Linear momentum and its conservation

If there are 2 particles which are isolated and do not experience any outside force, when they collide into each other, their momentum is conserved.

The particle on the left exerts a force F to the right, and the particle on the right exerts a force -F to the left. When they collide, they exchange momentum so it is conserved. The total momentum stays constant.

$p = p_1 + p_2 = $ constant

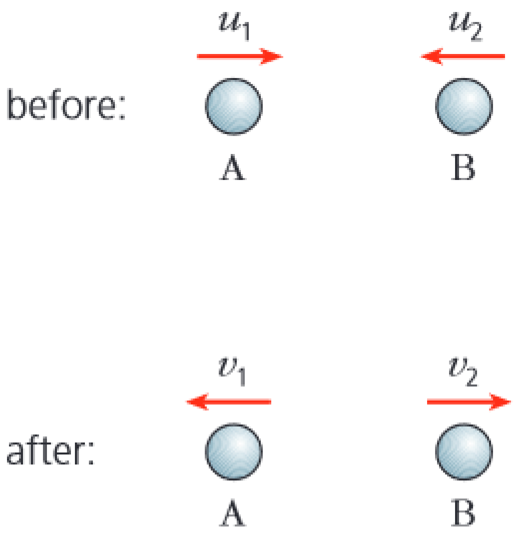
where p is the total momentum, p_1 and p_2 are the 2 individual momenta.

> If no external forces act upon the system, the total momentum of the system is conserved, or constant.

This is the **principal of conservation of momentum**. It is a direct consequence of Newton's third law of motion.

Collisions

Imagine 2 balls collide to each other with velocity.



Since $p = p_1 + p_2 =$ constant,

$m_1u_1 - m_2u_2$ is the momentum before collision.

$-m_1v_1 + m_2v_2$ is the momentum after collision.

Because the total momentum is conserved,

$m_1u_1 - m_2u_2 = -m_1v_1 + m_2v_2$

Momentum and impulse

> **If a constant force F acts upon an object for time Δt, the impulse of the force is defined as $F\Delta t$.**

The unit of impulse is Ns or Newton second.

Since we know that $F = \dfrac{\Delta p}{\Delta t}$,

$F\Delta t = \Delta p$

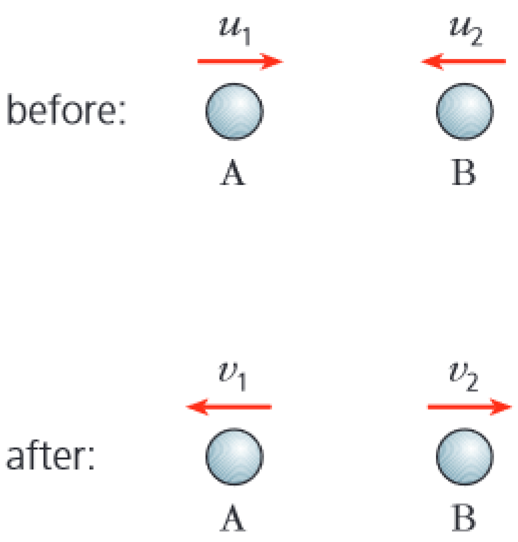
So the impulse of a force is equal to the change in momentum.

Elastic and inelastic collisions

In some collisions, kinetic energy is conserved as well as momentum.

> ## Conservation of kinetic energy

This means that no kinetic energy is lost to deforming the 2 objects, or as heat or sound. When the 2 objects collide, some kinetic energy is converted to elastic energy but is reconverted to kinetic energy again.



$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$ is the total energy before collision.
$\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$ is the total energy after collision.

> **If the collision is elastic, the total kinetic energy before collision is the same as the total kinetic energy after collision.**

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

Since energy is scalar, you do not need minus sign to indicate the direction.

This can be simplified to find the velocities.

$u_1 + u_2 = v_1 + v_2$

However!! This only applies to perfectly elastic collisions.

> **Collisions in which the kinetic energy before and after are not equal are called inelastic collisions.**

> **Although kinetic energy may or may not be conserved, momentum and total energy are always conserved.**