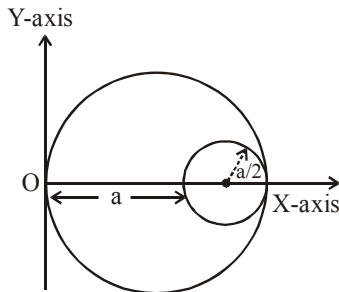


**COM & COLLISION**

1. A ball with a speed of 9 m/s collides with another identical ball at rest. After the collision, the direction of each ball makes an angle of 30° with the original direction. The ratio of velocities of the balls after collision is  $x : y$ , where  $x$  is \_\_\_\_\_.
2. A circular hole of radius  $\left(\frac{a}{2}\right)$  is cut out of a circular disc of radius 'a' as shown in figure. The centroid of the remaining circular portion with respect to point 'O' will be :



- (1)  $\frac{1}{6}a$       (2)  $\frac{10}{11}a$       (3)  $\frac{5}{6}a$       (4)  $\frac{2}{3}a$

3. Two solids A and B of mass 1 kg and 2 kg respectively are moving with equal linear momentum. The ratio of their kinetic energies  $(K.E.)_A : (K.E.)_B$  will be  $\frac{A}{1}$ , so the value of A will be \_\_\_\_.
4. Two particles having masses 4 g and 16 g respectively are moving with equal kinetic energies. The ratio of the magnitudes of their linear momentum is  $n : 2$ . The value of  $n$  will be \_\_\_\_\_.

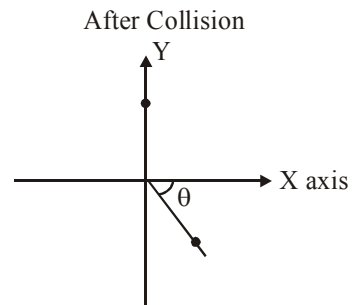
5. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

**Assertion A :** Body 'P' having mass  $M$  moving with speed 'u' has head-on collision elastically with another body 'Q' having mass 'm' initially at rest. If  $m \ll M$ , body 'Q' will have a maximum speed equal to '2u' after collision.

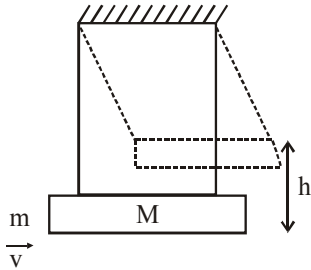
**Reason R :** During elastic collision, the momentum and kinetic energy are both conserved.

In the light of the above statements, choose the most appropriate answer from the options given below :

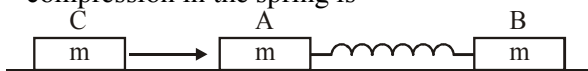
- (1) A is not correct but R is correct.
  - (2) Both A and R are correct but R is NOT the correct explanation of A.
  - (3) Both A and R are correct and R is the correct explanation of A.
  - (4) A is correct but R is not correct.
6. A ball of mass 10 kg moving with a velocity  $10\sqrt{3} \text{ ms}^{-1}$  along X-axis, hits another ball of mass 20 kg which is at rest. After collision, the first ball comes to rest and the second one disintegrates into two equal pieces. One of the pieces starts moving along Y-axis at a speed of 10 m/s. The second piece starts moving at a speed of 20 m/s at an angle  $\theta$  (degree) with respect to the X-axis. The configuration of pieces after collision is shown in the figure. The value of  $\theta$  to the nearest integer is \_\_\_\_\_.



