz}$$

train goes far then

$$f'_L = f_S\left(\frac{v}{v + v_S}\right),\ f'_L = 941.17\ \text{Hz}$$

$$\text{percentage change in frequency} = \frac{f_L - f'_L}{f_S} \times 100$$

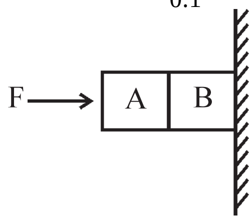
$$= \frac{1066.67 - 941.17}{1000} \times 100 = \frac{125.5}{10}$$

$= 12.55\ \% = 12\ \%$

(14) **Answer [B]**

Solution : For block - A, $m_1 g = \mu_1 F$

$$20 = 0.1 \times F,\ F = \frac{20}{0.1} = 200\ \text{N}$$



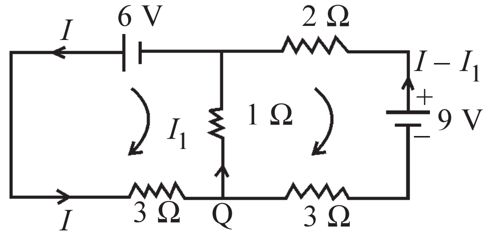
Friction force on block A in normal direction $= \mu_1 F = 0.1 \times 200 = 20$ N

The force of block-A, on block - B is 20 N in downward direction so,

$$\mu_2 F = m_2 g + \mu_1 F = 100 + 20 = 120\ \text{N}$$

(17) **Answer [B]**

$-6 + I_1 + 3I = 0,\ 3I + I_1 = 6$ ...(1)



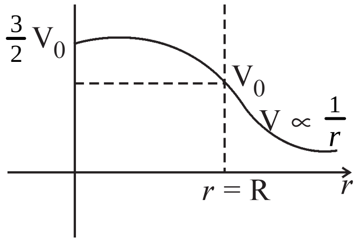
and $2(I - I_1) - 9 + 3(I - I_1) - I_1 = 0$ ...(2)

Solving equation (1) and (2)

$I_1 = \frac{3}{23} = 0.13$ A (Q to P)

(18) Answer [B]

Solution : electric - potential in inside region



$$V_{in} = \frac{Q}{4\pi\varepsilon_0 R}\left[\frac{3}{2} - \frac{r^2}{2R^2}\right]$$

$$V_S = \frac{Q}{4\pi\varepsilon_0 R} = V_0, V_{out} = \frac{Q}{4\pi\varepsilon_0 r}$$

$V_C = \frac{3}{2}V_0, \frac{5}{4}V_0$ is possible for inside region of sphere $\therefore \frac{5}{4}V_0 = V_0\left(\frac{3}{2} - \frac{r^2}{2R^2}\right)$

$r = \frac{R}{\sqrt{2}} = R_2$, $\frac{3V_0}{4}$ is possible for outside region of sphere.

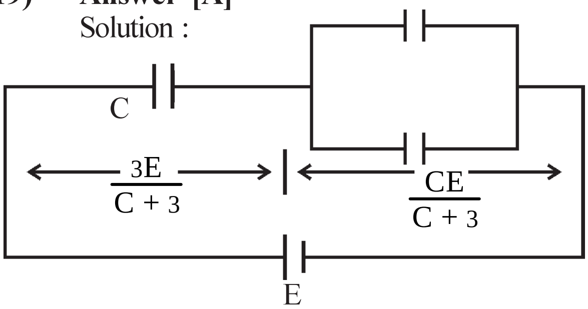
$$\frac{3V_0}{4} = \frac{Q}{4\pi\varepsilon_0 r}, \frac{3}{4}\frac{Q}{4\pi\varepsilon_0 R} = \frac{Q}{4\pi\varepsilon_0 r}$$

$r = \frac{3}{4}R = R_3$

Similarly, $r = 4R = R_4$. So, $\frac{3}{2}V_0$ Possible at $R_1 = 0$. So, $R_2 < (R_4 - R_3)$

(19) Answer [A]

