PHYSICS

DPP

DAILY PRACTICE PROBLEMS

DPP No. 54

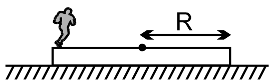
Total Marks : 27

Max. Time : 29 min.

Topics : Center of Mass, Circular Motion

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.2	(3 marks, 3 min.)	[6, 6]
Multiple choice objective ('–1' negative marking) Q.3	(4 marks, 4 min.)	[4, 4]
Subjective Questions ('–1' negative marking) Q.4 to Q.5	(4 marks, 5 min.)	[8, 10]
Comprehension ('–1' negative marking) Q.6 to Q.8	(3 marks, 3 min.)	[9, 9]

1. A uniform disc of mass 'm' and radius R is placed on a smooth horizontal floor such that the plane surface of the disc is in contact with the floor. A man of mass m/2 stands on the disc at its periphery. The man starts walking along the periphery of the disc. The size of the man is negligible as compared to the size of the disc. Then the centre of disc.



(A) moves along a circle of radius $\frac{R}{3}$ (B) moves along a circle of radius $\frac{2R}{3}$

(C) moves along a circle of radius $\frac{R}{2}$ (D) does not move along a circle

2. For a two-body system in absence of external forces, the kinetic energy as measured from ground frame is K_o and from center of mass frame is K_{cm}. Pick up the wrong statement

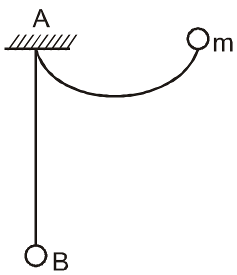
(A) The kinetic energy as measured from center of mass frame is least

(B) Only the portion of energy K_{cm} can be transformed from one form to another due to internal changes in the system.

(C) The system always retains at least $K_o - K_{cm}$ amount of kinetic energy as measured from ground frame irrespective of any kind of internal changes in the system.

(D) The system always retains at least K_{cm} amount of kinetic energy as measured from ground frame irrespective of any kind of internal changes in the system

3. A ball of mass m = 200 gm is suspended from a point A by an inextensible string of length L. Ball is drawn to a side and held at same level as A but at a distance $\frac{\sqrt{3}}{2}L$ from A as shown. Now the ball is released. Then : (assume string applies only that much jerk which is required so that velocity along string becomes zero).



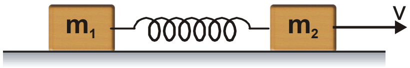
(A) speed of ball just before experiencing jerk is $\sqrt{gL}$

(B) speed of ball just after experiencing jerk is $\frac{\sqrt{3gL}}{2}$

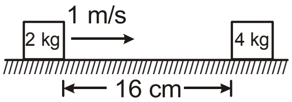
(C) Impulse applied by string $\frac{\sqrt{gL}}{10}$

(D) ball will experience jerk after reaching to point B.

4. Two blocks of mass m_1 and m_2 are connected with an ideal spring on a smooth horizontal surface as shown in figure. At t = 0 m_1 is at rest and m_2 is moving with a velocity v towards right. At this time spring is in its natural length. Prove that if $m_1 < m_2$ block of mass m_2 will never come to rest.

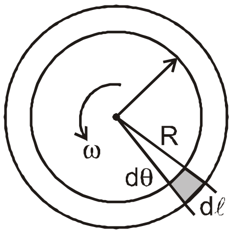


5. The friction coefficient between the horizontal surface and each of the blocks shown in figure is 0.20. The collision between the blocks is perfectly elastic. Find the separation between the two blocks (in cm) when they come to rest. Take g = 10 m/s².



COMPREHENSION

A ring of radius R is made of a thin wire of material of density ρ having cross section area a. The ring rotates with angular velocity ω about an axis passing through its centre and perpendicular to the plane. If we consider a small element of the ring, it rotates in a circle. The required centripetal force is provided by the component of tensions on the element towards the centre. A small element of length $d\ell$ of angular width $d\theta$ is shown in the figure.



6. The centripetal force acting on the element is

(A) $(a.\rho\, d\ell\, \omega^2 R)$ (B) $R^2 d\theta.\omega^2$ (C) $\frac{1}{2} a\rho\, d\ell\, \omega^2 R$ (D) zero

7. If T is the tension in the ring, then

(A) $T = \frac{a\rho R^2\omega^2}{2}$ (B) $T = a\,\rho\, R^2\omega^2$ (C) $a^2\,\rho\,\omega^2$ (D) $T = 2\,a\,\rho\, R^2\omega^2$

8. If for a given mass of the ring and angular velocity, the radius R of the ring is increased to 2R, the new tension will be
(A) T/2 (B) T (C) 2T (D) 4T

Answers Key

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1. (A) 2. (D) 3. (A), (B), (C)
4. Kinetic energy of m_1 > initial mechanical energy of system
5. 5 cm 6. (A) 7. (B) 8. (C)

Hint & Solutions

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1. The centre of mass of man + disc shall always remain at rest. Since the man is always at periphery of disc, the centre of disc shall always be at distance R/3 from centre of mass of two body system. Hence centre of disc moves in circle of radius R/3.