7. A large block of wood of mass  $M = 5.99 \text{ kg}$  is hanging from two long massless cords. A bullet of mass  $m = 10 \text{ g}$  is fired into the block and gets embedded in it. The (block + bullet) then swing upwards, their centre of mass rising a vertical distance  $h = 9.8 \text{ cm}$  before the (block + bullet) pendulum comes momentarily to rest at the end of its arc. The speed of the bullet just before collision is : (Take  $g = 9.8 \text{ ms}^{-2}$ )

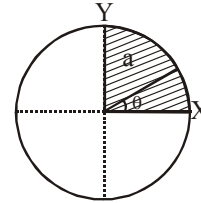


- (1) 841.4 m/s                      (2) 811.4 m/s  
 (3) 831.4 m/s                      (4) 821.4 m/s
8. A rubber ball is released from a height of 5 m above the floor. It bounces back repeatedly, always rising to  $\frac{81}{100}$  of the height through which it falls. Find the average speed of the ball. (Take  $g = 10 \text{ ms}^{-2}$ )
- (1)  $3.0 \text{ ms}^{-1}$                       (2)  $3.50 \text{ ms}^{-1}$   
 (3)  $2.0 \text{ ms}^{-1}$                       (4)  $2.50 \text{ ms}^{-1}$
9. Two identical blocks A and B each of mass  $m$  resting on the smooth horizontal floor are connected by a light spring of natural length  $L$  and spring constant  $K$ . A third block C of mass  $m$  moving with a speed  $v$  along the line joining A and B collides with A. The maximum compression in the spring is

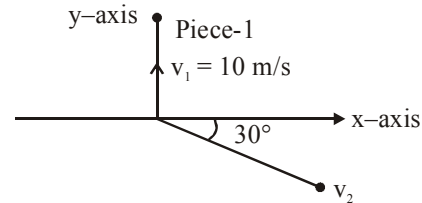


- (1)  $v\sqrt{\frac{M}{2K}}$                       (2)  $\sqrt{\frac{mv}{2K}}$   
 (3)  $\sqrt{\frac{mv}{K}}$                       (4)  $\sqrt{\frac{m}{2K}}$

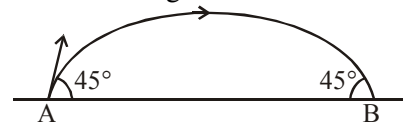
10. The disc of mass  $M$  with uniform surface mass density  $\sigma$  is shown in the figure. The centre of mass of the quarter disc (the shaded area) is at the position  $\frac{x}{3\pi}, \frac{x}{3\pi}$  where  $x$  is \_\_\_\_\_. (Round off to the Nearest Integer) [a is an area as shown in the figure]



11. A ball of mass 10 kg moving with a velocity  $10\sqrt{3} \text{ m/s}$  along the x-axis, hits another ball of mass 20 kg which is at rest. After the collision, first ball comes to rest while the second ball disintegrates into two equal pieces. One piece starts moving along y-axis with a speed of 10 m/s. The second piece starts moving at an angle of  $30^\circ$  with respect to the x-axis. The velocity of the ball moving at  $30^\circ$  with x-axis is  $x \text{ m/s}$ . The configuration of pieces after collision is shown in the figure below. The value of  $x$  to the nearest integer is \_\_\_\_\_.



12. An object of mass  $m_1$  collides with another object of mass  $m_2$ , which is at rest. After the collision the objects move with equal speeds in opposite direction. The ratio of the masses  $m_2 : m_1$  is :
- (1) 3 : 1    (2) 2 : 1    (3) 1 : 2    (4) 1 : 1
13. The projectile motion of a particle of mass 5 g is shown in the figure.

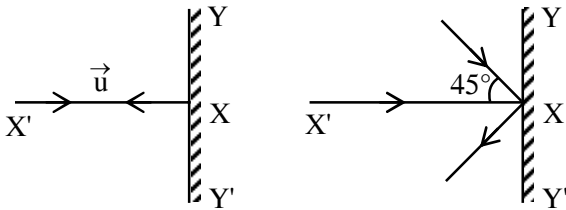


The initial velocity of the particle is  $5\sqrt{2} \text{ ms}^{-1}$  and the air resistance is assumed to be negligible. The magnitude of the change in momentum between the points A and B is  $x \times 10^{-2} \text{ kgms}^{-1}$ . The value of  $x$ , to the nearest integer, is \_\_\_\_\_.

