COLLISIONS

PREVIOUS EAMCET QUESTIONS
ENGINEERING

1. A body of mass 5kg makes an elastic collision with another body at rest and continues to move in the original direction after collision with a velocity equal to 1/10th of its original velocity. Then the mass of the second body is : **(2009 E)**

1) 4.09 kg 2) 0.5 kg 3) 5 kg 4) 5.09 kg

Ans : 1

Sol: $v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2$

Given m_1 = 5kg, u_1 = u, u_2 = 0, $v_1 = \frac{u}{10}$, m_2 = ?

$$\therefore \frac{u}{10} = \left(\frac{5 - m_2}{5 + m_2}\right)u$$

$50 - 10m_2 = 5 + m_2$

$45 = 11m_2 \Rightarrow m_2 = 4.09$ kg

2. A particle of mass 4m explodes into three pieces of masses m, m and 2m. The equal masses move along X and Y-axes with velocities 4ms^{-1} and 6ms^{-1} respectively. The magnitude of the velocity of the heavier mass is : **(2009 E)**

1) $\sqrt{17}ms^{-1}$ 2) $2\sqrt{13}ms^{-1}$ 3) $\sqrt{13}ms^{-1}$ 4) $\frac{\sqrt{13}}{2}ms^{-1}$

Ans : 3

Sol: According to the law of conservation of linear momentum $\overline{p_1} + \overline{p_2} + \overline{p_3} = 0$

$$\therefore \left(\overline{p_1} + \overline{p_2}\right) = -\overline{p_3}$$

(i.e) the vector p_3 is opposite to the direction of the resultant of p_1 & p_2

$$\therefore p_3 = \sqrt{p_1^{\,2} + p_2^{\,2}}$$

$$\Rightarrow (2m)v = \sqrt{(4m)^2 + (6m)^2}$$

$$\therefore v = \sqrt{13}ms^{-1}$$

3. A ball is dropped from a height 'h' on a floor of coefficient of restitution 'e'. The total distance covered by the ball just before second hit is **(2008 E)**

1) h(1-2e^2) 2) h(1+2e^2) 3) h(1-e^2) 4) he^2

Ans : 3

Sol: From the def. of coefficient of restitution

$$e = \sqrt{\frac{h_1}{h}}$$

$$\Rightarrow e^2 = \frac{h_1}{h}$$

$$\Rightarrow h_1 = e^2 h$$

S = Total distance traveled before second impact = h +2h_1

$$\therefore S = h + 2e^2 h = h(1-e^2)$$

4. An object of mass 2m is projected with a speed of 100ms^{-1} at an angle $\theta = \sin^{-1}\left(\frac{3}{5}\right)$ to the horizontal. At the highest point, the object breaks into two pieces of same mass m and the first one comes to rest. The distance between the point of projection and the point of landing of the bigger piece (in metre) is : **(2007 E)**

1) 3840 2) 1280 3) 1440 4) 960

Ans: 3

Sol: Horizontal range of the object fired $R = \frac{u^2 \sin 2\theta}{g}$

At the highest point, when object is exploded into two equal masses then from law of conservation of momentum

$$2mu \cos\theta = m(0) + mv$$

$$V = 2u\cos\theta$$

Therefore, the horizontal velocity becomes double at the highest point, hence it covers double the distance during the remaining flight.

$$\therefore \text{ Total range } = \frac{R}{2} + R = \frac{3R}{2}$$

$$= \frac{3}{2}\left[\frac{u^2 \sin 2\theta}{g}\right]$$

$$= \frac{3}{2} \times \frac{(100)^2 \times 2 \times \frac{3}{5} \times \frac{4}{5}}{10}$$

$$= 1440$$

5. In two separate collisions, the coefficient of restitution e_1 and e_2 are in the ratio 3:1. In the first collision the relative velocity of approach is twice the is twice the relative velocity of separation, then and the ratio between relative velocity of approach to the relative velocity of separation in the second collision is : **(2007 E)**

1) 1:6 2) 2:3 3) 3:2 4) 6:1

Ans : 4

Sol: Given $\frac{e_1}{e_2} = \frac{3}{1}$ …………………….(1)

