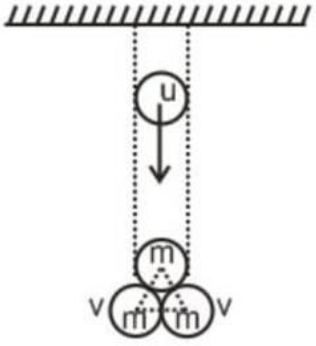
1. A Stationary hydrogen atom in the first excited state emits a photon. If the mass of the hydrogen atom is m and its ionization energy is E, then the recoil velocity acquired by the atom is [speed of light = c]

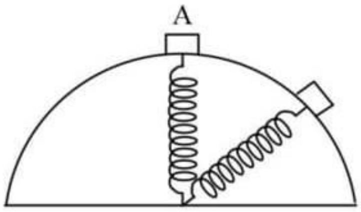
A) $\left(\sqrt{\frac{3E}{2m}+c^2}\right)-c$ B) $\left[\sqrt{\frac{3E}{4m}+c^2}\right]-c$ C) $\frac{3E}{4mc}$ D) $\frac{E}{mc}$

2. Two identical spheres, each of mass m are suspended by vertical strings such that they are in contact with their centers are the same level. A third identical sphere strikes the other two spheres simultaneously with a velocity ***u*** such that the centers of the spheres at the instant of impact from an equilateral triangle in a vertical plane. If the collision is perfectly elastic, then the combined impulse due to the strings is



A) $\frac{12}{7}mu$ B) $\frac{6}{7}mu$ C) $\frac{2\sqrt{3}}{7}mu$ D) $\frac{8}{7}mu$

3. A bead of mass m can slide without friction along a vertical ring of radius R. One end of a spring of force constant $k=\frac{3mg}{R}$ is connected to the bead and the other end is fixed at the centre of the ring. Initially, the bead is at the point A and due to a small push, it starts sliding down the ring. If the bead momentarily loses contact with the ring at the instant when the spring makes an angle of 60^0 with the vertical, then the natural length of the spring is

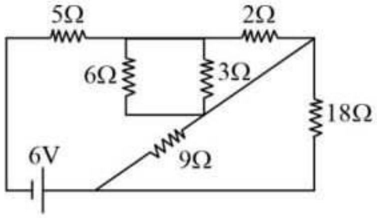


$A)\frac{5R}{9}$ $B)\frac{3R}{4}$ $C)\frac{5R}{6}$ $D)\frac{4R}{7}$

4. A glass prism of angle A= 60^0 gives a minimum angle of deviation $\theta=30^\circ$ with the maximum error of 1° when a beam of parallel light passed through the prism during an experiment. The permissible error in the measurement of refractive index μ of the material of the prism is:

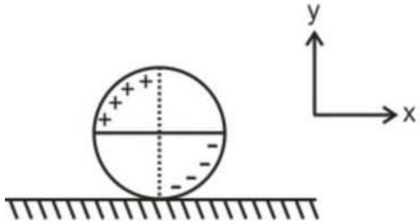
$A)\frac{100\pi}{180}\%$ $B)\frac{5\pi}{180}\%$ $C)\frac{50\pi}{180}\%$ $D)\frac{5\pi}{18}\%$

5. Find the resister in which the dissipated power is the greatest-



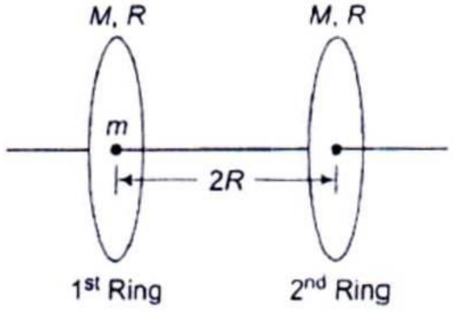
$A)2\Omega$ $B)9\Omega$ $C)18\Omega$ $D)5\Omega$

6. A non-conducting ring of mass m and radius $\boldsymbol{R}$ is charged as shown. The charged density i.e., charge per unit length is λ. It is then placed on a rough non-conducting horizontal surface plane. At time t = 0, a uniform electric field $\vec{E} = E_0\hat{i}$ is switched on and the ring starts rolling without sliding. The friction force (magnitude and direction) acting on the ring, when it starts moving is