14. A bullet of '4g' mass is fired from a gun of mass 4 kg. If the bullet moves with the muzzle speed of  $50 \text{ ms}^{-1}$ , the impulse imparted to the gun and velocity of recoil of gun are :
- (1)  $0.4 \text{ kg ms}^{-1}$ ,  $0.1 \text{ ms}^{-1}$
  - (2)  $0.2 \text{ kg ms}^{-1}$ ,  $0.05 \text{ ms}^{-1}$
  - (3)  $0.2 \text{ kg ms}^{-1}$ ,  $0.1 \text{ ms}^{-1}$
  - (4)  $0.4 \text{ kg ms}^{-1}$ ,  $0.05 \text{ ms}^{-1}$
15. The position of the centre of mass of a uniform semi-circular wire of radius 'R' placed in x-y plane with its centre at the origin and the line joining its ends as x-axis is given by  $\left(0, \frac{xR}{\pi}\right)$ .

Then, the value of |x| is \_\_\_\_\_.

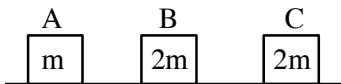
16. Two billiard balls of equal mass 30 g strike a rigid wall with same speed of 108 kmph (as shown) but at different angles. If the balls get reflected with the same speed then the ratio of the magnitude of impulses imparted to ball 'a' and ball 'b' by the wall along 'X' direction is :



ball (a)

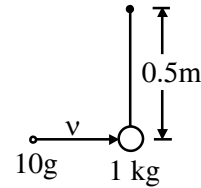
ball (b)

- (1) 1 : 1
  - (2)  $\sqrt{2} : 1$
  - (3) 2 : 1
  - (4)  $1 : \sqrt{2}$
17. A body of mass 2 kg moving with a speed of 4 m/s. makes an elastic collision with another body at rest and continues to move in the original direction but with one fourth of its initial speed. The speed of the two body centre of mass is  $\frac{x}{10} \text{ m/s}$ . Then the value of x is \_\_\_\_\_.
18. Three objects A, B and C are kept in a straight line on a frictionless horizontal surface. The masses of A, B and C are m, 2 m and 2 m respectively. A moves towards B with a speed of 9 m/s and makes an elastic collision with it. Thereafter B makes a completely inelastic collision with C. All motions occur along same straight line. The final speed of C is :

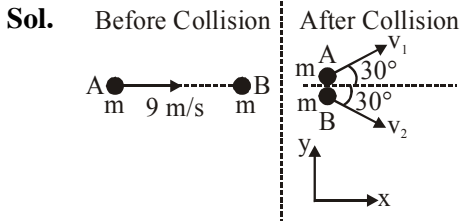


- (1) 6 m/s
- (2) 9 m/s
- (3) 4 m/s
- (4) 3 m/s

19. The initial mass of a rocket is 1000 kg. Calculate at what rate the fuel should be burnt so that the rocket is given an acceleration of  $20 \text{ ms}^{-2}$ . The gases come out at a relative speed of  $500 \text{ ms}^{-1}$  with respect to the rocket : [Use  $g = 10 \text{ m/s}^2$ ]
- (1)  $6.0 \times 10^2 \text{ kg s}^{-1}$
  - (2)  $500 \text{ kg s}^{-1}$
  - (3)  $10 \text{ kg s}^{-1}$
  - (4)  $60 \text{ kg s}^{-1}$
20. A bullet of 10 g, moving with velocity v, collides head-on with the stationary bob of a pendulum and recoils with velocity 100 m/s. The length of the pendulum is 0.5 m and mass of the bob is 1 kg. The minimum value of v = \_\_\_\_\_ m/s so that the pendulum describes a circle. (Assume the string to be inextensible and  $g = 10 \text{ m/s}^2$ )



