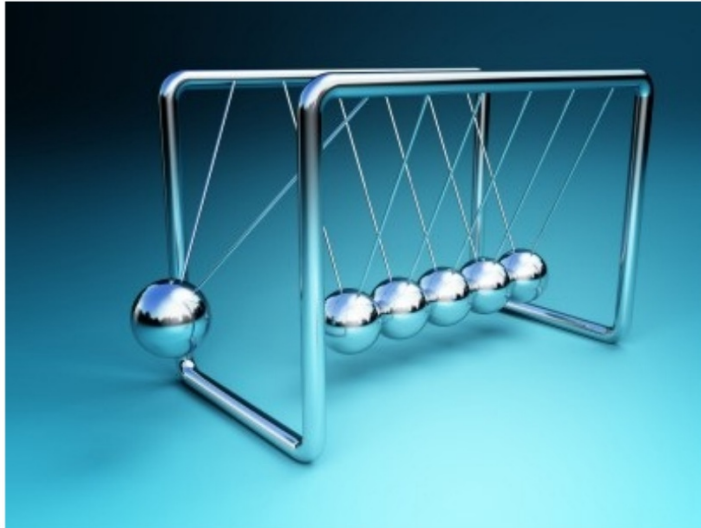


Momentum (Chapter 4)





momentum: p , how much resistance something has to being stopped (c.f. mass)

how much resistance something has to being *accelerated*

$$p=mv$$

momentums (momenta) add together

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

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

(i.e. no outside forces)

Example: Newton's Cradle

<http://www.youtube.com/watch?v=0LnbyjOyEQ8>



Why science teachers
should not be given
playground duty.



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

$$p_A = m v = 2000 \text{ kg} \cdot 20 \frac{\text{m}}{\text{s}} = 40,000 \frac{\text{kg} \cdot \text{m}}{\text{s}}$$

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

$$p_B = m v = 1000 \text{ kg} \cdot 40 \frac{\text{m}}{\text{s}} = -40,000 \frac{\text{kg} \cdot \text{m}}{\text{s}}$$

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

$$40,000 \frac{\text{kg} \cdot \text{m}}{\text{s}} - 40,000 \frac{\text{kg} \cdot \text{m}}{\text{s}} = 0$$

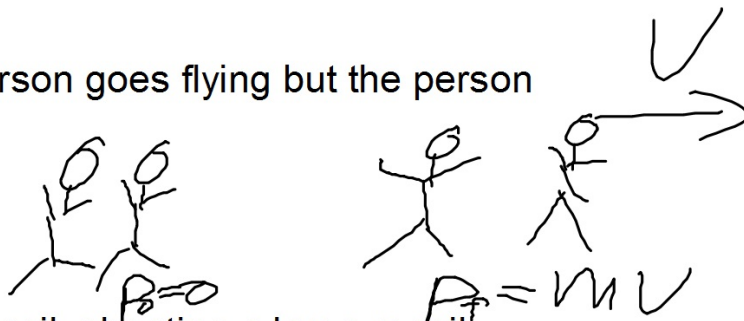
If the two cars collide, they stop. What is p_{tot} now? Explain this.



$$p_{\text{tot}} = m_1 \cdot 0 + m_2 \cdot 0 = 0$$

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

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



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

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

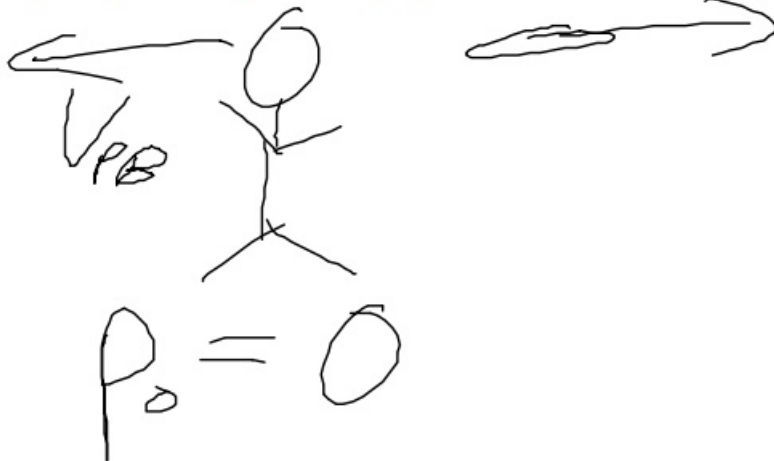


$$p = mV$$

$$0.50 \text{ kg} \cdot 3.0 \frac{\text{m}}{\text{s}}$$

$$= 1.5 \frac{\text{kg} \cdot \text{m}}{\text{s}}$$

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



$$P_T = P_n + P_{PB} = 0$$

$$= m_n \cdot V_n + m_{PB} \cdot V_{PB} = 0$$

$$[1.5 \frac{\text{kg} \cdot \text{m}}{\text{s}} + 50 \text{ kg} \cdot V_{PB} = 0] - 1.5 \frac{\text{m}}{\text{s}}$$