In the first collision u_1-u_2=2(v_2-v_1)

$$\therefore \frac{2(v_2 - v_1)}{u_1 - u_2} = 1$$

From the def. of coefficient of restitution = $\frac{\textit{relative velocity of separation}}{\textit{relative velocity of approach}}$

$e_1 = \frac{1}{2}$ ……………………….(2)

From equation (1) $e_2 = \frac{1}{6}$

But $e_2 = \frac{v_2 - v_1}{u_1 - u_2} \Rightarrow \frac{1}{6} = \frac{v_2 - v_1}{u_1 - u_2}$

$$\therefore \frac{u_1 - u_2}{v_2 - v_1} = 6$$

6. A man of 50 kg is standing at one end on a boat of length 25m and mass 200kg. If he starts running and when he reaches the other end, he has a velocity 2ms^{-1} with respect to the boat. The final velocity of the boat is (in ms^{-1}) **(2006 E)**

1) $\frac{2}{5}$ 2) $\frac{2}{3}$ 3) $\frac{8}{5}$ 4) $\frac{8}{3}$

Ans : 1

Sol: According to the law of conservation of momentum $mu_1 + Mu_2 = mv_1 + (M+m)v_2$ where m& M are the masses of the man and boat

v_1 and v_2 are the final velocities of man and boat

$\therefore\ 50 \times 0 + 200 \times 0 = 50 \times 2 + (200 + 50)v_2$

$$\therefore v_2 = -\frac{2}{5} ms^{-1}$$

7. For a system to follow the law of conservation of linear momentum during a collision, the condition is **(2006 E)**

(a) total external force acting on the system is zero

(b) total external force acting on the system is finite and time of collision is negligible

(c) total internal force acting on the system is zero

1) (a) only 2) (b) only 3) (c) only 4) (a) or (b)

Ans: 1

Sol: From newtons second law of motion

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

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

Therefore, if external force acting on the system is zero, then linear momentum of the system remains conserve.

8. Consider the following statements A and B and identify the correct answer:

A: In an elastic collision, if a body suffers a head on collision with another of same mass at rest, the first body comes to rest while the other starts moving with the velocity of the first one.

B: Two bodies of equal masses suffering a head-on elastic collision merely exchanges their velocities. **(2005 E)**

1. Both A and B are true
2. Both A and B are false
3. A is true but B is false
4. A is false but B is true

Ans. 1

Sol: We know that

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

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

A) If $u_2 = 0$ and $m_1 = m_2$

Then $v_1 = 0$

$$v_2 = \left(\frac{2m}{2m}\right)u_1 \Rightarrow v_2 = u_1$$

B) If $m_1 = m_2$ then $v_1 = u_2$ and $v_2 = u_1$

Then $v_1 = 0$

$$v_2 = \left(\frac{2m}{2m}\right)u_1 \Rightarrow v_2 = u_1$$

$\therefore$ Both A and B are true

9. A 2 kg ball moving at $24\ ms^{-1}$ undergoes head on elastic collision with a 4 kg ball moving in the opposite direction at $48\ ms^{-1}$. If the coefficient of restitution is 2/3, their velocities, in ms^{-1} after impact are **(2004 - E)**

1) - 56, - 8
2) - 28, - 4
3) - 14, - 2
4) -7 , -1

Ans: 1

Sol: From the relations $e = \frac{v_2 - v_1}{u_1 - u_2}$ and

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\frac{2}{3} = \frac{v_2 - v_1}{u_1 - u_2} \text{ ……………………….(1)}$$

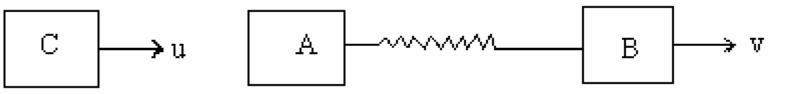
$$2 \times 24 + 4(-48) = 2v_1 + 4v_2 \text{ …….(2)}$$

