COLLISIONS

2010

1. A ball falls from a height of 20m on the floor and rebounds to a height of 5m. Time of contact is 0.02s. Find the acceleration during impact.

a) $1200ms^{-2}$ b) $1000ms^{-2}$ c) $2000ms^{-2}$ d) $1500ms^{-2}$

2008

2. A shell of mass 200g is ejected from a gun of mass 4kg by an explosion that generates 1/05kJ of energy. The initial velocity of the shell is

a) $100ms^{-1}$ b) $80ms^{-1}$ c) $40ms^{-1}$ d) $120ms^{-1}$

3. For a system to follow the law of conservation of linear momentum during a collision, the condition is

1) total external force acting on the system is zero

2) total external force acting on the system is finite and time of collision is negligible.

3) total internal force acting on the system is zero

a) 1 only b) 2 only c) 3 only d) 1 or 2

4. Assertion A quick collision between two bodies is more violent than a slow collision, even when the initial and final velocities are identical

Reason : The momentum is greater in first case

a) Both assertion and reason are true and reason is the correct explanation of assertion

b) Both assertion and reason are true but reason is not the correct explanation of assertion

c) Assertion is true but reason is false d) Both assertion and reason are false

5. In the figure, pendulum bob on left side is pulled a side to a height h from its initial position. After it is released it collides with the right pendulum bob at rest, which is of same mass. After the collision the two bobs stick together and rise to a height

a) $\frac{3h}{4}$ b) $\frac{2h}{3}$ c) $\frac{h}{2}$ d) $\frac{h}{4}$

2007

6. A stationary particle explodes into two particles of masses m_1 and m_2 which move in opposite directions with velocities v_1 and v_2. The ratio of their kinetic energies E_1 / E_2 is

a) 1 b) m_1v_2 / m_2v_1 c) m_2 / m_1 d) m_1 / m_2

2004

7. A ball is dropped from a height of 20cm. Ball rebounds to a height of 10cm. What is the loss of energy?

a) 25% b) 75% c) 50% d) 100%

8. A 10kg ball moving with velocity $2ms^{-1}$ collides with a 20kg mass initially at rest. If both of them coalesce, the final velocity of combined mass is

a) $\frac{3}{4}ms^{-1}$ b) $\frac{1}{3}ms^{-1}$ c) $\frac{3}{2}ms^{-1}$ d) $\frac{2}{3}ms^{-1}$

2003

9. A neutron makes a head-on elastic collision with a stationary deuteron. The fractional energy loss of the neutron in the collision is

a) 16/81 b) 8/9 c) 8/27 d) 2/3

KEY

1) **d**	2) **a**	3) **a**	4) **a**	5) **d**	6) **c**	7) **c**
8) **d**	9) **b**					

HINTS

1. According to Newton's second law of motion, the force acting on a body is equal to the rate of change of momentum during impact

$$F = \frac{\Delta p}{\Delta t}$$

Also, $F = ma \Rightarrow ma = \frac{p_2 - p_1}{\Delta t}$

$$\Rightarrow a = \frac{mv_2 - (-mv_1)}{m\Delta t}$$

$$= \frac{v_2 + v_1}{\Delta t}$$

So, $a = \frac{\sqrt{2\times10\times20} + \sqrt{2\times10\times5}}{0.02}$

$$= \frac{20+10}{0.02} = 1500ms^{-2}$$

2. Conservation of momentum yields

$m_1v_1 + m_2v_2 = 0$

Or $4v_1 + 0.2v_2 = 0$ ……………. (i)

Conservation of energy yields

$$\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 = 1050$$

Or $\frac{1}{2}\times 4v_1^2 + \frac{1}{2}\times v_2^2 = 1050$

Or $2v_1^2 + 0.1v_2^2 = 1050$ …………….. (ii)

Solving eqs (i) and (ii), we have

$v_1 = 100ms^{-1}$

3. From Newton's second law

$$F = \frac{dp}{dt}$$

If F = 0, then $\frac{dp}{dt} = 0$

$\Rightarrow$ p = constant

Thus, if total external force acting on the system is zero, then linear momentum of the system remains conserved.

4. Momentum p = mv or $p \propto v$

Ie, momentum is directly proportional to its velocity, so the momentum is greater in a quicker collision between two bodies than in slower one. Hence due to greater momentum quicker collision between two bodies will be more violent even initial and final velocities are identical

5. When bob A strikes the bob B, then $mu = (m+m)v'$

$\Rightarrow v' = \frac{u}{2}$ …………….. (i)

The potential energy of A at height h converts into kinetic energy of this mass, at point O, ie.

$$mgh = \frac{1}{2}mu^2$$

Or $u = \sqrt{2gh}$

$$\therefore v' = \frac{\sqrt{2gh}}{2} = \sqrt{\frac{gh}{2}}$$

Let combined mass moves to a height h', then

$$2mgh' = \frac{1}{2}(2m)v'^2$$

Or $gh' = \frac{gh}{4}$ or $h' = \frac{h}{4}$

6. From conservation of linear momentum

$$p_{initial} = p_{final}$$

$$0 = m_1v_1 - m_2v_2$$

Or $m_1v_1 = m_2v_2$ ………………. (i)

Or $\frac{v_1}{v_2} = \frac{m_2}{m_1}$

Thus ratio of kinetic energies

$$\frac{E_1}{E_2} = \frac{\frac{1}{2}m_1v_1^2}{\frac{1}{2}m_2v_2^2} = \frac{m_1}{m_2} \times \left(\frac{m_2}{m_1}\right)^2 = \frac{m_2}{m_1}$$

7. Since ball is at a specific height it possess potential energy = mgh

Where m is mass, g is gravity and h is height

Initial energy of ball $= mgh_1$

Final energy of ball $= mgh_2$

Therefore, the loss in energy $= \frac{initial\,energy - final\,energy}{initial\,energy} \times 100$

$$= \frac{20mg - 10mg}{20mg} \times 100$$

= 50%

8. Using law of conservation of momentum

$$m_1u_1 + m_2u_2 = (m_1 + m_2)v$$

Here, $m_1 = 10kg$, $m_2 = 20kg$, $u_1 = 2ms^{-1}$, u = 0

$$\therefore 10 \times 2 + 0 = (10 + 20)v$$

Or $v = \frac{20}{30} = \frac{2}{3}ms^{-1}$

9. Let the two balls of mass m_1 and m_2 collide each other elastically with velocities u_1 and u_2. Their velocities become v_1 and v_2 after the collision.

Applying conservation of linear momentum, we get

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ ………………. (i)

Also from conservation of kinetic energy

$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$ …………….. (ii)

Solving eqs (i) and (ii) we get

$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2$ ………….. (iii)

And $v_2 = \left(\frac{m_2 - m_1}{m_1 + m_2}\right)u_2 + \left(\frac{2m_1}{m_1 + m_2}\right)u_1$ …………… (iv)

On taking approximate value the mass of deuteron is twice the mass of neutron

Given $u_1 = u$, $u_2 = 0$, $m_1 = m$, $m_2 = 2m$

Velocity of neutron $v_1 = \left(\frac{m - 2m}{m + 2m}\right)u = -\frac{u}{3}$

Velocity of deuteron $v_2 = \frac{2mu}{m + 2m} = \frac{2}{3}u$

Fractional energy loose $= \dfrac{\frac{1}{2}mu^2 - \frac{1}{2}m\left(-\frac{u}{3}\right)^2}{\frac{1}{2}mu^2}$

$= 1 - \frac{1}{9} = \frac{8}{9}$