2. It can be shown that

$K_0 = K_{cm} + \frac{1}{2}MV_{cm}^2$ where M is the total mass of the system and V_{cm} is velocity of centre of mass with respect to ground.

Due to internal changes K_{cm} can change but V_{cm} will remain same. Hence only K_{CM} portion of kinetic energy can be transformed to some other form of energy. Thus D is the wrong statement.

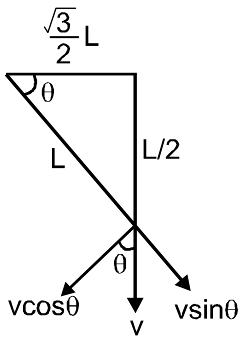
3. By conservation of energy

$$\frac{1}{2}mv^2 = mg\frac{L}{2}$$

$$v = \sqrt{gL}$$

After jerk vsinθ becomes zero

Impulse applied by string = mv sin θ



$$= 0.2\sqrt{gL}\ \frac{1}{2} = \frac{\sqrt{gL}}{10}$$

velocity of ball after jerk

$$v\cos\theta = \sqrt{gL}\ \frac{\sqrt{3}}{2} = \frac{\sqrt{3gL}}{2}.$$

4. If velocity of m_2 is zero then by momentum conservation

$m_1 v' = m_2 v$

$$v' = \frac{m_2 v}{m_1}$$

Now kinetic energy of m_1

$$= \frac{1}{2} m^1 v'^2 = \frac{1}{2} m_1 \left(\frac{m_2}{m_1}\right)^2 v^2$$

$$= \frac{1}{2}\left(\frac{m_2}{m_1}\right) m_2 v^2 = \left(\frac{m_2}{m_1}\right)\frac{1}{2} m_2 v^2 = \frac{m_2}{m_1}$$

× initial Kinetic energy

Kinetic energy of m_1 > initial mechanical energy of system

Hence proved

5. $a = \mu g = (.2)(10) = 2\ m/s^2$.

$$v^2 = 1^2 - 2(2)\left(\frac{16}{100}\right) = 1 - \frac{16}{25} = \frac{9}{25}$$

$\therefore v = 3/5\ m/s$

cons. of linear momentum $\Rightarrow 2(3/5) = 2(v_1) + 4 v_2$

$\therefore v_1 + 2v_2 = 3/5$ .... (1)

$e = 1 \Rightarrow 3/5 = v_2 - v_1$ .... (2)

(1) and (2) $\Rightarrow 3v_2 = 6/5$

$\Rightarrow v_2 = 2/5\ m/s.$

and $v_1 = v_2 - 3/5 = \frac{2}{5} - \frac{3}{5} = -\frac{1}{5}\ m/s$

x_2 = Distance covered by 4 kg block = $\frac{(2/5)^2}{2(2)}$

$= \frac{4}{100}\ m = 4\ cm$

x_1 = Distance covered by 2 kg block in left direction = $\frac{1}{100}\ m = 1\ cm.$

Hence $X = x_1 + x_2 = 5\ cm.$

6. to 8 As the small element ($dm = a.\rho.d\ell$) is rotating in the circle, centripetal force

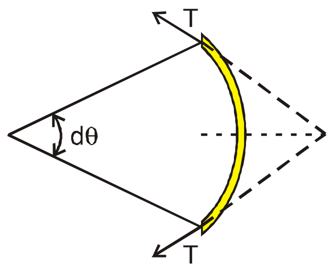
$F_C = dm\omega^2 R = a\rho d\ell.\omega^2 R$

7. $2T \sin\frac{d\theta}{2} = F_c = a\rho\, d\ell\, \omega^2 R$

As $d\theta$ is small $\sin\frac{d\theta}{2} = \frac{d\theta}{2}$

$2T.\frac{d\theta}{2} = a\rho\,(Rd\theta)\,\omega^2 R$

$\Rightarrow\ T = a\rho R^2 \omega^2$



8. $T = a\rho R^2\omega^2 = \frac{m}{2\pi}R\omega^2 \propto R$

Radius is doubled, tension is doubled. (2 T)

$T = a\rho R^2\omega^2 = \frac{m}{2\pi}R\omega^2 \propto R$