JEE MAIN-2021 DATE:20-07-2021 (SHIFT-1)| PAPER-1-PHYSICS

1. A deuteron & α -particle both enters in a region of magnetic field perpendicular to it with same kinetic energy find the ratio of their radii?

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

Ans: 3

Sol: $r = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}$

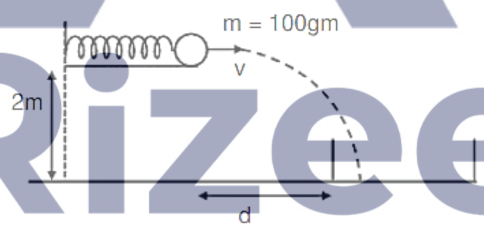
$r \propto \frac{\sqrt{m}}{q}$

$m_\alpha = 2m_d$

$q_\alpha = 2q_d$

$\frac{r_d}{r_q} = \frac{\sqrt{m_d}}{q_d} \times \frac{2q_d}{\sqrt{2m_d}} = \sqrt{2}$

2. In the given arrangement, spring of spring constant 100 N/m is compressed by 0.5 m. The height of the arrangement is 2m. A basket is placed at distance d such that after projection, ball will fall in the basket. If the mass of the ball is 100 gm, find maximum value of d?



(1) 5 m (2) 10 m (3) 15 m (4) 20 m

Ans: 2

Sol: By energy conservation

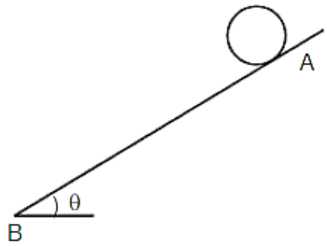
$\frac{1}{2}kx^2 = \frac{1}{2}mv^2 \Rightarrow v = x\sqrt{\frac{k}{m}}$ $v = 0.5 \times \sqrt{\frac{100}{0.1}} = 5\sqrt{10} m/s$

Time of flight of ball $T = \sqrt{\frac{2H}{g}} = \sqrt{\frac{2 \times 2}{10}} = \frac{2}{\sqrt{10}}$ sec

Range of ball $S = ut$

$d = 5\sqrt{10} \times \left(\frac{2}{\sqrt{10}}\right) = 10m$

3. When a disc slides on smooth inclined surface from rest, the time taken to move from A to B it t_1. When disc performs pure rolling from rest then time taken to move from A to B is t_2. If $\frac{t_2}{t_1} = \sqrt{\frac{3}{x}}$ find x.



Ans: 2

Sol: When disc slides $a_1 = g\sin\theta$ so $S = ut_1 + \frac{1}{2}a_1 t_1^2 = \frac{1}{2}g\sin\theta . t_1^2 ....(1)$

When disc do pure rolling $a_2 = \frac{g\sin\theta}{1 + k^2/R^2} = \frac{g\sin\theta}{1+1/2} = \frac{2}{3}g\sin\theta$

So $S = ut_2 + \frac{1}{2}a_2 t_2^2 = \frac{1}{2}.\frac{2}{3}g\sin\theta . t_2^2 ....(2)$

From (1) & (2)

$\frac{t_2}{t_1} = \sqrt{\frac{3}{2}}$

4. We have a charge of magnitude Q. If we divide charge in two parts, what should be their ratio so that there will be max repulsion force between them?

(1) 1 : 1 (2) 2 : 1 (3) 1 : 2 (4) 3 : 2

Ans: 1

Sol:

$F = \frac{Kq_1q_2}{r^2} = \frac{K(q)(Q-q)}{r^2}$

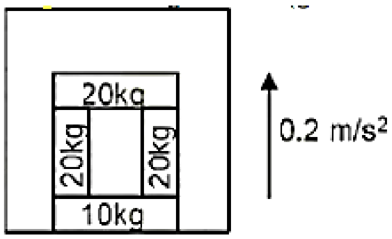
$\frac{dF}{dq} = 0$

$Q - 2q = 0$

$q = Q/2$

Ratio= 1 : 1

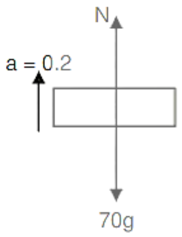
5. Four planks are arranged in a lift going upwards with an acceleration of 0.2 m/s^2 as shown in figure. Find the normal reaction applied by the lift on 10 kg block : ($g=9.8\ m/s^2$)