Solving (1) & (2) $v_1 = -56\ ms^{-1}$, $v_2 = -8\ ms^{-1}$

10. Two identical blocks A and B, each of mass m, resting on smooth floor are connected by a light spring of natural length L and the spring constant k, with the spring at its natural length. A third identical block C (mass m) moving with a speed v along the line joining A and B collides inelastically with A. The maximum compression in the spring is **[2003 -E]**

1) $v\sqrt{\frac{m}{2k}}$
2) $m\sqrt{\frac{v}{2k}}$
3) $\sqrt{\frac{mv}{k}}$
4) $\frac{mv}{2k}$

Ans: 1

Sol: 

When 'c' hits A, both A & B system move in the right direction with velocity V.

According to conservation of linear momentum

$$m_c u = \left(m_A + m_B\right) v$$

as $m_c = m_A = m_B = m$

$$\text{mu} = (\text{m+m})\text{v} \Rightarrow v = \frac{u}{2} \ldots\ldots\ldots\ldots\ldots(1)$$

K.E of combines system = P.E stored in the spring

$$\frac{1}{2}\left(m+m\right)\left(v\right)^2 = \frac{1}{2}kx^2$$

On solving $x = v\sqrt{\frac{m}{2k}}$

11. A particle falls from a height 'h' upon a fixed horizontal plane and rebounds. If 'e' is the coefficient of restitution, the total distance travelled before rebounding has stopped is

[2001 - E]

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

Ans: 1

Sol: H = total distance traveled before it stops rebounding

or coming to rest = $h+h_1+h_2+\ldots$

$= h + 2e^2h + 2e^4h + \ldots$

[Since $h_x = e^{2x}h$] where x = number of rebounds

$$\therefore H = h + 2e^2h\left[1+e^2+....\right]$$

$$S_\infty = \frac{a}{1-r} = \frac{1}{1-e^2}$$

$$\therefore H = h + 2e^2h\left[\frac{1}{1-e^2}\right] = h\left(\frac{1+e^2}{1-e^2}\right)$$

12. A body of mass m_1 moving with a velocity $10\,ms^{-1}$ collides with another body at rest of mass m_2. After collision the velocities of the two bodies are $2\,ms^{-1}$ and $5\,ms^{-1}$ respectively along the direction of motion of m_1. The ratio of $\frac{m_1}{m_2}$ is **[2000-E]**

1) $\frac{5}{12}$ 2) $\frac{5}{8}$ 3) $\frac{8}{5}$ 4) $\frac{12}{5}$

Ans: 2

Sol: According to the law of conservation of linear momentum

$$m_1u_1 = m_1v_1 + m_2v_2$$

$$m_1\left(10\right) = m_1\left(2\right) + m_2\left(5\right)$$

$$8m_1 = 5m_2 \Rightarrow \frac{m_1}{m_2} = \frac{5}{8}$$

MEDICAL

13. Six marbles are lined up in a straight groove made on a horizontal frictionless surface as shown below. Two similar marbles in contact, with a common velocity v collide with a row of 6 marbles from left. Which of the following is observed? **(2009 M)**

1) One marble from the right rolls out with a speed 2v, the remaining marbles do not move.

2) Two marbles from the right roll out with speed v each, the remaining marbles do not move

3) All six marbles in the row will roll out with a speed v/6 each, the two incident marbles will come to rest

4) All eight marbles will start moving to the right, each with a speed of v/8

Ans : 1

Sol: According to the law of conservation of linear momentum when two bodies of same mass collide they exchange velocities.

$\therefore$ Only two marbles from the extreme right will roll with a speed 'v' and the other balls will remain at rest.

14. A body of mass 5kg makes an elastic collision with another body at rest and continues to move in the original direction after collision with a velocity equal to $1/10^{th}$ of its original velocity. Then the mass of the second body is : **(2009 M)**

1) 4.09 kg 2) 0.5 kg 3) 5 kg 4) 5.09 kg

Ans : 1

Sol: We know that $v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2$

As second body is at rest $u_2 = 0$

$$\therefore\ v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1$$

$$\text{given } v_1 = \frac{u_1}{10} \Rightarrow \frac{u_1}{10} = \left(\frac{5 - m_2}{5 + m_2}\right)u_1$$

$\Rightarrow$ m_2= 4.09 kg

15. The object at rest suddenly explodes into three parts with the mass ratio 2:1:. The parts of equal masses move at right angles to each other with equal speeds. The speed of the third part after the explosion will be **(2008 M)**

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

Ans: 2

Sol: Let the total mass of the object is 4m.