Solution :



$\therefore Q_2 = \frac{2EC}{C+3}, Q_2 = \frac{2E}{1+3/C}$

The value of C increases 1 μF to 3 μF. So, for constant value of E, Q_2 increases,

(20) Answer [B]

Solution : $E_1 = \frac{1}{2}m(2v)^2 + \frac{1}{2}2mv^2$

$= \frac{1}{2}m4v^2 + mv^2 = 2mv^2 + mv^2 = 3mv^2$

After collision $3mv' = \sqrt{2} \cdot 2mv$

$v' = \frac{2\sqrt{2}v}{3}$

$$E_2 = \frac{1}{2}3m\left(\frac{2\sqrt{2}v}{3}\right)^2 = \frac{3}{2}m\frac{8v^2}{9} = \frac{4}{3}v^2$$

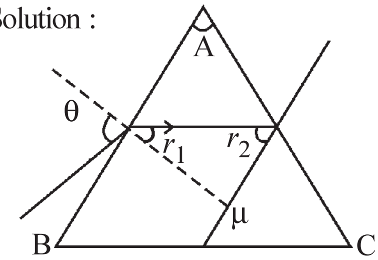
$$E_1 - E_2 = 3mv^2 - \frac{4}{3}mv^2 = \frac{9v^2 - 4v^2}{3}m = \frac{5}{3}mv^2$$

$$\therefore \frac{E_1 - E_2}{E_1} = \frac{\frac{5}{3}v^2}{3v^2} = \frac{5}{9}$$

$\therefore$ Percentage decrease $= \frac{5}{9} \times 100 = 55.6 = 56$ %

(21) Answer [D]

Solution :



$1 \sin\theta = \mu\sin r_1, \mu\sin\theta_2 = \sin 90$

$\sin\theta_C = \frac{1}{\mu}, r_2 < \theta_C, \sin r_2 < \sin\theta_C$

$r_1 + r_2 = A, r_1 = A - r_2$

$r_1 = A - \theta_2, \therefore \sin r_1 > \sin(A - \theta_C)$

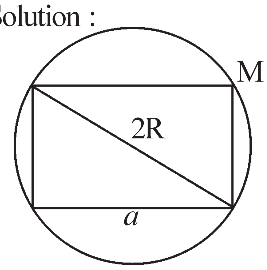
$\mu\sin r_1 > \mu\sin(A - \theta_C)$

$\sin\theta > \mu\sin(A - \theta_C)$

$$\theta > \sin^{-1}\left\{\mu\sin\left(A - \sin^{-1}\frac{1}{\mu}\right)\right\}$$

(22) Answer [B]

Solution :



Volume of sphere $V = \frac{4}{3}\pi R^3$

density of sphere $\rho = \frac{M}{V} = \frac{3M}{4\pi R^3}$

Cutting the cube having maximum volume from solid sphere, $2R = \sqrt{3}\,a \because a = \frac{2R}{\sqrt{3}}$

mass of cube $M' = \rho a^3 = \frac{3M}{4\pi R^3}\ \frac{8R^3}{3\sqrt{3}} = \frac{2M}{\sqrt{3}\pi}$

moment of inertia of cube

$$M'\frac{a^2}{6} = \frac{2M}{\sqrt{3}\pi} \times \frac{1}{6} \times \left(\frac{2R}{\sqrt{3}}\right)^2$$

$$= \frac{8MR^2}{18\sqrt{3}\pi} = \frac{4MR^2}{9\sqrt{3}\pi}$$

(23) Answer [B]

Solution :

(a) Frank-Hertz's experiment $\rightarrow$ descreate energy levels of atom (ii)

(b) Experiment of photo electric $\rightarrow$ particle nature of light (i)

(c) Davision-Germer's experiment $\rightarrow$ Wave nature of electron (iii)

(24) Answer [C]