(1) 500 (2) 700 (3) 672 (4) 800

Ans: 2

Sol:

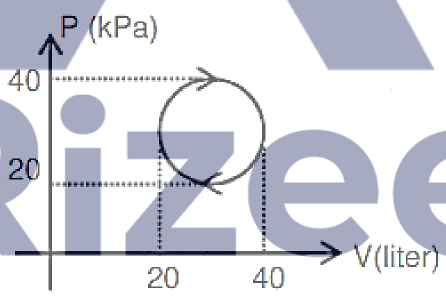


$N - 70g = 70 \times 0.2$

$N = 70(g + 0.2)$

$N = 700$

6. For given PV curve, Find net heat taken by gas system in cyclic process.



(1) 25π (2) 50π (3) 75π (4) 100π

Ans: 4

Sol: $\Delta Q = W + \Delta U = W$ =area enclosed by the curve

$\Delta Q = \pi ab$

$= \left[\frac{40-20}{2} \times 10^3\right] \times \left[\frac{40-20}{2} \times 10^{-3}\right]$

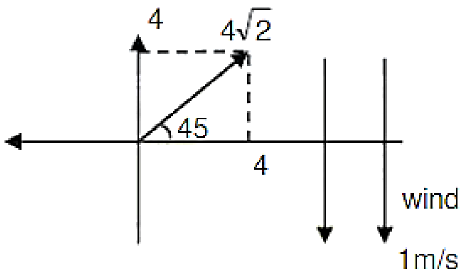
$= 100\pi$ Joule

7. A butterfly is flying in North-East with $4\sqrt{2}$ m/s w.r.t. wind. Wind is blowing at 1 m/s southwards. Displacement of butterfly in 3s is

(1) 10 meter (2) 15 meter (3) 20 meter (4) 5 m

Ans: 2

Sol:



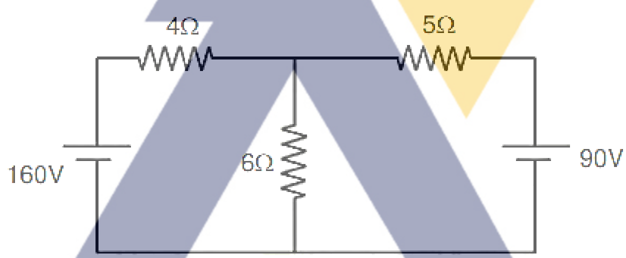
$\vec{D} = V_{F,G} \times T$ c

$= \left\{\left(4\hat{i} + 4\hat{j} + (-\hat{j})\right)\right\} \times 3s$

$= \left(4\hat{i} + 3\hat{j}\right) \times 3s$

$\left|\vec{D}\right| = 15m$

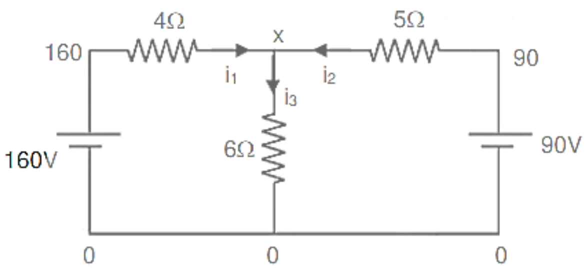
8. In the given circuit, find current passing through 6Ω resistor



(1) 15.67 (2) 16.50 (3) 18.47 (4) 10.46

Ans: 1

Sol:



Let potential at junction point =x

By KCL $\sum i_{in} = 0$

$$\Rightarrow \frac{160-x}{4} + \frac{90-x}{5} + \frac{0-x}{6} = 0$$

$$\Rightarrow \frac{160\times15 - 15x + 90\times12 - 12x + 0 - 10x}{60} = 0$$

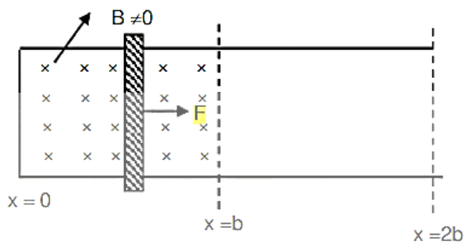
$$\Rightarrow 37x = 2400 + 1080$$

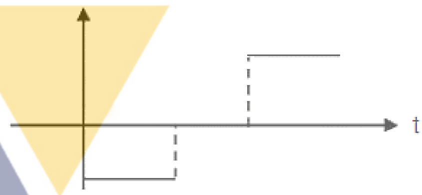
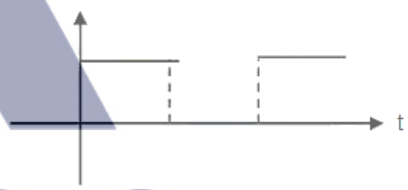
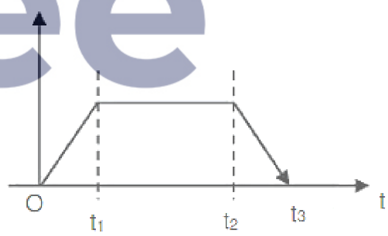
$$x = 94.05$$

So current $i_3 = \frac{x}{6}$

$= \frac{94.05}{6} = 15.67$

9. In the given system, uniform magnetic field exists from x=0 to x=b. A rod is first moved from x=0 to x=2b uniformly and then moved reverse uniformly from x=2b to x=0. Match the quantities with proper curves



Column-I	Column-II
(a) Flux (ϕ)	(i) 
(b) EMF (e)	(ii) 
(c) Power (P)	(iii) 

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

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

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

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

Ans: 1

Sol: Flux= $\phi = B.A$

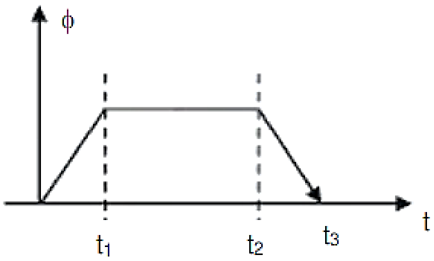
$\Rightarrow B \times A \cos 0$

Where $A = \ell vt$

$\phi = B\ell vt$

One rod go at x>b then ϕ stop changing this constant flux $= B\ell b$.

When rod come back and when x<b flux start decreasing so graph $\phi v / St$



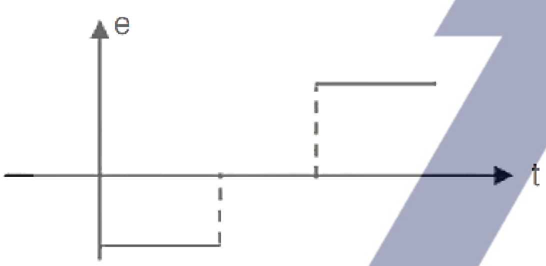
$b \rightarrow (ii)$

$e = \frac{-d\phi}{dt}$

e= -slope of $\phi - t$ graph

In $0 - t_1$ graph slope +ve and constant so e=negative and zero.

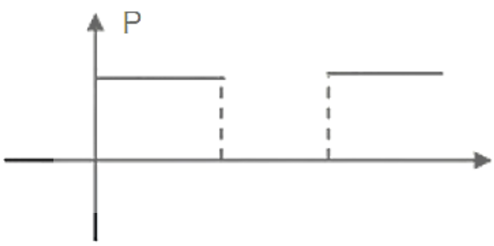
In $t_2 - t_3$ slope of $\phi - t$ is negative and constant so e=positive and zero



Power $= \frac{e^2}{R}$

Resistance is only of rod so R of the circuit is constant

$P = \frac{B^2 \ell^2 V^2}{R}$ =constant



10. A uniform rod of young’s modulus Y is stretched by two tension T_1 and T_2 such that rods get expanded to length L_1 and L_2 respectively. Find initial length of rod?

(1) $\frac{L_1T_1 - L_2T_2}{T_1 - T_2}$ (2) $\frac{L_2T_1 - L_1T_2}{T_2 - T_1}$ (3) $\frac{L_1T_2 - L_2T_1}{T_2 - T_1}$ (4) $\frac{L_1}{T_1} \times \frac{T_2}{L_2}$

Ans: 3

Sol: Let initial length of rod be L_0 and Area A.