$\therefore$ equal masses of 'm' move at right angles with equal speeds 'u'

$\therefore$ from law of conservation of linear momentum $\overline{p_1} + \overline{p_2} + \overline{p_3} = 0$

$$\overline{p_3} = -\left(\overline{p_1} + \overline{p_2}\right)$$

The angle between p_1 & p_2 is 90^0

$$\therefore p_3 = \sqrt{p_1^{\,2} + p_2^{\,2}} = \sqrt{2}\,mu$$

Let the velocity of heavier part is V

$$\therefore (2m)\ v = \sqrt{2}\,mu \Rightarrow v = \frac{u}{\sqrt{2}}$$

16. A body of mass 'm' strikes another body at rest of mass $\frac{'m'}{9}$. Assuming the impact to be inelastic the fraction of the initial kinetic energy transformed into heat during the contact is **(2008 M)**

1) 0.1 2) 0.2 3) 0.5 4) 0.64

Ans: 1

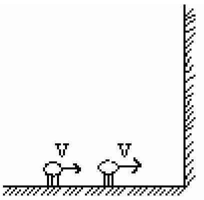
Sol: Loss in K.E during perfect inelastic collision = $\frac{1}{2}\frac{m_1 m_2}{m_1 + m_2}u_1^2$

Fraction of initial K.E lost = $\dfrac{\frac{1}{2}\frac{m_1 m_2}{m_1 + m_2}u_1^2}{\frac{1}{2}m_1 u_1^2}$

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

$$= \frac{\frac{m}{9}}{m + \frac{m}{9}} = 0.1$$

17. Two balls of same,. Masses each 'm' are moving with same velocities v on a smooth surface as shown in figure. If all collisions between the masses and with the wall are perfectly elastic, the possible number of collisions between the bodies and wall together is **(2008 M)**



1) 1 2) 2 3) 3 4) infinity

Ans:3

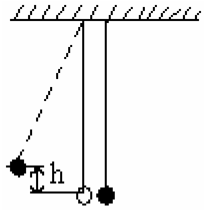
Sol: No. of collisions made by the two bodies with wall = 2

No of collisions make with each other = 1

$\therefore$ Total No. of collisions = 3

18. In the figure, pendulum bob on left side is pulled aside to a height h form 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 raise to a height

(2007 M)



1) $\frac{3h}{4}$ 2) $\frac{2h}{3}$ 3) $\frac{h}{2}$ 4) $\frac{h}{4}$

Ans: 4

Sol: Let 'u' is the initial velocity of the first body and the second body is at rest. After collision both of them move combinedly with a velocity v and raises to a height h_1.

$\therefore$ According to the law of conservation of linear momentum

$$m_1 u = (m_1 + m_2) v$$

But $m_1 = m_2 = m$ and $v = \sqrt{2gh_1}$, $u = \sqrt{2gh}$

$$\therefore\ m\sqrt{2gh} = (2m)\sqrt{2gh_1} \Rightarrow h_1 = \frac{h}{4}$$

19. A sphere of mass m moving with constant velocity u, collides with another stationary sphere of same mass. If e is the coefficient of restitution, the ratio of the final velocities of the first and second spheres is **(2007 M)**

1) $\frac{1+e}{1-e}$ 2) $\frac{1-e}{1+e}$ 3) $\frac{e}{1-e}$ 4) $\frac{1+e}{e}$

Ans:2

Sol: According to the law of conservation of linear momentum

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

$$\Rightarrow mu + m \times 0 = (v_1 + v_2) m$$

$$\Rightarrow u = v_1 + v_2 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

Similarly $e = \frac{v_2 - v_1}{u_1 - u_2} = \frac{v_2 - v_1}{u}$ ……………….(2)

