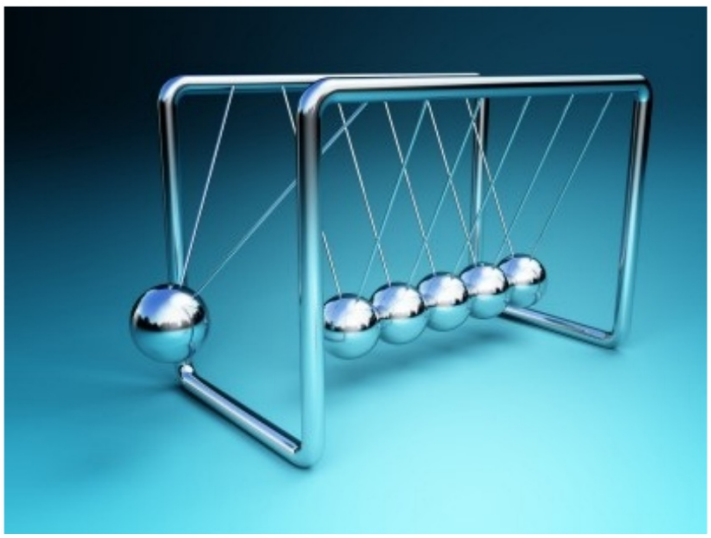
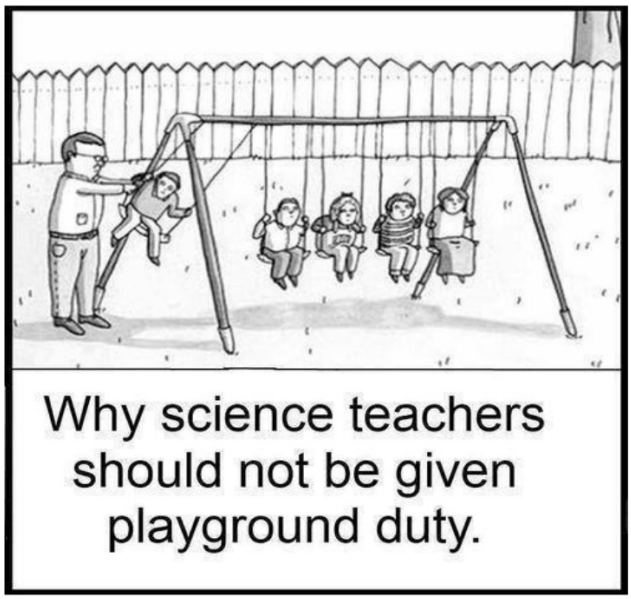
Momentum Conservation (Chapter 4)



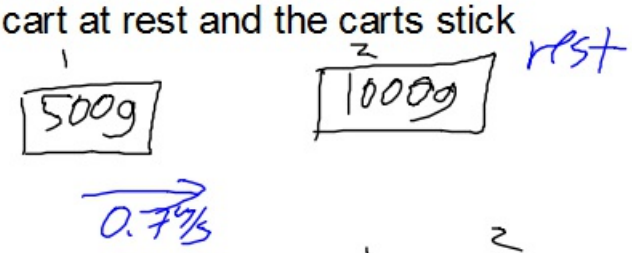
Free body diagram - one object. **Momentum** - systems of objects that are interacting

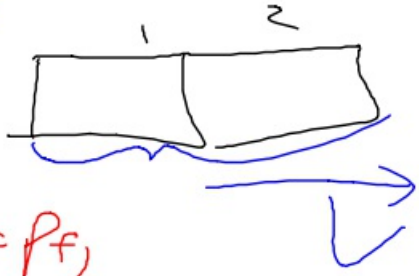
Conservation of momentum: momentum is always conserved (constant) in a closed system of objects

Example: Newton's Cradle
http://www.youtube.com/watch?v=0LnbyjOyEQ8



Example: What happens if a 500-g cart going 0.7m/s hits a 1000-g cart at rest and the carts stick together?





$p_0 = p_{10} + p_{20}$

$= 500g \cdot 0.7 m/s + 0$

$= 350 g\,m/s$ — $p_0 = p_f$

$p_f = p_{1f} + p_{2f}$

$= 500g\,V + 1000g \cdot V$

$= (500g + 1000g)V = M_{tot} V$

$= 1500g\,V$

$p_0 = p_f$

$[350 g\,m/s = 1500g\,V] / 1500$

$\frac{350}{1500} m/s = V = 0.23 m/s$

$p_{1f} = 500g \cdot 0.23 m/s = 116.7 g\,m/s$

$p_{2f} = 1000g \cdot 0.23 m/s = 233 g\,m/s$

$p_f = p_{1f} + p_{2f} = 350 g\,m/s$

Example:

What is p_A, the momentum of Car A, a 2000-kg car moving 20m/s to the right?

