CHAPTER 8

Momentum,Impulse,and Collisions.

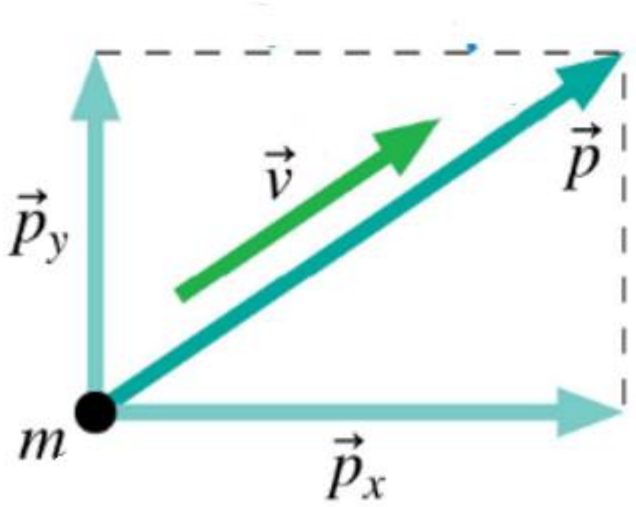
CONTENTS

1. Momentum and Impulse.
2. Conservation of momentum.
3. Momentum conservation and collisions.
4. Elastic collisions.
5. Center of mass.

1.MOMENTUM AND IMPULSE

The product of the particle's mass (m) and velocity(v) is called momentum, or linear momentum, of the particle.

$$\vec{p} = m\vec{v} \qquad (\text{kg. m/s})$$



Example 8.1: A 1200 kg car drives west at 25 m/s. What is the car's momentum?

Solution:

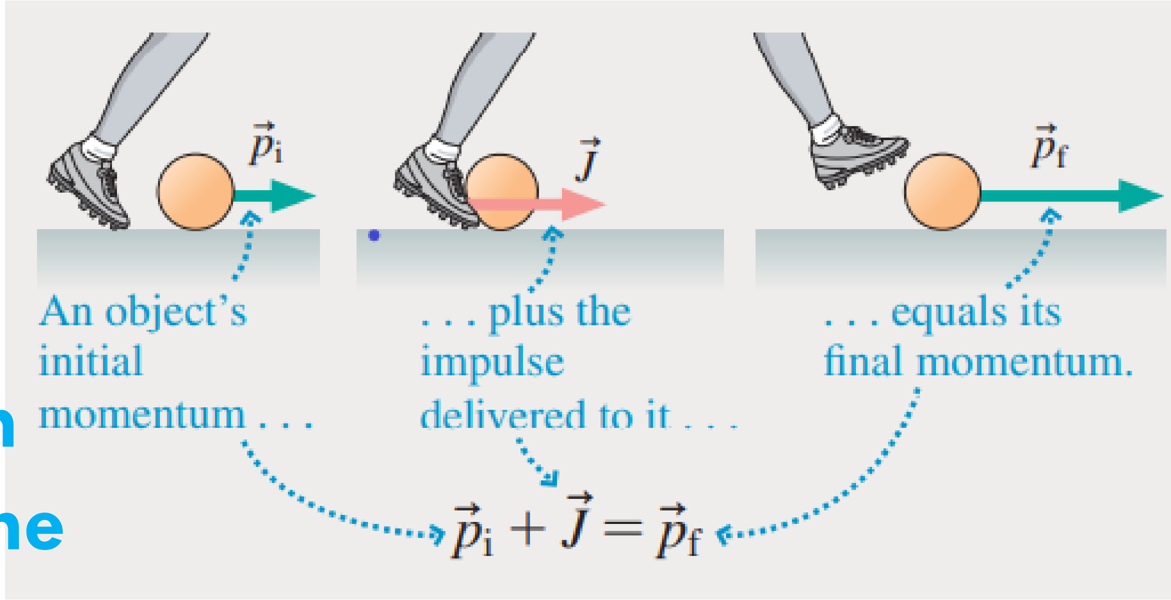
$$p = mv = 1200 \times 25 = 3 \times 10^4 \text{ kg. m/s}$$

Impulse is the average force over a period of time.

$$\vec{J} = \vec{F}_{av}\Delta t \quad (N.s)$$

Also **Impulse** is the change in momentum

$$\vec{J} = m(\vec{v}_2 - \vec{v}_1) \quad (kg.m/s)$$



Example 8.2: A force 50N applied on an object over a period of 15s find the impulse?

