Momentum

Defining MOMENTUM

Momentum $\equiv$ Mass x Velocity

Momentum is given by the symbol: $\vec{p}$. So, $\vec{p} = m\vec{v}$

You can think of momentum as the "amount of motion" something has.

For example, which has a momentum of greater magnitude?

A) A 1000 kg car travelling at 60 mi/hr, or

B) A 20000 kg locomotive travelling at 3 mi/hr.

Answer: Both have the same magnitude of momentum.

Momentum is a VECTOR

Momentum has a directional aspect. Momentum is a vector and is fully described by having BOTH magnitude AND direction.

Compare the momentum of a 20 kg cheetah sprinting at 25 m/s to that of a 25 kg cheetah sprinting at 20 m/s.

A) They both have the same momentum.

B) Not enough information given.

Answer: (B) Not enough information…

(We don't know the directions the cheetahs are sprinting.)

Follow-up to the previous example:

A 0.2-kg rubber ball is dropped. The rubber ball hits the floor at a speed of 8.0 m/s and rebounds back up at the same speed. What impulse did the floor impart to the ball to change its momentum?

Impulse = $\Delta\vec{p} = \vec{p}_{final} - \vec{p}_{initial}$

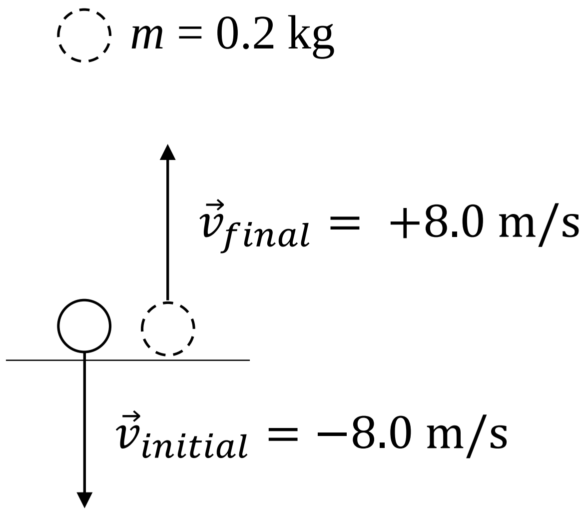
$= m\vec{v}_{final} - m\vec{v}_{initial}$

= (0.2 kg)(+8.0 m/s) – (0.2 kg)(–8.0 m/s)

= +3.2 kg·m/s

(Note that it takes a greater impulse

to make something bounce backward.)



Conservation of Momentum

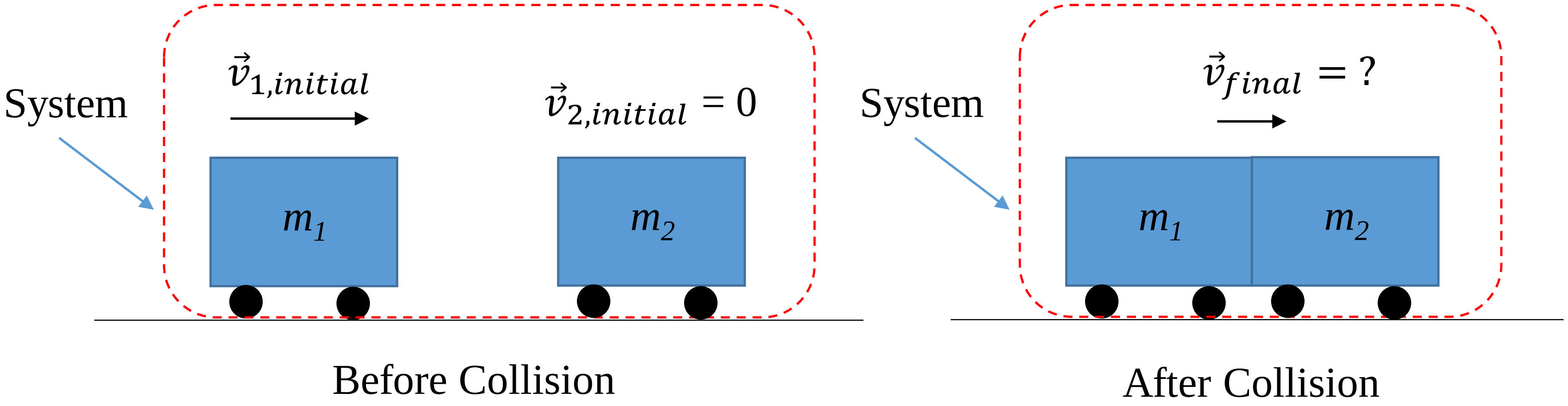
What makes momentum a useful concept?

If the net force on a system is zero, then $\vec{F}_{net}\Delta t$ = 0 and there is no impulse imparted to the system. Therefore, the momentum of the system remains constant. This is conservation of momentum.

Consider cue ball (mass *m*) hitting a stationary 8-ball (same mass *m*):

By conservation of $\vec{p}$, $m\vec{v}$ + 0 = 0 + $m\vec{v}$, so we know that the velocity of the 8-ball after the collision is the same is the incoming cue ball which comes to rest.

Consider a two-cart system where a moving cart bumps into a stationary cart. After the collision, the two carts stick together. Calculate the speed v_{final} of the combination after the collision.



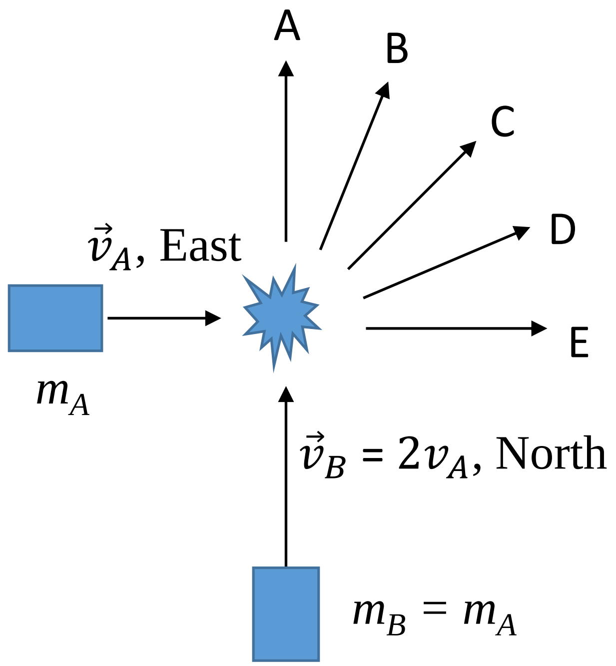
Use Conservation of Momentum: $\vec{p}_{initial} = \vec{p}_{final}$

$$m_1\vec{v}_{1,initial} + m_2\vec{v}_{2,initial} = (m_1 + m_2)\vec{v}_{final}$$

$$\vec{v}_{final} = \frac{m_1\vec{v}_{1,initial}}{(m_1 + m_2)}$$

2-Dimensional Collisions

The figure shows an overhead view of two cars of the same mass approaching an intersection where they collide and stick together. The speed of the northbound car Is twice that of the eastbound car. What path does the wreckage take?



Answer: Path B