$p_A = 2000\,kg \cdot 20\,m/s$
$= 40{,}000\,kg\,m/s$

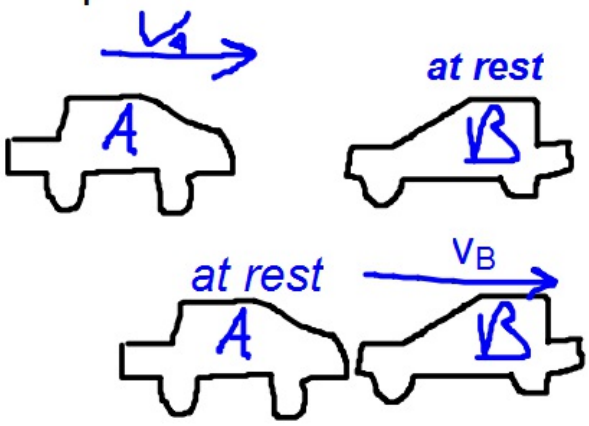
What is p_B, the momentum of Car B, a 1000-kg car at rest?

$p_B = 0$

What is p_{tot}, the momentum of car A plus the momentum of car B?

$p_{TOT} = 40{,}000\,kg\,m/s + 0$
$= 40{,}000\,kg\,m/s$

Example:



initial $V_i = V_{final}$

final

The two cars collide. Car A stops. What is v_B, the final velocity of car B?

$$p_A' = m_A \cdot v_A' = m_A \cdot 0 = 0$$

$$p_B' = m_B v_B' = 1000kg\, v_B'$$

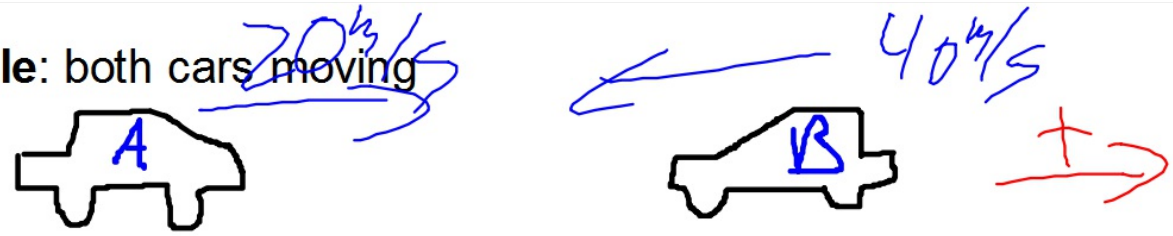
$$p_{TOT}' = 0 + 1000kg\, v_B'$$

$$p_0 = p_f$$

$$40{,}000kg\,m/s = 1000kg\, v_B'$$

$$40\,m/s = v_B'$$

Example: both cars moving



What is p_A, the momentum of Car A, a 2000-kg car moving 20m/s to the right?

$p_A = m_A v_A = 40{,}000\ \text{kg}\cdot\text{m/s}$

What is p_B, the momentum of Car B, a 1000-kg car moving 40m/s to the left?

$p_B = m_B \cdot v_B = 1000\ \text{kg} \cdot 40\ \text{m/s}$

$= 40{,}000\ \text{kg}\cdot\text{m/s}$

What is p_{tot}, the momentum of car A plus the momentum of car B?

$p_{TOT} = 80{,}000\ \text{kg}\cdot\text{m/s}$

$\vec{p}_{TOT} = \vec{p}_A + \vec{p}_B$

$p_{TOT} = 40{,}000\ \text{kg}\cdot\text{m/s} - 40{,}000\ \text{kg}\cdot\text{m/s}$

$= 0$

If the two cars collide, they stop. What is p_{tot} now? Explain this.

$p'_{TOT} = 0$

$p_{TOTO} = 80{,}000 \frac{4}{5}$

How you see ***bad physics*** in movies:

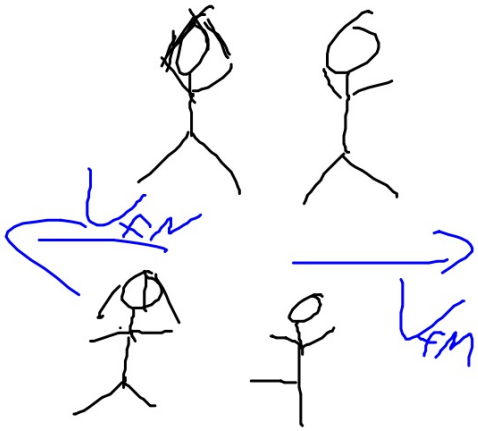
Fight scenes: one person goes flying but the person pushing does not

https://www.youtube.com/watch?v=EmEPXXJ4sKw

Guns that have no recoil: shooting a large recoil gun without preparing for recoil