21. A body of mass M moving at speed  $V_0$  collides elastically with a mass 'm' at rest. After the collision, the two masses move at angles  $\theta_1$  and  $\theta_2$  with respect to the initial direction of motion of the body of mass M. The largest possible value of the ratio M/m, for which the angles  $\theta_1$  and  $\theta_2$  will be equal, is :
- (1) 4
  - (2) 1
  - (3) 3
  - (4) 2
22. A block moving horizontally on a smooth surface with a speed of  $40 \text{ ms}^{-1}$  splits into two equal parts. If one of the parts moves at  $60 \text{ ms}^{-1}$  in the same direction, then the fractional change in the kinetic energy will be x : 4 where x = \_\_\_\_\_.
23. A block moving horizontally on a smooth surface with a speed of 40 m/s splits into two parts with masses in the ratio of 1:2. If the smaller part moves at 60 m/s in the same direction, then the fractional change in kinetic energy is :-
- (1)  $\frac{1}{3}$
  - (2)  $\frac{2}{3}$
  - (3)  $\frac{1}{8}$
  - (4)  $\frac{1}{4}$
24. A block moving horizontally on a smooth surface with a speed of 40 m/s splits into two parts with masses in the ratio of 1:2. If the smaller part moves at 60 m/s in the same direction, then the fractional change in kinetic energy is :-
- (1)  $\frac{1}{3}$
  - (2)  $\frac{2}{3}$
  - (3)  $\frac{1}{8}$
  - (4)  $\frac{1}{4}$

**SOLUTION****1. Official Ans. by NTA (1)**

From conservation of momentum along y-axis.

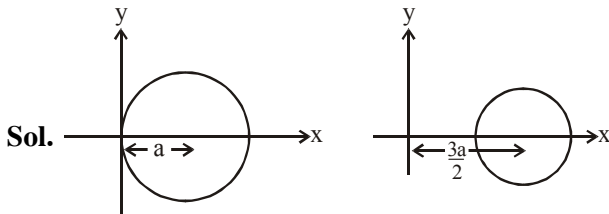
$$\vec{P}_{iy} = \vec{P}_{fy}$$

$$0 + 0 = mv_1 \sin 30^\circ \hat{j} + mv_2 \sin 30^\circ (-\hat{j})$$

$$mv_2 \sin 30^\circ = mv_1 \sin 30^\circ$$

$$v_2 = v_1 \text{ or } \frac{v_1}{v_2} = 1$$

Ans. 1

**2. Official Ans. by NTA (3)**

Let  $\sigma$  be the uniform mass density of disc then

$$x_{\text{COM}} = \frac{(\sigma\pi a^2)a - \sigma\pi\left(\frac{a^2}{4}\right) \times \frac{3a}{2}}{\sigma\pi a^2 - \frac{\sigma\pi a^2}{4}}$$

$$= \frac{a - \frac{3a}{8}}{1 - \frac{1}{4}} = \frac{5a}{6}$$

Option (2) is correct.

**3. Official Ans. by NTA (2)**

**Sol.** Kinetic energy  $K = \frac{P^2}{2m}$ , ( $P_A = P_B$ )

$$K \propto \frac{1}{m}$$

$$\frac{K_A}{K_B} = \frac{m_B}{m_A} = \frac{2}{1}$$

Ans. (2)

**4. Official Ans. by NTA (1)**

**Sol.**  $\frac{p_1^2}{2 \times 4} = \frac{p_2^2}{2 \times 16}$

$$\frac{p_1}{p_2} = \frac{1}{2}$$

**5. Official Ans. by NTA (3)**

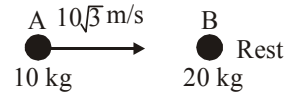
**Sol.** For  $e = 1$  & second body at rest

$$V_2 = \frac{2m_1 u_1}{m_1 + m_2} = \frac{2u(M)}{M + m} \approx 2u$$

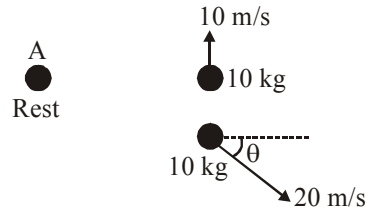
Since  $M \gg m$

**6. Official Ans. by NTA (30)**

**Sol. Before Collision**



**After Collision**



From conservation of momentum along x axis;

