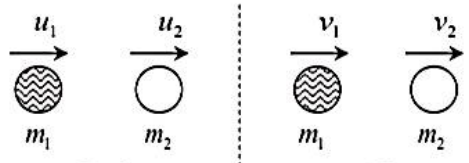
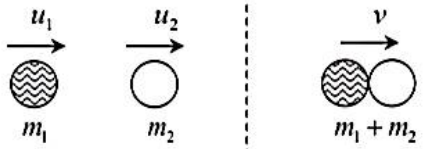
LO 3.2 b) Apply the principle of conservation of momentum in elastic and elastic collisions in 1D and 2D collisions
LO 3.2 c) Differentiate elastic and inelastic collisions (similarities & differences)

<table>
<tr><th colspan="2">Collision</th></tr>
<tr><td colspan="2">
• When 2 or more bodies (the colliding bodies) exert relatively strong forces on each other for a relatively short time.
• In a collision, the change in momentum of the system is zero because no external forces are acting on the system i.e. momentum is conserved.
</td></tr>
<tr><th colspan="2">1D Collision</th></tr>
<tr><th>Elastic Collision</th><th>Inelastic Collision</th></tr>
<tr><td colspan="2">
• The total momentum of a system is conserved.
$$\sum \vec{p}_{initial} = \sum \vec{p}_{final}$$
• The total energy of a system is conserved.
$$\sum E_{initial} = \sum E_{final}$$
</td></tr>
<tr><td>The total kinetic energy of a system is conserved.
$$\sum K_{initial} = \sum K_{final}$$</td><td>The total kinetic energy of a system is NOT conserved.
$$\sum K_{initial} \neq \sum K_{final}$$
$$\sum K_{initial} = \sum K_{final} + \text{Energy loss}$$</td></tr>
<tr><td>
Example of elastic collision :


• Conservation of momentum :
$$\sum \vec{p}_{initial} = \sum \vec{p}_{final}$$
$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$
• Conservation of kinetic energy :
$$\sum K_{initial} = \sum K_{final}$$
$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$
</td><td>
Example of <u>perfectly</u> inelastic collision :


• Conservation of momentum :
$$\sum \vec{p}_{initial} = \sum \vec{p}_{final}$$
$$m_1u_1 + m_2u_2 = m_1v + m_2v$$
• Kinetic energy is NOT conserved :
$$\sum K_{initial} \neq \sum K_{final}$$
$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 \neq \frac{1}{2}m_1v^2 + \frac{1}{2}m_2v^2$$
*Not all objects undergo inelastic collision will stick together and moving with the same velocity after the collision.
</td></tr>
<tr><td>Always rebound after the collision</td><td>Rebound or
stick together (perfectly inelastic collision) after the collision</td></tr>
</table>

Example 4

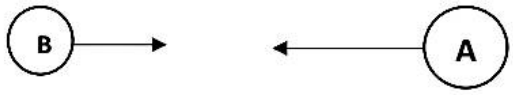


Figure shows an object A and object B are moving directly to each other at a same speed of 10.6 m s^{-1} and finally they will collide. Right after the collision, car A bounces backward at a speed of 8.4 m s^{-1}. Given that the mass of object A and object B are 2.5 kg and 2.6 kg respectively.

a) Determine the velocity of object A after collision. **[Answer : 7.67 m s^{-1}]**
b) Is the collision elastic or inelastic?

2D Collison

- The total momentum of a system is conserved in both x and y axis.

$$x-\text{axis}: \sum \vec{p}_{x,initial} = \sum \vec{p}_{x,final}$$
$$y-\text{axis}: \sum \vec{p}_{y,initial} = \sum \vec{p}_{y,final}$$

- The total energy of a system is conserved.

$$\sum E_{initial} = \sum E_{final}$$

Example of 2D collision :

Consider m_1 moving with u_1 strikes another m_2 that is initially at rest. After the collision, the two masses move off with different direction.

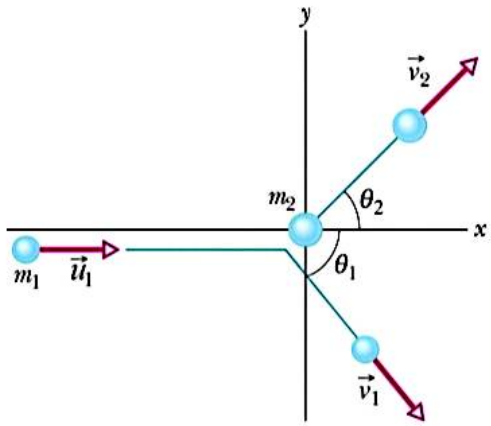


Figure 3.1

Momentum along x-axis :

$$\sum \vec{p}_{x,initial} = \sum \vec{p}_{x,final}$$
$$m_1u_1 = m_1v_{1x} + m_2v_{2x}$$
$$m_1u_1 = m_1v_1\cos\theta_1 + m_2v_2\cos\theta_2$$

Momentum along y-axis :

$$\sum \vec{p}_{y,initial} = \sum \vec{p}_{y,final}$$
$$0 = m_1v_{1y} + m_2v_{2y}$$
$$0 = m_1(-v_1\sin\theta_1) + m_2v_2\sin\theta_2$$

If the collision shown in **Figure 3.1** is an **elastic collision, total kinetic energy is conserved.**

$$\sum K_{initial} = \sum K_{final}$$
$$\frac{1}{2}m_1u_1^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

Kinetic energy is NOT a vector quantity. Thus, no need to resolve into ***x***- and ***y***-components.

Example 5

A tennis ball of mass m_1 moving with initial velocity 20 m s^{-1} collides with a soccer ball of mass 900 g initially at rest. After the collision, the tennis ball is deflected 50° from its initial direction with a velocity 4 m s^{-1} v_1 as shown in the figure. Calculate the magnitude and direction of velocity of soccer ball after the collision and sketch its direction.

[Answer : 4.91 ms^{-1}, 9.97° above positive *x*-axis)