As $\frac{T}{A}=Y\frac{\Delta\ell}{\ell}$

So, $\frac{T_1}{A}=\frac{Y\left(L_1-L_0\right)}{L_0}$

$\frac{T_2}{A}=\frac{Y\left(L_2-L_0\right)}{L_0}$

Dividing

$\frac{T_1}{T_2}=\frac{L_1-L_0}{L_2-L_0};T_1L_2-T_1L_0=T_2L_1-T_2L_0;L_0=\frac{L_1T_2-L_2T_1}{T_2-T_1}$

11. If $\vec{A}.\vec{B}=\left|\vec{A}\times\vec{B}\right|$; Find $\left|\vec{A}-\vec{B}\right|$

(1) $\sqrt{A^2+B^2-\sqrt{2}AB}$ (2) $\sqrt{A^2+B^2+\sqrt{2}AB}$

(3) $A-B$ (4) $A+B$

Ans: 1

Sol: $\vec{A}.\vec{B}=\left|\vec{A}\times\vec{B}\right|$

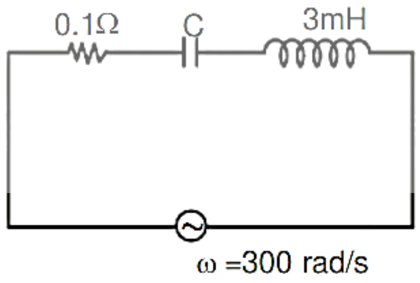
$\Rightarrow AB\cos\theta=AB\sin\theta$

$\therefore \theta=45^0$

$\therefore\left|\vec{A}-\vec{B}\right|=\sqrt{A^2+B^2-2AB\cos 45^0}$

$=\sqrt{A^2+B^2-\sqrt{2}AB}$

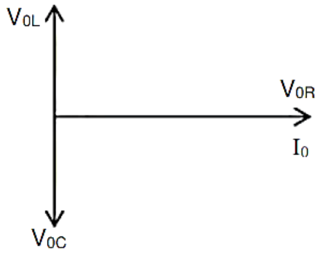
12. In the L-C-R series A.C. circuit shown fellow, current leads source voltage by 45^0. Find capacitance of the capacitor.

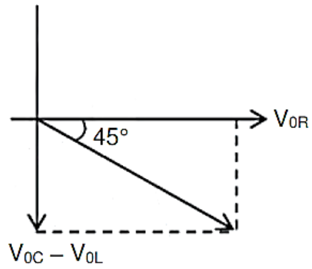


(1) 2.1 mF (2) 3.33 mF (3) 4.3 mF (4) 5.1 mF

Ans: 2

Sol:





$$\tan 45^0 = \frac{V_{0C} - V_{0L}}{V_{0R}} = \frac{X_C - X_L}{R}$$

$$R = \frac{1}{\omega C} - \omega L$$

$$0.1\Omega = \frac{1}{300C} - 3\times10^{-3}\times300$$

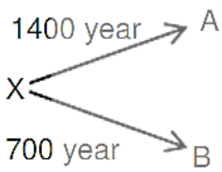
$$\Rightarrow C = 3.33mF \text{ (approx)}$$

13. A radioactive material having number of active nuclei N is decaying by two process, one with half-life of 1400 yr and other with half-life of 700 yr. After how much time number of active nuclei will be N/3?

(1) 520 yr (2) 740 yr (3) 470 yr (4) 640 yr

Ans: 2

Sol:



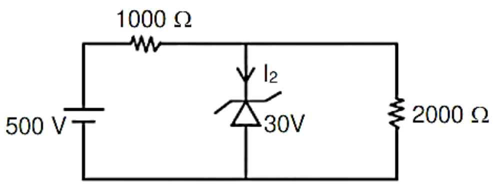
$$-\frac{dN_x}{dt} = \lambda_1 N_x + \lambda_2 N_x$$

$$\int_N^{N/3} \frac{dN_x}{N_x} = \int_0^t (\lambda_1 + \lambda_2)\,dt$$

$$\ln 3 = \left(\frac{\ln 2}{1400} + \frac{\ln 2}{700}\right)t$$

$$t = \frac{\ln 3}{\ln 2} \times \frac{1400}{3} = 740\,year$$

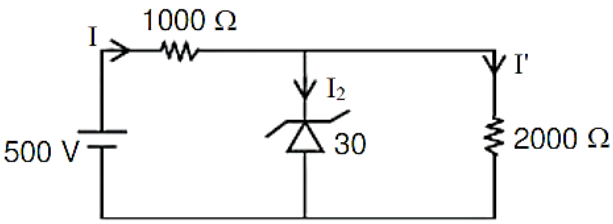
14. In the given circuit find current 'I' passing through Zener diode?