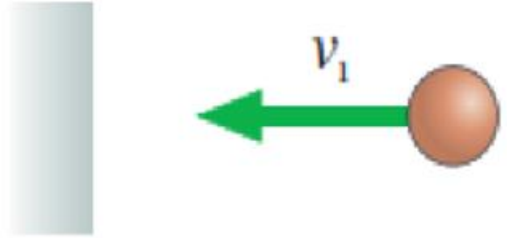
Solution:

$$J = F_{av}\,\Delta t = 50 \times 15 = 750 \quad (N.s)$$

Example 8.3:

You throw a ball with a mass of **0.40 kg** against a brick wall. It hits the wall moving horizontally to the left at **30 m/s** and **rebounds** horizontally to the right at **20 m/s.**

(a) Find the impulse of the net force on the ball during its collision with the wall.

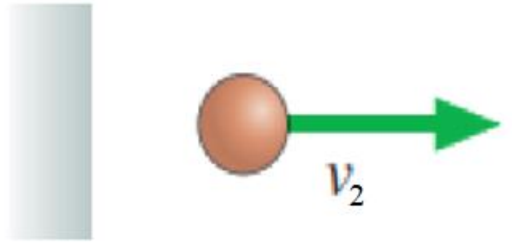


$$v_1 = -30\,m/s, \quad v_2 = +20\,m/s\,, \quad \Delta t = 0.01\,s$$

$$J = m(v_2 - v_1) = 0.4 \times \left(20 - (-30)\right)$$

$$= 0.4 \times (20 + 30) = 0.4 \times 50 = 20 \quad \mathrm{N.s}$$

(b) If the ball is in contact with the wall for 0.01 s, find the average horizontal force that the wall exerts on the ball during the impact.



Solution

$$J = F_{\mathrm{av}}\,\Delta t$$

$$20 = F_{\mathrm{av}} \times 0.01$$

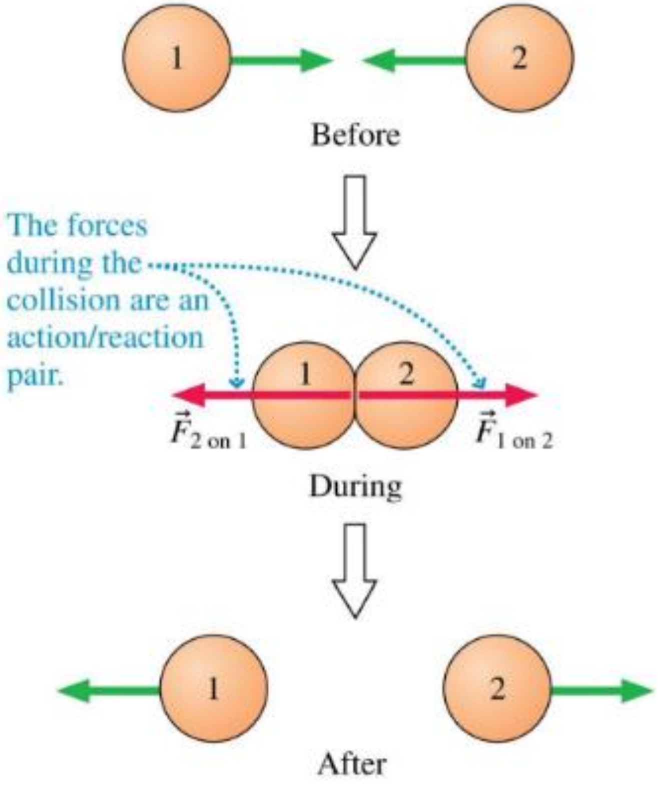
$$F_{\mathrm{av}} = \frac{20}{0.01} = 2000\,N$$

2- CONSERVATION OF MOMENTUM

In the absence of an external force the momentum of a closed system is conserved .

In a closed system, the momentum before collision is equals momentum after collision.

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$



3. MOMENTUM CONSERVATION AND COLLISIONS

When no external forces act on a system consisting of two objects that collide with each other, the total momentum of the system remains constant in time.