$A)\lambda RE_0\hat{i}$ $B)3\lambda RE_0\hat{i}$ $C)\sqrt{2}\lambda RE_0\hat{i}$ $D)\frac{2}{\lambda RE_0}\hat{i}$

7. Consider two identical rings of mass M and radius R fixed on a horizontal axis in a gravity-free space. A particle of mass m is held at rest at the centre of 1st ring and projected along the axis towards 2nd ring. The minimum speed of projection so that the particle reaches the centre of 2nd ring is



$A)\sqrt{\frac{GM}{R}}$ $B)\sqrt{\frac{2GM}{R}}$ $C)\frac{2GM}{R}\sqrt{\left(1+\frac{1}{\sqrt{5}}-\sqrt{2}\right)}$ $D)\sqrt{\frac{GM}{R}\left(1+\sqrt{5}-\frac{1}{\sqrt{2}}\right)}$

8. Two metal rods of the same lengths and area of cross –section are fixed end to end between rigid supports. The materials of the rods have young’s module Y1 and Y2 and coefficients of linear expansion are α_1 *and* α_2 .The junction between the rods does not shift if the rods are cooled. Then

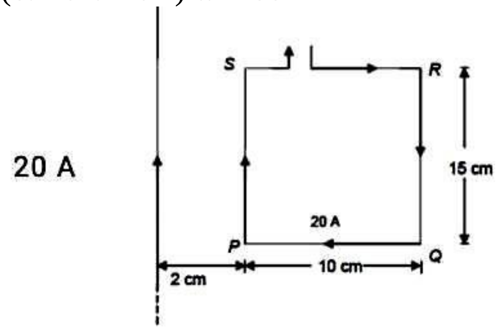
$A) Y_1\alpha_1 = Y_2\alpha_2$ $B) Y_1\alpha_2 = Y_2\alpha_1$ $C) Y_1\alpha_1^{\,2} = Y_2\alpha_2^{\,2}$

$D) Y_1^2\alpha_1 = Y_2^{\,2}\alpha_2$

9. Two cylinders A and B fitted with pistons contain equal amounts of an ideal diatomic gas at 300K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30 K, then the rise in temperature of the gas in B is.

A) 30K B)18K C)50K D)42K

10. The resultant force on the current loop PQRS due to a long current-carrying conductor (current=20A) will be

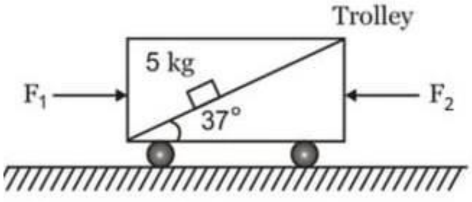


$A) 10^{-4} N$ $B) 3.6\times10^{-4} N$ $C) 1.8\times10^{-4} N$ $D) 5\times10^{-4} N$

11. A particle is projected with velocity $2\sqrt{gh}$ So that is just clears two walls of equal height h, which are at a distance of $2h$ from each other. what is time interval of passing between the two walls?

A) $\frac{2h}{g}$ B) $\sqrt{\frac{2h}{g}}$ C) $\sqrt{\frac{h}{g}}$ D) $2\sqrt{\frac{h}{g}}$

12. There is a trolley in which there is a fixed inclined surface on which a smooth block of mass 5Kg is placed. Two horizontal forces of magnitude F_1 and F_2 are applied on the trolley as shown to keep the trolley at rest. The value of $F_1 - F_2$ is: (Assume there is no friction between the trolley and horizontal ground and $g=10ms^{-2}$)



A)0N B)24N C)-24N D)-30N

13. Two radioactive nuclei ***P*** and ***Q, in*** a given sample decay into a stable nucleus R. At time t=0, the number of P species are $4N_0$and that of Q is N_0. The half-life of P (for conversion to R) is 1 minute whereas that of Q is 2 minutes. Initially, there are no nuclei of R present in the sample. When the number of nuclei of ***P*** and ***Q*** is equal, the number of nuclei of R present in the sample would be

A)$2N_0$ B)$3N_0$ C) $\frac{9N_0}{2}$ D) $\frac{5N_0}{2}$

SOLUTIONS

PHYSICS

1. m$\upsilon = \frac{h}{\lambda}$,here υ is recoil speed of H-atom and λ is the wavelength of the photon.