$$p_0 = 0$$

$$p_f = M_{veo} v_f$$



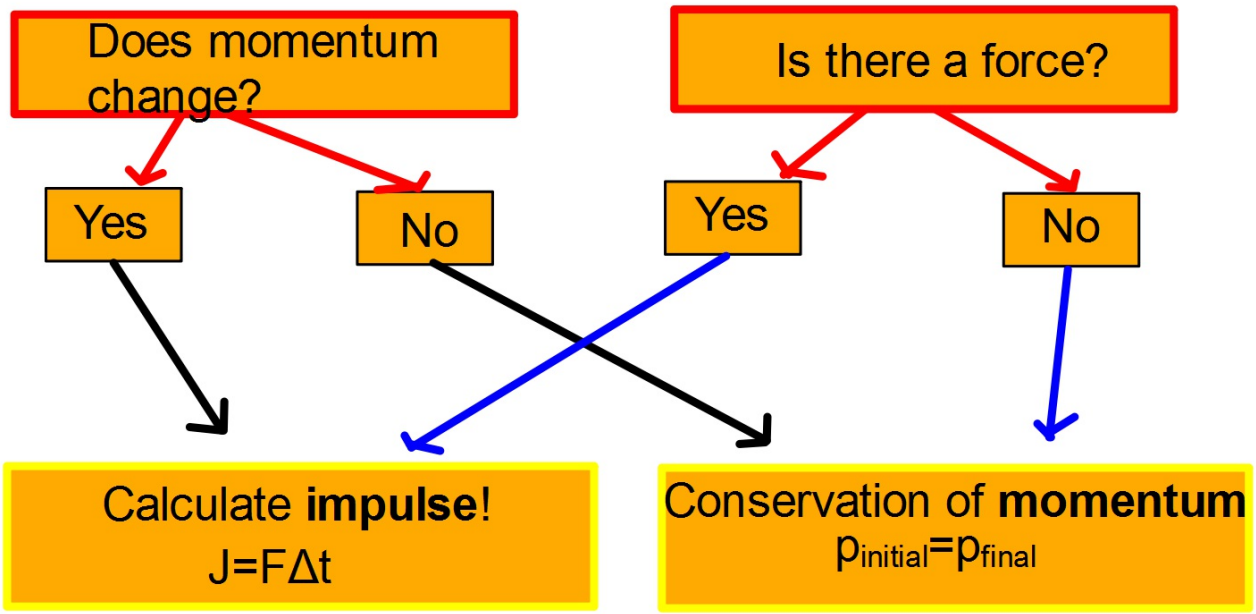
What is the momentum of a 0.50-kg newspaper traveling at a velocity of 3.0m/s?

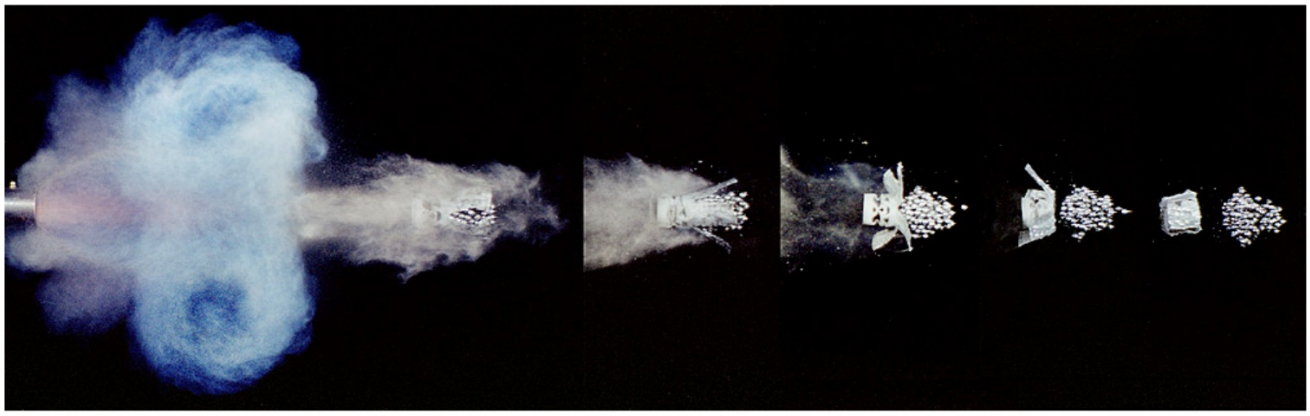
What is the velocity of the 50-kg paperboy throwing the newspaper?

Example: boxcar
A 7700-kg boxcar traveling at 14m/s strikes a second car at rest. The two stick together and move off with a speed of 5.0m/s. What is the mass of the second car?

Example: boxcar
A 7700-kg boxcar traveling at 14m/s strikes a second car at rest (same mass as before). The second car bounces off the first car at a speed of 5m/s, what is the final speed of the first car?

How to solve momentum problems





Example: Terminator 2

The 60kg bad guy is knocked back at 2m/s from each shot of Sarah Connor's shotgun.

If Sarah Connor has a mass of 51kg, what should her velocity be from shooting the gun? Which direction?