(1) 0.445 A (2) 0.345 A (3) 0.245 A (4) 0.145 A

Ans: 1

Sol:



$$I = \frac{500-30}{1000} = 0.47A$$

$$I' = \frac{30}{2000} = 0.015$$

$$I = I_Z + I'$$

$$I_Z = I - I = 0.47 - 0.015 = 0.445A$$

15. The wave number of the spectral line in the emission spectrum of hydrogen will be equal to 8/9 times of the Rydberg's constant. Then the electron jumps from

(1) $5 \to 2$ (2) $5 \to 3$ (3) $3 \to 1$ (4) $4 \to 2$

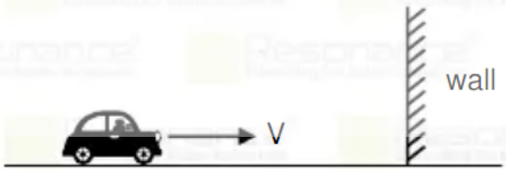
Ans: 3

Sol: $\bar{v} = Rz^2\left(\frac{1}{n_L^2} - \frac{1}{n_H^2}\right)$

If $n_L = 1, n_H = 3; \bar{v} = R.1\left[\frac{1}{1} - \frac{1}{(3)^2}\right]; \bar{v} = \frac{8}{9}R$

16.

A vehicle moving with velocity v and releasing sound of frequency 400 Hz. Listening the reflected sound from a wall of frequency 500 Hz. Find the velocity of vehicle v.



(1) 36.67 m/s (2) 30.12 m/s (3) 22.37 m/s (4) 20.25 m/s

(1)

Ans: 1

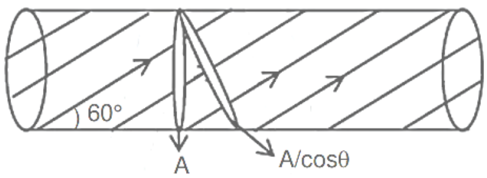
Sol: Frequency received by wall $f' = \left(\frac{V_S}{V_S - V}\right)f_0$

Reflected frequency received by man is $f'' = \left(\frac{V_S + V}{V_S}\right) f'$

$$\Rightarrow f'' = \left(\frac{V_s + V}{V_s}\right)\left(\frac{V_S}{V_S - V}\right) f_0 \Rightarrow f'' = \left(\frac{V_S + V}{V_S - V}\right) f_0 \Rightarrow 500 = \left(\frac{330 + V}{330 - V}\right) 400$$

$$\Rightarrow V = \frac{330}{9} = 36.67 m/s$$

17. In a magnesium rod of area $3m^2$, current I=5A is flowing at angle of 60^0 from axis of rod. Resistivity of material is $44 \times 10^{-2} ohm \times m$. Find electric field inside the rod?



(1) 0.567 (2) 0.367 (3) 0.667 (4) 0.767

Ans: 2

Sol: $J = \sigma E$

$$\frac{I}{A_{effective}} = \frac{E}{\rho}$$

$$E = \frac{\rho I}{A} \cos 60^0 = \frac{44 \times 10^{-2} \times 5}{3 \times 2}; E = 0.367$$

18. Four moles of a diatomic gas is heated from 0°C to 50°C. Find the heat supplied to the gas if work done by it is zero.

(1) 700 R (2) 600 R (3) 500 R (4) 100 R

Ans: 3

Sol: n=4

$$\Delta T = 50K$$

$$C_V = \frac{5R}{2}$$

As W=0. It means isochoric process

$$Q = \Delta U$$

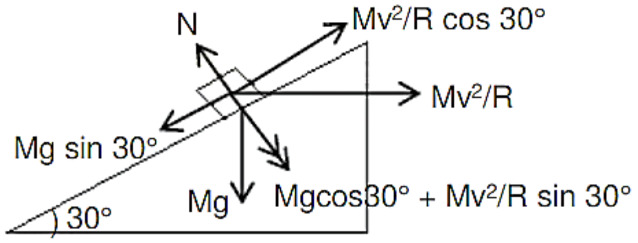
$$= nC_V \Delta T = 4 \times \frac{5R}{2} \times 50 = 500R$$

19. A car is moving on a Banked rough road, the mass of car is 800 kg. The angle of Banking is 30°. car is moving with maximum speed given that μ_s = 0.2. find the Normal Reaction (in Newton)?