When the electron jumps down from the first excited state to the group state the energy release is

$$\Delta E_{2\to 1} = E(1-\frac{1}{2^2}) = \frac{3E}{4}$$

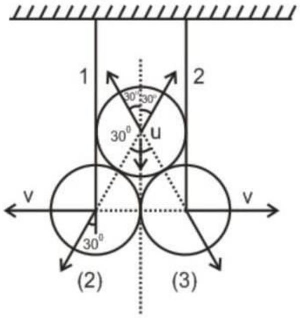
$$\frac{3E}{4} = \frac{1}{2}m\upsilon^2 + \frac{hc}{\lambda}$$

$$\frac{3E}{4} = \frac{1}{2}m\upsilon^2 + m\upsilon c$$

$$\left(\frac{m}{2}\right)\upsilon^2 + (mc)\upsilon - \left(\frac{3E}{4}\right) = 0$$

$$\Rightarrow \upsilon = \left[\sqrt{\frac{3E}{2m} + c^2}\right] - c$$

2.



Let us assume that after the collision, the velocity of the incoming ball changes from u to $u'$and the other two balls move in the opposite directions with the same speed υ ,then

$$-2\left(N\Delta t\right)\cos 30° = mu' - mu$$

$$\Rightarrow -(N\Delta t)\sqrt{3} = mu^{/} - mu$$

For the ball attached to the string,

$$(N\Delta t)\sin 30^0 = m\upsilon$$

$$\Rightarrow N\Delta t = 2m\upsilon$$

Eliminating N Δt , We obtain

$$-2\sqrt{3m\upsilon = mu^l - mu}$$

Using the coefficient of restitution equation, we get

$$1 = \frac{\upsilon\cos 60^0 - u^l - \cos 30^0}{u\cos 30^0}$$

$$\Rightarrow \sqrt{3}u = \upsilon - \sqrt{3}u^l$$

$$\Rightarrow 2\sqrt{3}\upsilon = 6u + 6u^l$$

$$6u + 6u^l = u - u^l$$

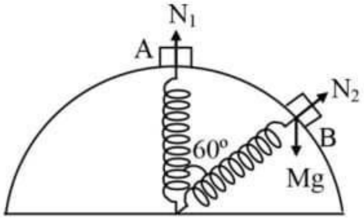
$$\Rightarrow u^l = -\frac{5}{7}u$$

The total impulse of tension is

$$-2T\Delta t = mu^l - mu$$

$$2T\Delta t = m\frac{5u}{7} + mu = \frac{12}{7}mu$$

3.



Let's say the bead loses contact with the ring at point B, then N_2 =0 and

$$mg\cos 60^0 + kx = \frac{m\upsilon^2}{R}$$

$$\frac{mg}{2} + kx = \frac{m\upsilon^2}{R}$$

Applying the conservation of mechanical energy principle between A &B

$$\frac{m\upsilon^2}{2} = mgR(1-\cos 60^0) = \frac{mgR}{2}$$

$$\Rightarrow \frac{m\upsilon^2}{R} = mg$$

$$\frac{mg}{2} + kx = mg$$

$$\Rightarrow x = \frac{mg}{2k} = \frac{R}{6}$$

The natural length of the spring

$$l = R - x = R - \frac{R}{6} = \frac{5R}{6}.$$

4. $\mu = \dfrac{\text{Sin}\left(\dfrac{\delta + A}{2}\right)}{\left(\text{Sin}\left(\dfrac{A}{2}\right)\right)}$, Where δ is the minimum deviation.

$$\frac{d\mu}{d\delta} = \frac{\text{Cos}\left(\frac{\delta + A}{2}\right)}{2\,\text{Sin}\left(\frac{A}{2}\right)}$$

$$\Rightarrow \frac{d\mu}{\mu} = \frac{\text{Cos}\left(\frac{\delta + A}{2}\right)}{2\,\text{Sin}\left(\frac{\delta + A}{2}\right)} d\delta$$