$$\vec{P}_i = \vec{P}_f$$

$$10 \times 10\sqrt{3} = 200 \cos \theta$$

$$\cos \theta = \frac{\sqrt{3}}{2}, \theta = 30^\circ$$

**7. Official Ans. by NTA (3)**

**Sol.** From energy conservation,

[after bullet gets embedded till the system comes momentarily at rest]

$$(M + m)gh = \frac{1}{2}(M + m)v_1^2$$

[ $v_1$  is velocity after collision]

$$\therefore v_1 = \sqrt{2gh}$$

Applying momentum conservation, (just before and just after collision)

$$mv = (M + m)v_1$$

$$v = \left(\frac{M + m}{m}\right)v_1 = \frac{6}{10 \times 10^{-3}} \times \sqrt{2 \times 9.8 \times 9.8 \times 10^{-2}} \approx 831.55 \text{ m/s}$$

**8. Official Ans. by NTA (4)**

**Sol.** (4)  $v_0 = \sqrt{2gh}$

$$v = e\sqrt{2gh} = \sqrt{2gh} \Rightarrow e = 0.9$$

$$S = h + 2e^2h + 2e^4h + \dots$$

$$t = \sqrt{\frac{2h}{g}} + 2e\sqrt{\frac{2h}{g}} + 2e^2\sqrt{\frac{2h}{g}} + \dots$$

$$v_{\text{av}} = \frac{S}{t} = 2.5 \text{ m/s}$$

**9. Official Ans. by NTA (1)**

**Sol.** (1) C comes to rest

$$V_{\text{cm}} \text{ of A \& B} = \frac{v}{2}$$

$$\Rightarrow \frac{1}{2} \text{ is } v_{\text{ret}}^2 = \frac{1}{2}kx^2$$

$$x = \sqrt{\frac{\mu \times v^2}{k}} = \sqrt{\frac{m}{2k}}v$$

10. Official Ans. by NTA (4)

Sol. C.O.M of quarter disc is at  $\frac{4a}{3\pi}, \frac{4a}{3\pi} = 4$

11. Official Ans. by NTA (20)

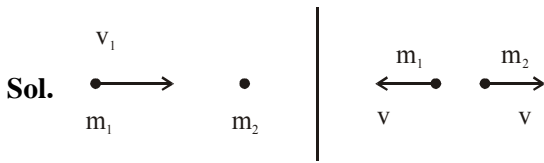
Sol. Let velocity of 2<sup>nd</sup> fragment is  $\vec{v}$  then by conservation of linear momentum

$$10(10\sqrt{3})\hat{i} = (10)(10\hat{j}) + 10\vec{v}$$

$$\Rightarrow \vec{v} = 10\sqrt{3}\hat{i} - 10\hat{j}$$

$$|\vec{v}| = \sqrt{300 + 100} = \sqrt{400} = 20\text{m/s}$$

12. Official Ans. by NTA (1)



$$m_1 v_1 = -m_1 v + m_2 v$$

$$v_1 = -v + \frac{m_2}{m_1} v$$

$$\frac{(v_1 + v)}{v} = \frac{m_2}{m_1}$$

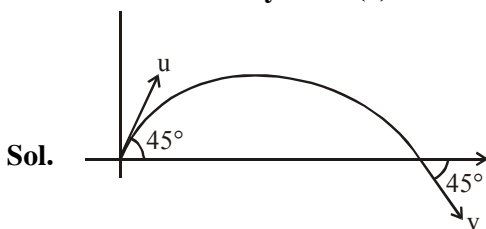
$$e = \frac{2v}{v_1} = 1$$

$$v = \frac{v_1}{2}$$

$$\frac{v_1 + v_1/2}{v_1/2} = \frac{m_2}{m_1}$$

$$3 = \frac{m_2}{m_1}$$

13. Official Ans. by NTA (5)



Sol.

$$|\vec{u}| = |\vec{v}| \quad \dots (1)$$

$$\vec{u} = u \cos 45^\circ \hat{i} + u \sin 45^\circ \hat{j} \quad \dots (2)$$

$$\vec{v} = v \cos 45^\circ \hat{i} - v \sin 45^\circ \hat{j} \quad \dots (3)$$

$$|\Delta \vec{P}| = |m(\vec{v} - \vec{u})| \quad \dots (4)$$

$$\Delta P = 2mu \sin 45^\circ$$

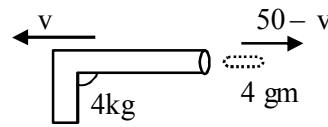
$$= 2 \times 5 \times 10^{-3} \times 5\sqrt{2} \times \frac{1}{\sqrt{2}}$$

$$= 50 \times 10^{-3}$$

$$= 5 \times 10^{-2}$$

14. Official Ans. by NTA (2)

Sol.