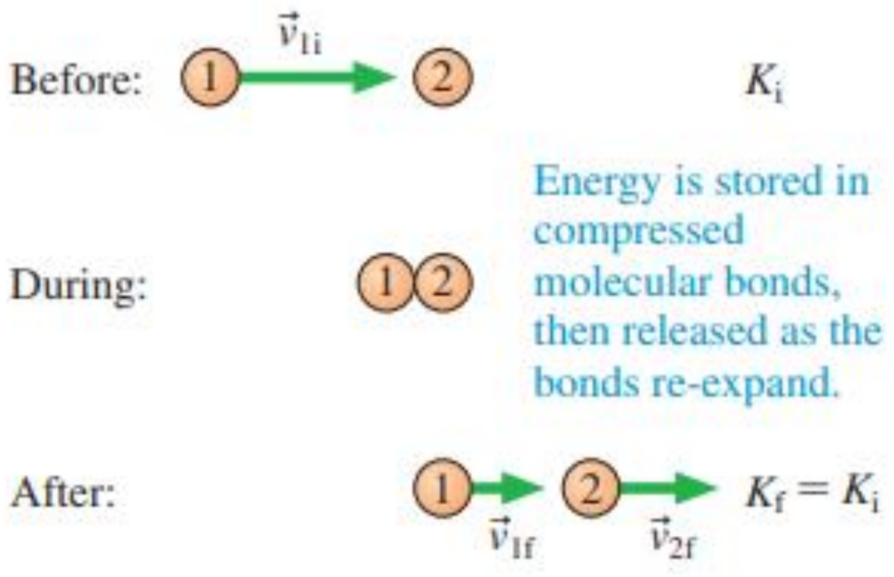
$$(\textbf{total momentum})_{\textbf{before}} = (\textbf{total momentum})_{\textbf{after}}$$

4- ELASTIC COLLISIONS

Both momentum and kinetic energy are conserved quantities in elastic collisions.

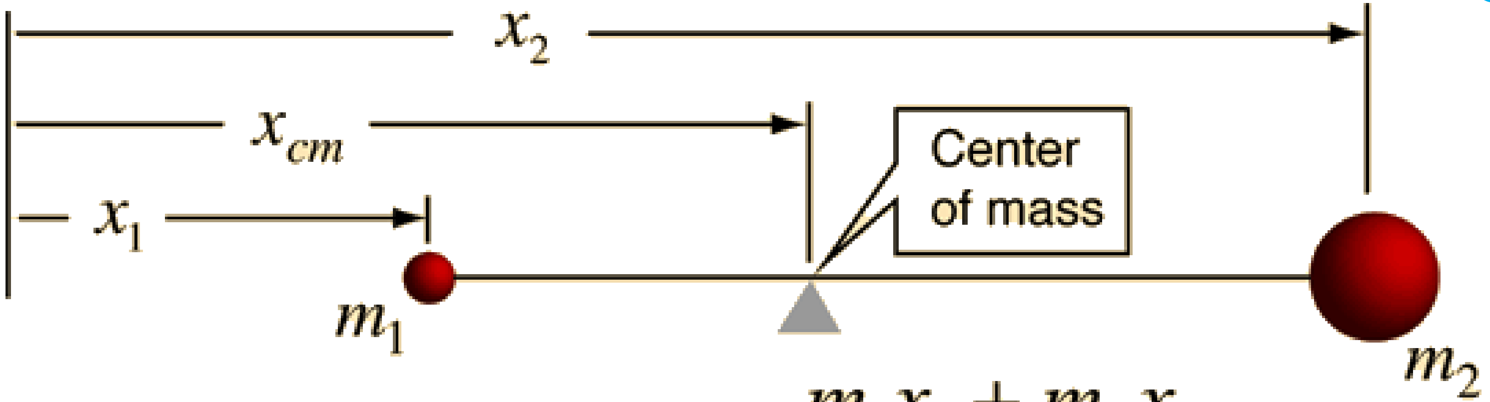
$$p_i = p_f \quad (1)$$

$$K_i = K_f \quad (2)$$



5-CENTER OF MASS

The center of mass is a position defined relative to an object or system of objects. It is the average position of all the parts of the system, weighted according to their masses. The center of mass lies on the line connecting the two masses.



For two masses: $x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$

Example 8.4:

If $x_1 = 20\ m$ and $x_2 = 30\ m$, $m_1 = 40$ kg, and $m_2 = 60$ kg , calculate the center of mass.

Solution

$$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2} = \frac{40 \times 20 + 60 \times 30}{40 + 60} = 26\ \text{m}$$