Solving (1) & (2) $\frac{v_1}{v_2} = \frac{1-e}{1+e}$

20. In two separate collisions, the coefficient of restitutions e_1 and e_2 are in the ratio 3:1. In the first collision the relative velocity of approach is twice the relative velocity of approach is twice the relative velocity of separation, then and the ratio between relative velocity of separation in the second collision is : **(2006 M)**

1) 1:6 2) 2:3 3) 3:2 4) 6:1

Ans : 4

Sol: We know that e = $\frac{v_2 - v_1}{u_1 - u_2} = \frac{Relative\ Velocity\ of\ Separation}{Relative\ Velocity\ of\ Approach}$

<u>Ist case</u> :-

given that u_1-u_2 = 2(v_2 - v_1)

$$\Rightarrow \frac{v_2 - v_1}{u_1 - u_2} = \frac{1}{2}$$

$$\therefore e_1 = \frac{1}{2}$$

<u>IInd case</u> :-

$$e_2 = \frac{v_2^1 - v_1^1}{u_1^1 - u_2^1}$$

But given $\frac{e_1}{e_2} = \frac{3}{1} \Rightarrow \frac{1/2}{e_2} = \frac{3}{1}$

$$\Rightarrow e_2 = 1/6$$

$\therefore \frac{Relative\ Velocity\ of\ Separation}{Relative\ Velocity\ of\ Approach} = \frac{1}{e} = \frac{1}{1/6} = 6$

21. A nucleus of mass 218 amu in free state decays to emit an α-particle, kinetic energy of the α-particle emitted is 6.7 MeV. The recoil energy (in MeV) of the daughter nucleus is : **(2005 M)**

1) 1.0 2) 0.5 3) 0.25 4) 0.125

Ans : 4

Sol: From the relation K.E = $\frac{p^2}{2m} \Rightarrow KE \propto \frac{1}{m}$

[Since momentum remains constant in any collision]

$\therefore KE_\propto, KE_D$ are the kinetic energy of α particle and daughter nucleus of masses m_α and m_D

$$\therefore 607 \times 4 = (KE)_D \times 214$$

$$\therefore (KE)_D = 0.125 \text{ MeV}$$

22. Consider the following statements A and B and identify the correct answer:

A: Coefficient of restitution varies between 0 and 1.

B: In inelastic collision, the law of conservation of energy is satisfied. **[2005-M]**

1. A and B are true
2. A and B are false
3. A is true but B is false
4. A is false but B is true.

Ans:1

Sol: A) For perfectly elastic collision the value of e = 1 and perfectly inelastic collision e = 0.

For all other collisions the value of e lies between 0 to 1.

B) In any collision the law of conservation of energy is satisfied.

23. A body x with a momentum p collides with another identical stationary body y one dimensionally. During the collision y gives an impulse J to the body x. Then the coefficient of restitution is **(2004 - M)**

1) $\frac{2J}{P}-1$ 2) $\frac{J}{P}+1$ 3) $\frac{J}{P}-1$ 4) $\frac{J}{2P}-1$

Ans: 1

Sol: As the collision is inelastic

$$v_1=\left(\frac{m_1-em_2}{m_1+m_2}\right)u_1+\left(\frac{m_2(1+e)}{m_1+m_2}\right)u_2$$

given $m_1 = m_2 = 0$ and $u_2 = 0$

$$\therefore v_1=\frac{mu_1(1-e)}{2m}=\frac{u_1}{2}(1-e)$$

Given the momentum of first body = p = mu_1

$$\therefore\ J=\Delta P=m(u_1-v_1)=m\left[u_1-\frac{u_1}{2}(1-e)\right]$$

$$\Rightarrow J=\frac{mu_1}{2}(1+e)=\frac{p}{2}(1+e)$$

$$\Rightarrow e=\frac{2J}{p}-1$$

24. Consider the following statements A and B. Identify the correct choice in the given answer : **[2003 - M]**

A : In a one - dimensional perfectly elastic collision between two moving bodies of equal masses, the bodies merely exchange their velocities after collision

