Conservation of momentum

Tuesday, June 25, 2019 4:21 AM

Let's return to the conservation of linear momentum. The total momentum of a system of N particles is the vector sum of the momenta of the individual particles

$$\bar{P} = \sum_{i=1}^{N} \bar{p}_i$$

Because of Newton's second law, the total external force acting on the system is equal to the time derivative of the total momentum.

$$\dot{\bar{P}} = \bar{F}_{ext}$$

From the above it is immediate to conclude that

Principle of conservation of momentum

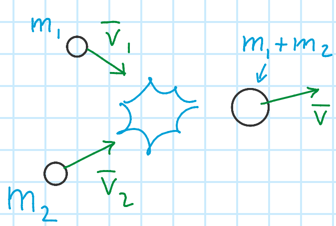
If the system is isolated, i.e. There are no external forces acting on the system, the total momentum of the system is conserved

Notice that in the case in which the system encompasses one single particle, the conservation of momentum coincides with Newton's first law: If a particle is not subject to a net force, its momentum does not change.

As a simple example of the conservation of momentum, let's consider an inelastic collision between two point particles in 2 dimensions

Inelastic collision between two bodies

We consider a maximally inelastic collision: Not only the total kinetic energy of the system is not conserved, but the two objects stick together after the collision.



$$\bar{P}_{before} = m_1 \bar{v}_1 + m_2 \bar{v}_2$$

$$\bar{P}_{after} = (m_1 + m_2)\,\bar{v}$$

$$\bar{P}_{before} = \bar{P}_{after} \longrightarrow \boxed{\bar{v} = \frac{m_1 \bar{v}_1 + m_2 \bar{v}_2}{m_1 + m_2}}$$

In the special case in which one of the two particles is at rest

$$\bar{v}_2 = 0 \longrightarrow \bar{v} = \frac{m_1}{m_1 + m_2} \bar{v}_1$$