By momentum conservation

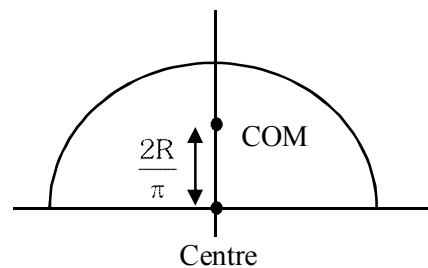
$$4 \times 10^{-3} (50 - v) - 4v = 0$$

$$v = \frac{4 \times 10^{-3} \times 50}{4 + 4 \times 10^{-3}} \approx 0.05 \text{ms}^{-1}$$

$$\text{Impulse } J = mv = 4 \times .05 = 0.2 \text{ kgms}^{-1}$$

15. Official Ans. by NTA (2)

Sol. COM of semi-circular ring is at  $\frac{2R}{\pi}$



Distance from centre  $\Rightarrow x = 2$

16. Official Ans. by NTA (2)

Sol. Impulse = change in momentum

$$\text{Ball (a)} \quad |\Delta p| = 2mu = J_1$$

$$\text{Ball (b)} \quad |\Delta p| = 2mu \cos 45^\circ = J_2$$

$$\frac{J_1}{J_2} = \frac{1}{\cos 45^\circ} = \sqrt{2}$$

17. Official Ans. by NTA (25)

Sol.

$$p_i = p_f$$

$$2 \times 4 = 2 \times 1 + m_2 \times v_2$$

$$m_2 v_2 = 6 \quad \dots (i)$$

by coefficient of restitution

$$1 = \frac{v_2 - 1}{4} \Rightarrow v_2 = 5 \text{ m/s}$$

by (i)

$$m_2 \times 5 = 6$$

$$m_2 = 1.2 \text{ kg}$$

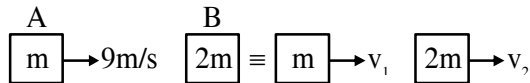
$$v_{cm} = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$$

$$v_{cm} = \frac{2 \times 1 + 1.2 \times 5}{2 + 1.2} = \frac{8}{3.2} = \frac{25}{10}$$

$$x = 25$$

## 18. Official Ans. by NTA (4)

Sol. Collision between A and B

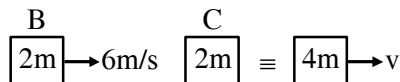


$$m \times 9 = mv_1 + 2m v_2 \text{ (from momentum conservation)}$$

$$e = 1 = \frac{v_2 - v_1}{9}$$

$$\Rightarrow v_2 = 6 \text{ m/sec.}, v_1 = -3 \text{ m/sec.}$$

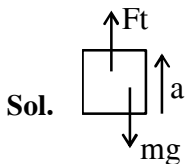
collision between B and C



$$2m \times 6 = 4mv \text{ (from momentum conservation)}$$

$$v = 3 \text{ m/s}$$

## 19. Official Ans. by NTA (4)



Sol.

$$F_{\text{thrust}} = \left( \frac{dm}{dt} \cdot V_{\text{rel}} \right)$$

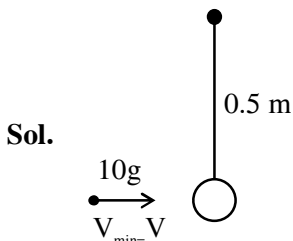
$$\left( \frac{dm}{dt} V_{\text{rel}} - mg \right) = ma$$

$$\Rightarrow \left( \frac{dm}{dt} \right) \times 500 - 10^3 \times 10 = 10^3 \times 20$$

$$\frac{dm}{dt} = (60 \text{ kg/s})$$

Option (4)