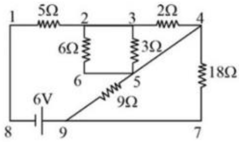
$$\Rightarrow \frac{d\mu}{\mu} = \frac{1}{2}\cot\left(\frac{\delta + A}{2}\right) d\delta$$

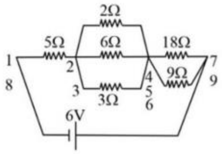
$$\left(\frac{\delta + A}{2}\right) = 45^0$$

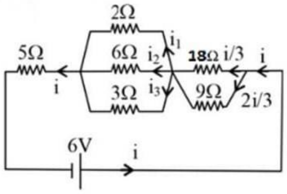
$$\Rightarrow \frac{d\mu}{\mu} \times 100 = \frac{1}{2}\cot(45^0)\frac{\pi}{180} \times 100$$

Percentage error = $\frac{5\pi}{18}\%$

5. Equivalent circult







$$i_1 : i_2 : i_3 = \frac{1}{2} : \frac{1}{6} : \frac{1}{3} = 3:1:2$$

$$i_1 = \frac{3}{6} \times i = \frac{i}{2}$$

$$i_2 = \frac{1}{6} \times i = \frac{i}{6}$$

$$i_3 = \frac{2}{6} \times i = \frac{i}{3}$$

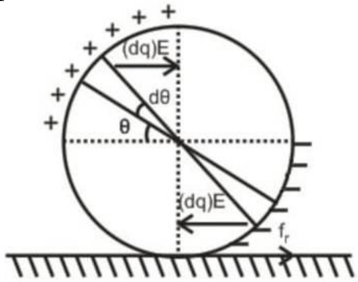
$$\Delta H \; in \, 5\,\Omega = i^2 \times 5$$

$$\Delta H \; in \, 2\,\Omega = \frac{i^2}{4} \times 2 = \frac{i^2}{2}$$

$$\Delta H \; in \, 9\,\Omega = \frac{4i^2}{9} \times 9$$

$$\therefore \textit{Maximum heat is in } 5\ \Omega$$

6. As $\vec{E}$ will try to rotate the ring is clockwise direction friction will oppose rotation and provide translational motion. So frictional force will act forward.



$$d\tau = (dq) \times \left(E_0\right) 2R \,\mathrm{Sin}\,\theta$$

$$d\tau = (\lambda R d\theta) 2RE_0 \,\mathrm{Sin}\,\theta$$

$$\tau = 2R^2 \lambda E_0 \int_0^{\frac{\pi}{2}} \mathrm{Sin}\,\theta d\theta = 2R^2 \lambda E_0 \;.... \;(1)$$

For translational motion

$$f = m\,a \Rightarrow a = \frac{f}{m} ....(2)$$

For rotational motion

$$\tau - fR = \left(mR^2\right)\left(\frac{a}{R}\right) ....(3)$$

From (2) and (3)

T = 2f_r R …. (4)

From (1) and (4)

$$fr = \frac{\tau}{2R} = \frac{2R^2\lambda E_0}{2R} = R\lambda E_0 \Rightarrow f^{\to} r$$

$$= R\lambda E_0\,\hat{i}$$

7. The particle should be projected such that it can reach half way because after midpoint it will move under the attraction of 2nd ring and will reach the centre of ring.

$$PE_i + KE_i = KE_f + PE_f$$

$$\frac{-GMm}{R} - \frac{GMm}{\sqrt{5}R} = \frac{1}{2}mv^2 = -\frac{GMm}{\sqrt{2}R} \times 2$$

$$V = \sqrt{\frac{2GM}{R}\left[1 + \frac{1}{\sqrt{5}} - \sqrt{2}\right]}$$

8. Here Y1 and d Y2 are young's module of the material of the rods and α_1 and α_2 are the co-efficient of thermal expansion. Using $Y = \frac{Stress}{Strain}$, $T = YA\alpha t$, where t is the temperature.

