Conservation of Momentum

A car of mass m_1 and a truck of mass m_2 collide on a frictionless road.

- How do the forces on each vehicle compare?

Equal & Opposite!

- How do the impulses of each vehicle compare?

Equal & Opposite!

Both experience force for same amount of time.

Derivation of Conservation of Momentum Formula:

$$-m_1\Delta v_1 = m_2\Delta v_2$$

$$-(m_1v_1 - m_1v_{1o}) = m_2v_2 - m_2v_{2o}$$

$$m_1v_{1o} + m_2v_{2o} = m_1v_1 + m_2v_2$$

***Remember: Velocity is a vector! Don't forget negative signs!

Ex1: A 1200 kg car traveling to the right at 24 m/s slams into the back of a 2600 kg bus traveling to the right at 14 m/s. After the collision, the car travels to the right at 16 m/s. What I the final velocity of the bus?

Ex2: A 60 kg ice skater traveling to the right at 2 m/s collides with a 70 kg skater moving to the left at 2.5 m/s. After the collision, the 60 kg skater bounces off at 0.5 m/s.

A) What is the final velocity of the other skater?

B) How much kinetic energy is lost in the collision?

Ex2: A 60 kg ice skater traveling to the right at 2 m/s collides with a 70 kg skater moving to the left at 2.5 m/s. After the collision, the 60 kg skater bounces off at 0.5 m/s.

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$$m_1 v_{1o} + m_2 v_{2o} = m_1 v_1 + m_2 v_2$$

- In every collision, **MOMENTUM** is conserved.
- In rare cases, **KINETIC ENERGY** is also conserved.
- When both quantities are conserved, the collision is **ELASTIC**.

- Most collisions are **INELASTIC** because some kinetic energy is converted into heat, sound energy, elastic energy, etc.
- Whenever two objects collide and stick together, the collision is classified as **PERFECTLY INELASTIC**.
- When this occurs, the conservation of momentum equation reads:

$$m_1 v_{1o} + m_2 v_{2o} = (m_1 + m_2) v$$

- No collision is truly elastic, but some are very close (i.e. billiard balls).

Ex3: A 300 kg railroad car traveling at 6 m/s collides with a 450 kg railroad car at rest. The two cars lock together and move as one unit. What is the final speed of the two cars?

***Collisions aren't the only examples when momentum is conserved. Another examples is when objects explode or spring apart.

Ex4: A stationary 16 kg bomb explodes and breaks into three pieces. One piece of mass 3 kg moves to the right at 6 m/s. A second piece of mass 5 kg move to the left at 14 m/s. What is the velocity of the third piece?