Solution : $v_d = \frac{I}{Ane} \therefore \frac{I}{A} = nev_d$

$\therefore I = \frac{V}{R} = \frac{V}{\frac{\rho l}{A}}, \therefore \rho = \frac{V}{\frac{I}{A}l} = \frac{V}{nev_d l}$

$$\therefore \rho = \frac{5}{2.5 \times 10^{-4} \times 8 \times 10^{28} \times 1.6 \times 10^{-19} \times 0.1}$$

$$= \frac{2}{8 \times 1.6 \times 10^4} = \frac{1}{6.4} \times 10^{-4}$$

$= 1.6 \times 10^{-5}\ \Omega m$

(25) Answer [A]

Solution : Potential energy $U = \frac{1}{2} Ky^2$

total energy $E = \frac{1}{2} KA^2$

kinetic energy $K = E - U = \frac{1}{2} K(A^2 - y^2)$

(26) Answer [B]

Solution :

Time taken to reach second stone to land

$d = v_0 t - \frac{1}{2} gt^2$, $-240 = 40t - 5t^2$

$5t^2 - 40t - 240 = 0$, $(t - 12)(t + 4) = 0$

$t = 12$ s,

for stone–1

$-240 = 10t - 5t^2$, $\quad 5t^2 - 10t - 240 = 0$

$(t - 8)(t + 6) = 0$, $t = 8$ s

During first 8 s both store is in air so,

$(y_2 - y_1) - (v_{02} - v_{01})\,t = 30t$

plot of $y_2 - y_1 \rightarrow t$ is linear.

after 8 s, $y_2 = vo_2 t - \frac{1}{2} gt^2 = 240$

Constant accelerated motion of stone-2, relative to stone 1 so, plot-B shows its true behaviour.

(27) Answer [ ]

Solution : $ds' = \frac{dQ}{T} = ms\frac{dT}{T}$

$$\Delta s' = \int ds' = ms\int\frac{dT}{T} = 1 \log_e \frac{T_2}{T_1} = 1 \log_e \frac{473}{373}$$

Answer : none of above from given options.

(28) Answer [A]

Solution : radius of eyeball $r = 0.25$ cm

$\therefore$ diameter $d = 0.5$ cm $= 5 \times 10^{-3}$ m

$\lambda = 500\ nm = 5 \times 10^{-7}$ m, $\sin\theta = \frac{1.22\lambda}{d}$

$$\therefore \sin\theta = \frac{1.22 \times 5 \times 10^{-7}}{0.5 \times 10^{-2}} = \frac{1.22 \times 5 \times 10^{-7}}{5 \times 10^{-3}}$$

$= 1.22 \times 10^{-4}$. Now, minimum distance for clear vision

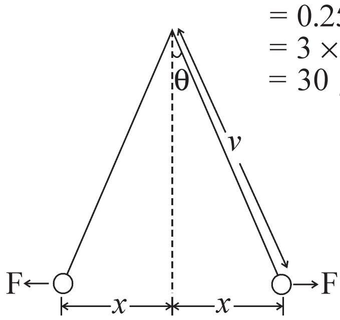
$D = 25$ cm $= 0.25$ m

$\therefore \sin\theta = \frac{x}{D} \Rightarrow x = D\sin\theta$

$= 0.25 \times 1.22 \times 10^{-4}$

$= 3 \times 10^{-5}$

$= 30\ \mu m$



(29) Answer [A]

$F = \frac{\mu_0 I^2}{4\pi x}$, $x = l\sin\theta$, $\therefore F = \frac{\mu_0 I^2}{4\pi l\sin\theta}$

Now, $T\sin\theta = \frac{\mu_0 I^2}{4\pi l\sin\theta}$ and $T\cos\theta = \lambda g$

$$\therefore \tan\theta = \frac{\mu_0 I^2}{4\pi l\sin\theta\lambda g}$$

$$\therefore I^2 = \frac{4\pi l\sin^2\theta\lambda g}{\mu_0\cos\theta}$$

$$\therefore I = 2\sin\theta\sqrt{\frac{\pi l\lambda g}{\mu_0\cos\theta}}$$

(30) Answer [C]

Solution : The ray of light goes from thin medium to dense medium. So, it bend towards upward.

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