## 20. Official Ans. by NTA (400)



Sol.

$$V' = \sqrt{5gR} = \sqrt{5 \times 10 \times 0.5}$$

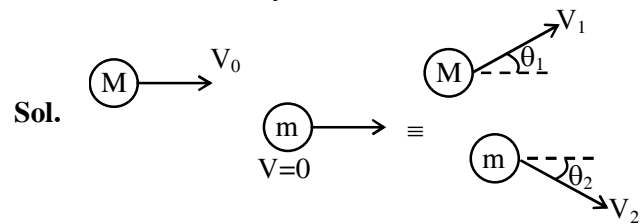
$$V' = 5 \text{ m/s}$$

$$m_1 V = m_2 \times 5 - m_1 \times 100$$

$$\frac{10}{1000} \times V = 5 - \frac{10}{1000} \times 100$$

$$V = 400 \text{ m/s}$$

## 21. Official Ans. by NTA (3)



Sol.

$$\text{given } \theta_1 = \theta_2 = \theta$$

from momentum conservation

$$\text{in x-direction } MV_0 = MV_1 \cos \theta + mV_2 \cos \theta$$

$$\text{in y-direction } 0 = MV_1 \sin \theta - mV_2 \sin \theta$$

Solving above equations

$$V_2 = \frac{MV_1}{m}, V_0 = 2V_1 \cos \theta$$

From energy conservation

$$\frac{1}{2} MV_0^2 = \frac{1}{2} MV_1^2 + \frac{1}{2} mV_2^2$$

Substituting value of  $V_2$  &  $V_0$ , we will get

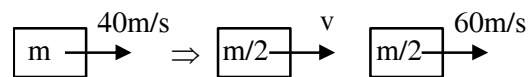
$$\frac{M}{m} + 1 = 4 \cos^2 \theta \leq 4$$

$$\frac{M}{m} \leq 3$$

Option (3)

## 22. Official Ans. by NTA (1)

Sol.



$$P_i = P_f$$

$$m \times 40 = \frac{m}{2} \times v + \frac{m}{2} \times 60$$

$$40 = \frac{v}{2} + 30 \Rightarrow v = 20$$

$$(K.E.)_i = \frac{1}{2} m \times (40)^2 = 800m$$

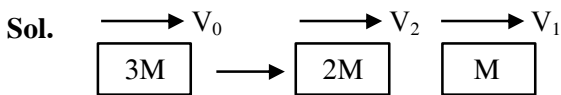
$$(K.E.)_f = \frac{1}{2} \frac{m}{2} \cdot (20)^2 + \frac{1}{2} \cdot \frac{m}{2} \cdot (60)^2 = 1000m$$

$$|\Delta K.E.| = |1000m - 800m| = 200m$$

$$\frac{\Delta K.E.}{(K.E.)_i} = \frac{200m}{800m} = \frac{1}{4} = \frac{x}{4}$$

$$x = 1$$

23. Official Ans. by NTA (3)



$$3MV_0 = 2MV_2 + MV_1$$

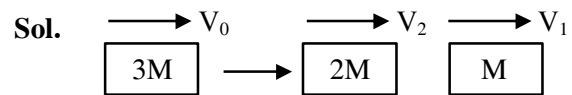
$$3V_0 = 2V_2 + V_1$$

$$120 = 2V_2 + 60 \Rightarrow V_2 = 30 \text{ m/s}$$

$$\frac{\Delta \text{K.E.}}{\text{K.E.}} = \frac{\frac{1}{2}MV_1^2 + \frac{1}{2}2MV_2^2 - \frac{1}{2}3MV_0^2}{\frac{1}{2}3MV_0^2}$$

$$= \frac{V_1^2 + 2V_2^2 - 3V_0^2}{3V_0^2} = \frac{3600 + 1800 - 4800}{4800} = \frac{1}{8}$$

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