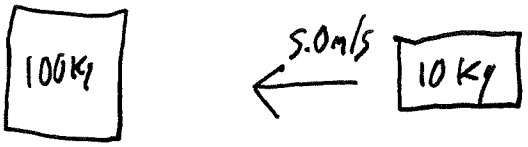
Collisions

A 10.0 kg block is moving at 5.0 m/s left towards a stationary 100.0 kg block.

Draw a diagram of this situation.



What is the momentum of the 10 kg block?

$p = mv = 10.0\,kg \times 5.0\,m/s\ left$

$= 50.0\,\frac{kg \cdot m}{sec}\ left$

What is the momentum of the 100 kg block?

0 since it is stationary

What is the total momentum of the system?

$50.0\,\frac{kg \cdot m}{sec}\ left$

The 10 kg block, hits the 100 kg block and applies a 250 N force to the 100kg block for 0.25 sec.

What impulse does the 10 kg block apply to the 100kg block?

$$\text{Impulse} = \Delta p = F \cdot t = 250\text{N} \cdot 0.25\text{sec} = 62.5\ \text{Ns left}$$

What is the change in the 100kg block's momentum?

$$62.5\ \frac{\text{kg}\cdot\text{m}}{\text{sec}}\ \text{left}$$

What is the new velocity of the 100 kg block?

$$v = \frac{p}{m} = \frac{62.5\ \frac{\text{kg}\cdot\text{m}}{\text{sec}}\ \text{left}}{100\ \text{kg}} = 0.625\ \frac{\text{m}}{\text{s}}\ \text{left}$$

While the 10 kg block is applying 250 N of force to the 100 kg block, how much force is the 100 kg block applying to the 10 kg block and in what direction?

250 N, right

What is the impulse the 100kg block is applying to the 10 kg block?

62.5 Ns right

$$p_f = p_i + \text{impulse}$$
$$= 50\ \frac{\text{kg}\cdot\text{m}}{\text{sec}}\ \text{left} + 62.5\ \frac{\text{kg}\cdot\text{m}}{\text{sec}}\ \text{right}$$
$$= 12.5\ \frac{\text{kg}\cdot\text{m}}{\text{sec}}\ \text{right}$$

What is the new velocity of the 10 kg block?

$$v = \frac{p}{m} = \frac{12.5}{10} = 1.25\ \frac{\text{m}}{\text{s}}\ \text{right}$$

What is the total momentum of the system after the collision?

$$p_{10\ \text{kg block}} = 12.5\ \frac{\text{kg}\cdot\text{m}}{\text{sec}}\ \text{right}$$

$$p_{100\ \text{kg block}} = 62.5\ \frac{\text{kg}\cdot\text{m}}{\text{sec}}\ \text{left}$$

$$= 50\ \frac{\text{kg}\cdot\text{m}}{\text{sec}}\ \text{left}$$

Since any force is applied in both directions by Newton's third law, the impulse of each object on the other is exactly the same. This is called the conservation of momentum

$$p_{total\ initial} = p_{total\ final}$$

$$m_A v_{Ai} + m_B v_{Bi} = m_A v_{Af} + m_B v_{Bf}$$

Example: A 6 500 kg railway car initially travels at 4.0 m/s along a track, it collides with, and sticks to a stationary 4 500 kg car. After the collision how fast will the combined cars be moving?

$$p_{initial} = 6500\,kg \times 4.0\,m/s = 26000\ \frac{kg \cdot m}{sec}$$

$$p_{final} = m v_f$$

$$= (\text{mass of both cars})\, v_f$$

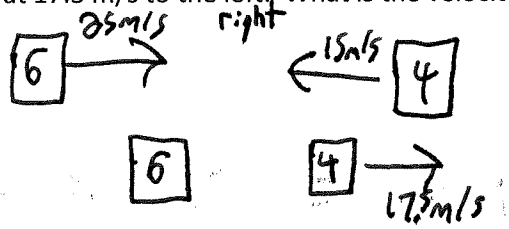
$$\frac{p_{final}}{m_{total}} = v_f$$

$$\frac{26000\ \frac{kg \cdot m}{sec}}{11000\,kg} = 2.4\,m/s$$

When objects collide a few different thing can happen

Situation	Name	Kinetic Energy Conserved?
Object stick together	Perfectly inelastic	No
Objects do not stick together, but some kinetic energy is lost.	Inelastic	No
Objects do not stick together, and no kinetic energy is lost.	Elastic	Yes

Example: A 4.0 kg block moving at 15 m/s to the left collides with a 6.0 kg block moving at 25 m/s to the right. After the collision, the 4.0 kg block is moving at 17.5 m/s to the ~~left~~ right. What is the velocity of the 6.0 kg block? What type of collision is this?



$p_{initial}$

right is positive

p of 6kg block $= 6\,kg \times 25\,m/s = 150\ \frac{kg \cdot m}{sec}$

p of 4kg block $= 4\,kg \times -15\,m/s = -60\ \frac{kg \cdot m}{sec}$

$p_{total} = 90\ \frac{kg \cdot m}{sec}$

$p_{final} = p_6 + p_4 \rightarrow p_{final} - p_4 = p_6$ p_4

$p_4 = 4 \times 17.5\,m/s = 70\ \frac{kg \cdot m}{sec}$ | $90\ \frac{kg \cdot m}{sec} - 70\ \frac{kg \cdot m}{sec} = 20\ \frac{kg \cdot m}{se}$

v of 6 kg block $= \frac{20\ \frac{kg \cdot m}{sec}}{6\,kg} = 3.3\,m/s$ right

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Initial kinetic energy $= \frac{1}{2}(4)(15)^2 + \frac{1}{2}(6)(25)^2 = 2325\,J$

Final kinetic energy $= \frac{1}{2}(4)(17.5)^2 + \frac{1}{2}(6)(3.3)^2 = 645\,J$

Inelastic