(1) 24000 (2) 5000 (3) 10000 (4) 9000

Ans: 3

Sol:



Perpendicular to inclined plane

$$N = mg\cos 30^0 + \frac{mv^2}{R}\sin 30^0$$

$$N - mg\cos 30^0 = \frac{mv^2}{R}\sin 30^0 ...(1)$$

Along inclined plane

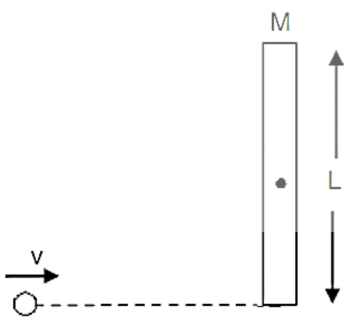
$$mg\sin 30^0 + \mu_S N = \frac{mV^2}{R}\cos 30^0 ...(2)$$

Dividing (1) by (2)

$$\frac{N - mg\cos 30^0}{mg\sin 30^0 + \mu_S N} = \tan 30^0$$

Solving N=10000(Approx)

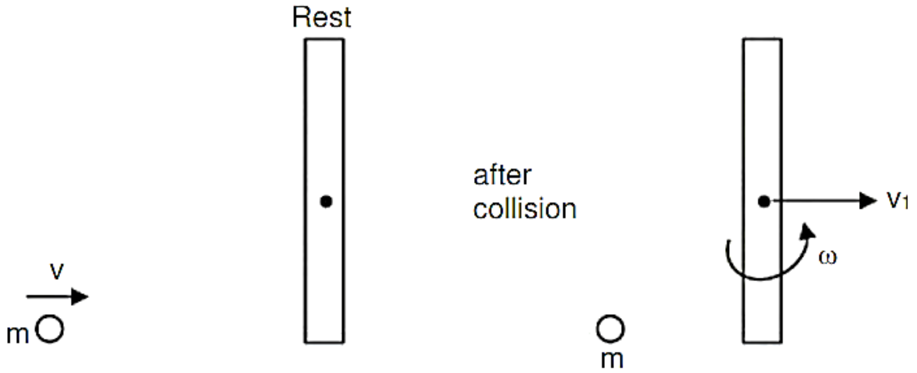
20. A particle of mass m moving with speed v collide elastically with the end of a uniform rod of mass M and length L perpendicularly as shown in figure. If the particle comes to rest after collision find the value of $\frac{m}{M}$.



(1) 1/3 (2) 1/2 (3) 1/4 (4) 1/5

Ans: 3

Sol:



Conservation of angular momentum about centre of mass of rod

$$mv\left(\frac{L}{2}\right)=\frac{ML^2}{12}(\omega)\ldots\text{(i)}$$

$$mv=Mv_1\ \ldots\text{(ii)}$$

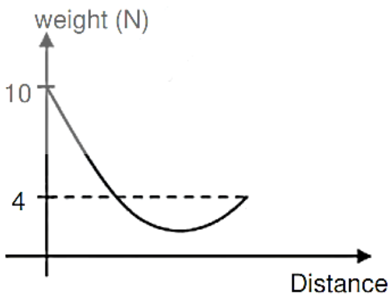
$$1=\frac{v_1+\omega\frac{L}{2}}{v}\ \ldots\text{(iii)}$$

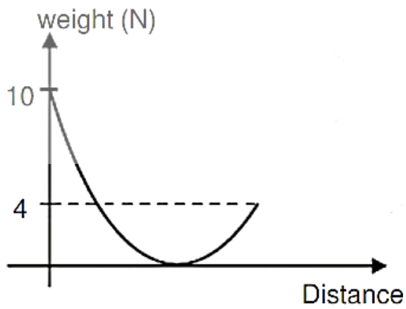
Putting v_1 from (ii) and ωL from (i) in (iii)

$$v=\frac{m}{M}v+\frac{6mv}{2M}$$

$$1=\frac{4m}{M};m/M=1/4$$

21. An object is moved from earth to moon. Choose the correct weight vs distance curve. Gravitational acceleration on earth surface is 10 m/s^2 and that on moon is $4 m/s^2$. Mass of the object is 1kg.

