Impulse and Momentum

Readings: Chapter 9



What is the velocity of ball A after the collision? ball B?

What is conserved during the collision?

MOMENTUM

$$\vec{p} = m\vec{v}$$

The total momentum is the sum of momentum of ball A and momentum of ball B.



The total momentum of the system is conserved during the collision:



- Momentum is a vector. It has the same direction as corresponding velocity.
- General expression for the momentum conservation: the total momentum before the collision is equal to the total momentum after the collision



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Usually this equation is written in terms of components.

Example:



After the collision the balls are moving together (have the same velocity). What is their velocity?



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Why do we have conservation of total momentum?

Newton's second law:

$$\vec{F}_{net} = m\vec{a}$$

Acceleration:

 $\vec{a} = \frac{d\vec{v}}{dt}$ momentum $\vec{F}_{net} = m \frac{d\vec{v}}{dt} = \frac{d(m\vec{v})}{dt} = \frac{d\vec{p}}{dt}$

Then

After integration

$$\Delta \vec{p} = \int_{t_1}^{t_2} \vec{F}_{net} dt \qquad \text{The area under } \vec{F}_{net}(t) \quad \text{curve.}$$

$$\vec{I}_{t_1} = \int_{t_1}^{t_2} \vec{F}_{net} dt \qquad \text{It is called IMPULSE, J.}$$

The impulse of the force is equal to the change of the momentum of the object. $\Delta \vec{p} = \vec{J}$



$$p_i = m v_{ix}$$

$$p_f = m v_{fx} < 0$$

$$J_x = p_f - p_i < 0$$







The law of conservation of momentum:

The total momentum of an isolated system (no external forces) does not change.

Interactions within system do not change the system's total momentum





The ball is dropped onto a hard floor:

- > The ball is not an isolated system (interaction with the floor)
- no conservation of momentum for the ball
- > Initial momentum is $\vec{p}_i = m\vec{v}_i$
- > Final momentum (after collision) is $\vec{p}_f = m\vec{v}_f$
- The ball+ the floor is an isolated system
- The total momentum (ball+floor) is conserved





Perfectly inelastic collision:

A collision in which the two objects stick together and move with a common final velocity.