B : If a lighter body at rest suffers perfectly elastic collision with a very heavy body moving with a certain velocity, after collision both travel with same velocity

1) A and B are correct 2) Both A and B are wrong

3) A is correct B is wrong 4) A is wrong B is correct

Ans: 3

Sol: A) Let V_1 is the velocity of the first body after collision V_2 is the velocity of second body

$$\therefore V_1=\left(\frac{m_1-m_2}{m_1+m_2}\right)u_1+\left(\frac{2m_2}{m_1+m_2}\right)u_2 \ldots\ldots\ldots\ldots(1)$$

$$V_2=\left(\frac{2m_1}{m_1+m_2}\right)u_1+\left(\frac{m_2-m_1}{m_1+m_2}\right)u_2 \ldots\ldots\ldots(2)$$

Sub $m_1 = m_2$ in (1) & (2)

$V_1 = u_2$ and $V_2 = u_1$

$\therefore$ A statement is correct

B) given $m_1 >> m_2$ $\therefore m_2+m_1\approx m_1$ i.e. $m_2\approx 0$

from (1) $V_1=\left(\frac{m_2-0}{0+m_2}\right)u_1+0$

since second body is at rest

$\therefore V_1 = u_1$ ……………………….(3)

From (2) $V_2 = \left(\frac{2m_1}{m_1}\right)u_1 + 0$

Since second body is at rest

$\therefore V_2 = 2u_1$ ………………...(4)

From 3 and 4 we can conclude that the velocity of heavy body remains same but velocity of lighter body becomes double

$\therefore$ B statement is wrong

25. A stationary body of mass 3 kg explodes into three equal pieces. Two of the pieces fly off at right angles to each other, one with a velocity $2\overline{i}$ m/s and the other with velocity $3\overline{j}$ m/s. If the explosion takes place in $10^{-5}\ s,$ the average force acting on the third piece in newtons is **[2003 - M]**

1) $\left(2\vec{i}+3\vec{j}\right)\times 10^{-5}$ 2) $-\left(2\vec{i}+3\vec{j}\right)\times 10^{5}$ 3) $\left(3\vec{j}-2\vec{i}\right)\times 10^{5}$ 4) $\left(2\vec{i}-3\vec{j}\right)\times 10^{-5}$

Ans : 2

Sol: $1\left(2\hat{i}\right)+1\left(3\hat{j}\right)+1\left(V_3\right)=0$

$\therefore V_3 = -\left(2\hat{i}+3\hat{j}\right)$

Force on the third piece

$$F = \frac{1\left[-\left(2\hat{i}+3\hat{j}\right)\right]}{10^{-5}}$$

$$\Rightarrow F = -\left(2\hat{i}+3\hat{j}\right)10^{5}\,N$$

26. A body of mass 2 kg moving with a velocity of 6m/s strikes inelastically another body of same mass at rest. The amount of heat evolved during collision is **[2002-M]**

1) 36 J 2) 18 J 3) 9 J 4) 3 J

Ans : 2

Sol: Amount of heat evolved = loss of energy

$$= \frac{1}{2}\frac{m_1 m_2}{m_1+m_2}\left(u_1-u_2\right)^2$$

$$= \frac{1}{2}\left[\frac{(2)(2)}{2+2}\right](6)^2 = 18J$$

27. A body 'A' experience perfectly elastic collision with a stationary body 'B'. If after collision the bodies fly apart in the opposite directions with equal velocities, the mass ratio of 'A' and 'B' is **[2001 M]**

1) $\frac{1}{2}$ 2) $\frac{1}{3}$ 3) $\frac{1}{4}$ 4) $\frac{1}{5}$

Ans: 2

Sol: When the collision is elastic, final velocity of the bodies

$$V_1 = \left[\frac{m_A + m_B}{m_A + m_B}\right]u_1$$

$$V_2 = \left[\frac{2m_A}{m_A + m_B}\right]u_1$$

But $V_1 = -V_2$ (as they move in opposite direction)

$\therefore m_A - m_B = 2m_A$

$\Rightarrow m_A : m_B = 1:3$

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