(1) 

(2) 

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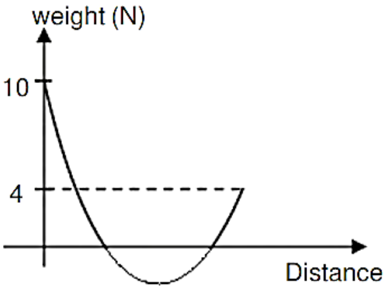

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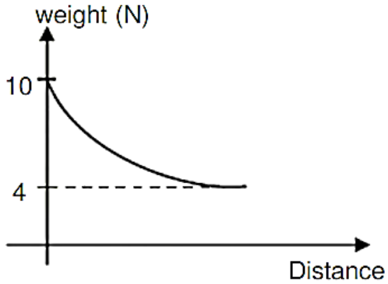


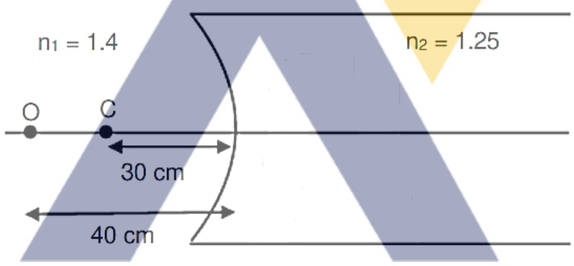
Ans: 2

Sol: $\vec{g}$ (at any point) $= \vec{g}_{Earth} + \vec{g}_{moon}$. Since distance is large so $|\vec{g}| = |\vec{g}_E| = 10$.

As we move away from earth, It decrease to zero at a point where $\vec{g}_E + \vec{g}_M = 0$

Then it increase to $|\vec{g}| = |\vec{g}_M| = 4$ at moon surface.

22. For the spherical interface of radius of curvature R=30 cm shown in figure. The two different media having refractive indices $n_1 = 1.4$ and $n_2 = 1.25$, an object is placed at 40 cm from the interface as shown in figure. Find position of image.



(1) 41.67 (2) 35.42 (3) 22.27 (4) 15.25

Ans: 1

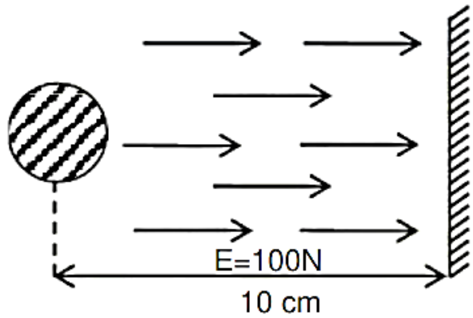
Sol: $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$

$\Rightarrow \frac{1.25}{v} - \frac{1.4}{-40} = \frac{1.25 - 1.4}{(-30)}$

$\Rightarrow \frac{1.25}{v} = 0.005 - 0.035$

$\Rightarrow v = -41.67 cm$

23. A ball of charge to mass ratio $8\mu C / g$ is placed at a distance of 10 cm from a wall. An electric field 100 N/m is switched on in the direction of wall. Find time period of its oscillations? Assume all collisions elastic.



(1) 1 sec (2) 2 sec (3) 3 sec (4) 4 sec.

Ans: 1

Sol: $a = \frac{qE}{m} = \frac{8\times10^{-6}}{10^{-3}}\times100 = 0.8m/s^2$

As electric field is switched on, ball first strikes to wall and returns back.

One oscillation

Thus $S = ut + \frac{1}{2}at_1^2$

$0.1 = \frac{1}{2}\times0.8t_1^2$

$t_1 = \frac{1}{2}S$

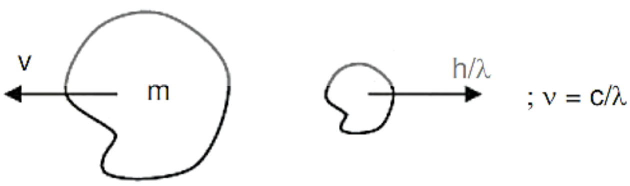
Thus time period $T = 2\times\frac{1}{2} = 1\sec$.