Tension must be the same in both the rods for their junction to be in equilibrium

$$\therefore Y_1 A \alpha_1 t = Y_2 A \alpha_2 t$$

9. ***A*** is free to move ; therefore, heat will be supplied at constant pressure.

$$\Delta Q_A = nC_{p_A}\Delta T_A \quad \ldots.\ (1)$$

B is held fixed, therefore, heat will be supplied at constant volume.

$$\Delta Q_B = nC_{vB}\Delta T_B$$

$$But\ \Delta Q_A = \Delta Q_B$$

$$nC_{P_A}\Delta T_A = nC_{n_B}\Delta T_B$$

$$\Delta T_B = \left(\frac{c_p}{c_v}\right)\Delta\ T_A$$

$$= \delta\left(\Delta T_A\right)(r = 1.4 diamatic)$$

$$(\Delta T_A = 30K)$$

$$= (1.4)(30K)$$

$$\Delta T_{\mathbf{B}} = 42K$$

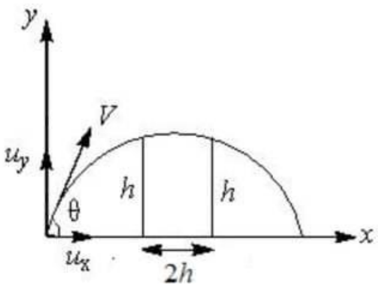
10. Force on SR and PQ are equal but opposite so their net will be zero.

Force between two parallel conductors carrying currents $I_1 and\ I_2$

$$F = \frac{\mu o}{2\pi}\,\frac{I_1 I_2 l}{r}$$

$$Fnet = F_{PS} - FQR$$

11. Let ***t*** be the time interval. Then,



$$2h = \left(u_{\chi}\right)(t)$$

or

$$ux = \frac{2h}{t}$$

$$Further, h = u_y t - \frac{1}{2} g t^2$$

$$or \; g t^2 - 2u_y t + 2h = 0$$

$$t_1 = \frac{2u_y + \sqrt{4u^2{}_y} - 8gh}{2g}$$

and

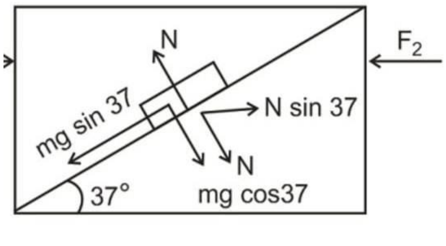
$$t_2 = \frac{2u_y - \sqrt{4u^2{}_y} - 8gh}{2g}$$

$$t = t_1 - t_2 = \frac{\sqrt{4u^2{}_y} - 8gh}{g}$$

$$or \; u^2{}_y = g^2 \frac{(t)^2}{4} + 2gh \; ....(ii)$$

12. There is a trolley for which $F_1 + N \sin 37^0 = F_2$

$\underset{\rightarrow}{F_1}$



$$F_1 - F_2 = [-N \, \text{Sin}\, 37^0]....(1)$$

$$N = [mg \cos 37^0]....(2)$$

13.

$$N_P = 4N_O\left(\frac{1}{2}\right)^{\frac{t}{1}} \; and \; N_Q = N_O\left(\frac{1}{2}\right)^{\frac{t}{2}}$$

$$AS \;\; N_P = N_Q$$

$$4No\left(\frac{1}{2}\right)^{\frac{t}{1}} = No\left(\frac{1}{2}\right)^{\frac{t}{2}}$$

$$\frac{4}{2^{\frac{t}{1}}} = \frac{1}{2^{\frac{t}{2}}} \; or \; 4 = \frac{2^t}{2^{\frac{t}{2}}}$$

$$or \; 4 = 2^{\frac{t}{2}} \; or \; 2^2 = 2^{\frac{t}{2}}$$

$$or \; \frac{t}{2} = 2 \; or \; t = 4\min$$

$$after \; 4 \min utes \; both \, P \; and \; Q \; have \, an \; equal \, number \; of \; nuclei.$$

$$\therefore Number \, of \; nuclei \, of \; R$$

$$= \left(4No - \frac{No}{4}\right) + \left(No - \frac{No}{4}\right)$$

$$= \frac{15No}{4} + \frac{3No}{4} = \frac{9No}{2}$$