Conservation of Momentum

For any collision between objects in a closed and isolated system, the total momentum before the collision is equal to the total momentum after the collision.

The Law of Conservation of Momentum

$$\vec{p}_A + \vec{p}_B = \vec{p}_A' + \vec{p}_B'$$

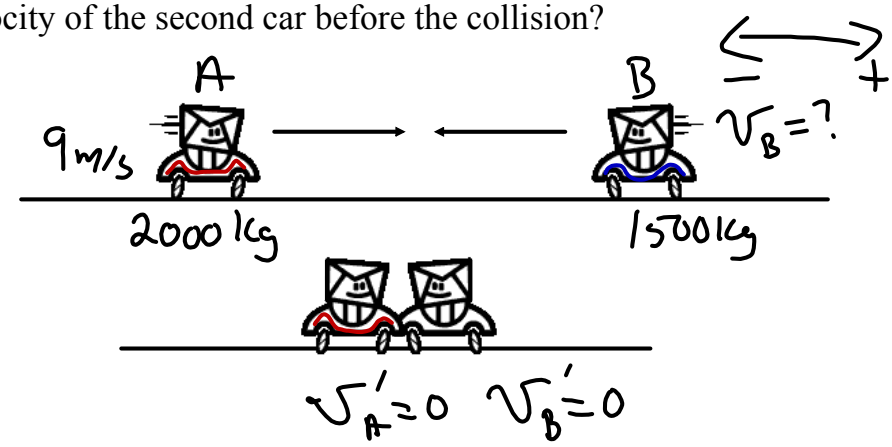
$$m_A\vec{v}_A + m_B\vec{v}_B = m_A\vec{v}_A' + m_B\vec{v}_B'$$

after collision

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

1D Collisions

Example: When a car of mass 2.0×10^3 kg moving at 9.0 m/s collides head on with a second car having a mass of 1.5×10^3 kg, the cars lock and come to rest at the point of collision. What was the velocity of the second car before the collision?



Before

$m_A = 2000$ kg

$v_A = 9.0$ m/s

$m_B = 1500$ kg

$v_B = ?$

After

$v_A' = 0$ m/s

$v_B = 0$ m/s

$$m_A v_A + m_B v_B = m_A v_A' + m_B v_B'$$

$$(2000)(9) + (1500)\, v_B = (2000)(0) + (1500)(0)$$

$$18000 + 1500 v_B = 0$$

$$1500 v_B = -18000$$

$$\boxed{v_B = -12 \text{ m/s}}$$

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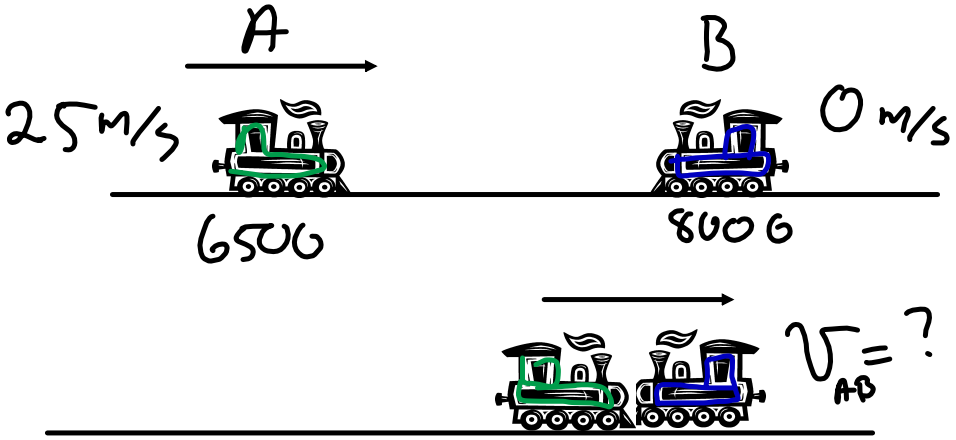
Example: A 6500 kg train travelling at 2.5 m/s collides with a stationary 8000 kg train. If they interlock upon collision, find their velocity after the collision.



$$m_A v_A + m_B \cancel{v_B}^{0} = m_A v_A' + m_B v_B'$$

$$(6500)(2.5) + 0 = (6500)v_A' + (8000)v_B'$$

$$v_A' = v_B' \rightarrow v_{AB}$$

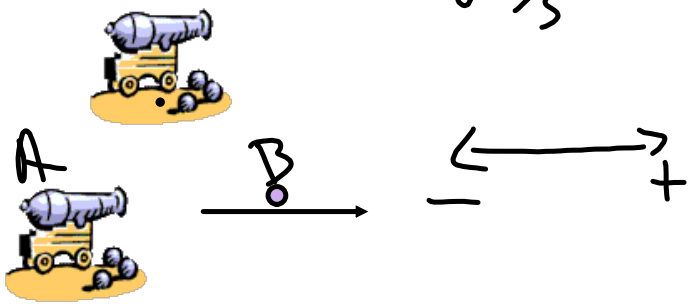
$$16250 = (6500 + 8000)v_{AB}$$

$$16250 = 14500\, v_{AB}$$

$$\boxed{1.12 \text{ m/s} = v_{AB}}$$

Example: A shell having a mass of 25.0 kg is fired horizontally eastward from a cannon with a velocity of 500 m/s. If the mass of the cannon is 1000 kg, what is the magnitude and direction of the recoil velocity?

$P_{Total} = 0 \text{ kg} \cdot \text{m/s}$



$\vec{P}$ Before $= \vec{P}$ after

$0 = m_A v_A' + m_B v_B'$

$0 = (1000) v_A' + (25)(500 \text{ m/s})$

$0 = 1000 v_A' + 12500$

$-12500 = 1000 v_A'$

$\boxed{-12.5 \text{ m/s} = v_A'}$