24. A body of mass m emits a photon frequency ν, then loss in its internal energy?

(1) $h\nu$ (2) $h\nu\left(1-\frac{h\nu}{2mc^2}\right)$ (3) $h\nu\left(1+\frac{h\nu}{2mc^2}\right)$ (4) zero

Ans: 3

Sol:



$mv = \frac{h}{\lambda} = \left(\frac{h\nu}{c}\right)$

Loss of energy $= \frac{1}{2}mv^2 + h\nu$

$= \frac{1}{2}\frac{p^2}{m} + h\nu$

$$=\frac{1}{2m}\left(\frac{hv}{c}\right)^2+hv$$

$$=hv\left(1+\frac{hv}{2mc^2}\right)$$

25. Consider an equation $S=\alpha^2\beta\ell n\left(\frac{nkR}{j\beta^2}-1\right)$

Where S=Entropy

n=No. of moles

k=Boltzmann constant

R=Universal gas constant

J=Mechanical equivalent of heat

Final dimension of α and β respectively:

(1) $\left[M^0L^0T^0\right],\left[M^1L^2T^2K^{-1}\right]$

(2) $\left[M^1L^2T^{-2}\right],\left[M^1L^2T^{-2}K^{-1}\right]$

(3) $\left[M^1L^2T^{-2}K^{-1}\right],\left[M^0L^0T^0\right]$

(4) None of these

Ans: 1

Sol: $S=\frac{Q}{\Delta T}$

$$[S]=\frac{ML^2T^{-2}}{K}$$

$$K=\frac{Energy}{T}$$

$$[K]=[S]=\frac{ML^2T^{-2}}{K}$$

$$[R]=\left[\frac{Energy}{nT}\right]=\frac{ML^2T^{-2}}{molK}$$

$$[J]=M^0L^0T^0$$

Now, $[nKR]=\left[J\beta^2\right]$

$$(mol)\times\frac{ML^2T^{-2}}{K}\times\frac{ML^2T^{-2}}{mol}=\left[\beta^2\right]$$

$$[\beta]=ML^2T^{-2}K^{-1}$$

$$\left[\alpha^2\right]=\left[\frac{S}{\beta}\right]=\frac{ML^2T^{-2}}{K\times ML^2T^{-2}K^{-1}};\alpha=M^0L^0T^0$$

26. The shape of travelling wave at $t=0$, is given by $y=\frac{1}{1+x^2}$. If after 3 sec shape of the wave pulse is represented by $y=\frac{1}{1+(1-x)^2}$, then speed of wave is:

(1) $\frac{1}{2}m/s$ (2) $\frac{4}{3}m/s$ (3) $\frac{1}{3}m/s$ (4) $\frac{5}{6}m/s$

Ans: 3

Sol: $x\to(x-vt)$

$y=\frac{1}{1+(x-vt)^2}$

At $t=0; y=\frac{1}{1+x^2}$

At $t=3; y=\frac{1}{1+(x-3v)^2}$

By comparing

$V=\frac{1}{3}m/s$

27. In hydrogen atom these is photon emitted by transition of electron from n=3 to n=1, this photon is then incident on a gold plate from which electron is emitted which will make a radius of 7 mm in a uniform magnetic filed of intensity 5×10^{-4}T find the work function of gold plate?

(1) 3.4 eV (2) 5.12 eV (3) 1.031 eV (4) 11.01 eV

Ans: 4

Sol: $E_p=13.6\left[\frac{1}{R_1^2}-\frac{1}{R_2^2}\right]eV$

$=13.6\left[\frac{1}{1}-\frac{1}{9}\right]$

E_p=12.08eV

For Gold plate

$\phi=E_p-KE\max$

$v=\frac{R_qB}{m}$

$$= \frac{7\times10^{-3}\times1.6\times10^{-19}\times5\times10^{-4}}{9.1\times10^{-31}} = 6.15\times10^{5}$$

$$\text{K.E.} = \frac{1}{2}mV^2$$

$$K.E = \frac{1}{2}\times\frac{9.1\times10^{-31}\times\left(6.15\times10^{5}\right)^2}{1.6\times10^{-19}}eV = 1.075eV$$

$$\phi = 12.05 - 1.075$$

$$\phi = 11.01eV$$