$$[50 \text{ kg} \cdot V_{PB} = -1.5 \frac{\text{kg} \cdot \text{m}}{\text{s}}] \div 50$$

$$V_{PB} = \frac{-1.5 \frac{\text{kg} \cdot \text{m}}{\text{s}}}{50 \text{ kg}}$$

$$= -0.03 \frac{\text{m}}{\text{s}}$$

Example: boxcar

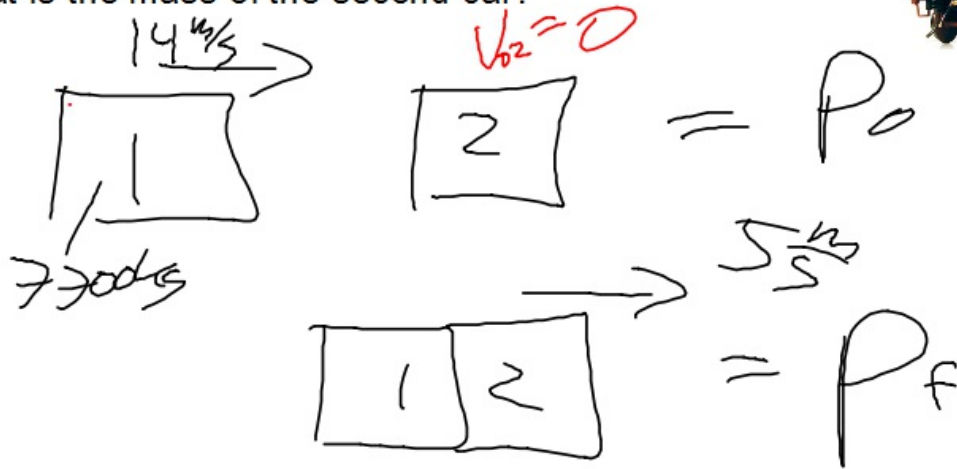
A 7700-kg boxcar traveling at 14m/s strikes a second car at rest. The two stick together and move off with a speed of 5.0m/s. What is the mass of the second car?



Example: boxcar

A 7700-kg boxcar traveling at 14m/s strikes a second car at rest. The cars stick together and move at 5m/s.

What is the mass of the second car?

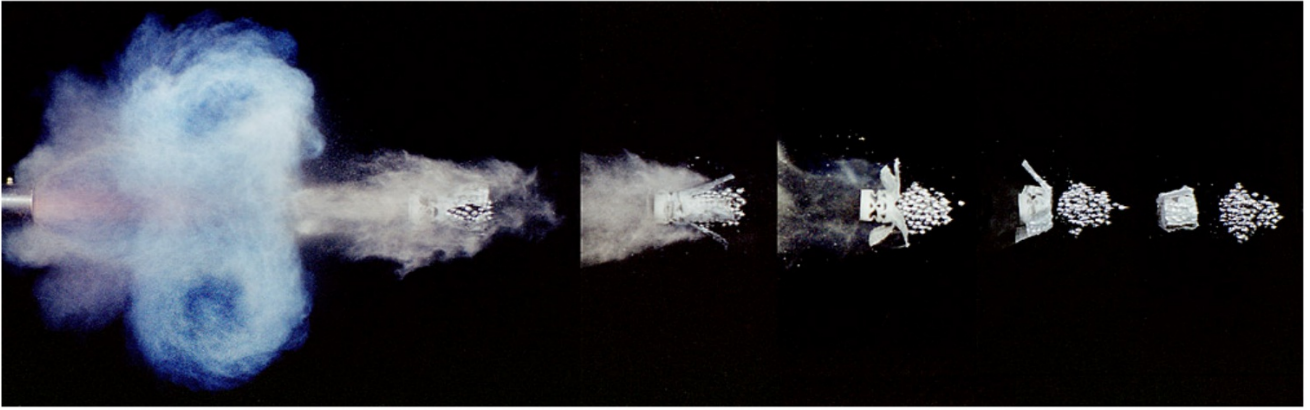


$$P_o = P_f$$

$$P_{1o} + P_{2o} = P_{1f} + P_{2f}$$

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$
$$7700 \text{ kg} \cdot 14 \frac{\text{m}}{\text{s}} + m_2 \cdot 0 = 7700 \text{ kg} \cdot 5 \frac{\text{m}}{\text{s}} + m_2 \cdot 5 \frac{\text{m}}{\text{s}}$$

$$107,800 \frac{\text{kg} \cdot \text{m}}{\text{s}} = 38,500 \frac{\text{kg} \cdot \text{m}}{\text{s}} + 5 \frac{\text{m}}{\text{s}} \cdot m_2$$
$$69,300 \frac{\text{kg} \cdot \text{m}}{\text{s}} = 5 \frac{\text{m}}{\text{s}} \cdot m_2 \quad \div 5$$
$$13,860 \text{ kg} = m_2$$



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?

