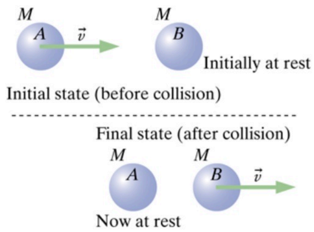
Consider the head-on collision of two identical bowling balls, each with mass 6 kg (see figure). Ball A with velocity $\vec{v}$ = < 3, 0, 0 > m/s strikes ball B, which was at rest. Then ball A stops and ball B moves with the same velocity $\vec{v}$ that ball A had initially.



(a) Choose a system consisting only of ball A.
What is the momentum change of the system during the collision?

$\Delta\vec{p}_{\text{system}}$ = ______ kg · m/s

What is the momentum change of the surroundings?

$\Delta\vec{p}_{\text{surroundings}}$ = ______ kg · m/s

(b) Choose a system consisting only of ball B.
What is the momentum change of the system during the collision?

$\Delta\vec{p}_{\text{system}}$ = ______ kg · m/s

What is the momentum change of the surroundings?

$\Delta\vec{p}_{\text{surroundings}}$ = ______ kg · m/s

(c) Choose a system consisting of both balls.
What is the momentum change of the system during the collision?

$\Delta\vec{p}_{\text{system}}$ = ______ kg · m/s

What is the momentum change of the surroundings?

$\Delta\vec{p}_{\text{surroundings}}$ = ______ kg · m/s

Part a

$$\Delta\vec{p}_{sys} = \langle -18, 0, 0 \rangle \, kg\frac{m}{s}$$

$$\Delta\vec{p}_{surr} = \langle 18, 0, 0 \rangle \, kg\frac{m}{s}$$

Part B

$$\Delta\vec{p}_{sys} = \langle 18, 0, 0 \rangle \, kg\frac{m}{s}$$

$$\Delta\vec{p}_{surr} = \langle -18, 0, 0 \rangle \, kg\frac{m}{s}$$

Part C

$$\Delta\vec{p}_{sys} = \langle 0, 0, 0 \rangle \, kg\frac{m}{s}$$

$\Delta \vec{p}_{surr} = \langle 0,0,0 \rangle \, kg\frac{m}{s}$

Object A has mass m_A = 8 kg and initial *momentum* $\vec{p}_{A,i}$ = < 22, -6, 0 > kg · m/s, just before it strikes object B, which has mass m_B = 10 kg. Just before the collision object B has initial *momentum* $\vec{p}_{B,i}$ = < 6, 7, 0 > kg · m/s.

Consider a system consisting of both objects A and B. What is the total initial momentum of this system, just before the collision?

$\vec{p}_{sys,i}$ = [ ] kg · m/s

The forces that A and B exert on each other are very large but last for a very short time. If we choose a time interval from just before to just after the collision, what is the approximate value of the impulse applied to the two-object system due to forces exerted on the system by objects outside the system?

$\vec{F}_{net}\Delta t$ = [ ] N · s

Therefore, what does the Momentum Principle predict that the total final momentum of the system will be, just after the collision?

$\vec{p}_{sys,f}$ = [ ] kg · m/s

Just after the collision, object A is observed to have momentum $\vec{p}_{A,f}$ = < 18, 4, 0 > kg · m/s. What is the momentum of object B just after the collision?

$\vec{p}_{B,f}$ = [ ] kg · m/s

Part A

$\vec{P}_{sys\,i} = \vec{P}_A + \vec{P}_b$

$= \langle 28, 1, 0 \rangle \, kg\frac{m}{s}$

Part B

$F_{net}\Delta t = \langle 0,0,0 \rangle \, kg\frac{m}{s}$

Part C

$\vec{P}_{sys\,f} = \langle 28, 1, 0 \rangle \, kg\frac{m}{s}$

Part D

$\vec{P}_{sys} = \vec{P}_a + \vec{P}_b$

$\vec{P}_b = \vec{P}_{sys} - \vec{P}_a$

$= \langle 10, -3, 0 \rangle \, kg\frac{m}{s}$

You and a friend each hold a lump of wet clay. Each lump has a mass of 25 grams. You each toss your lump of clay into the air, where the lumps collide and stick together. Just before the impact, the velocity of one lump was < 6, 3, -3 > m/s, and the velocity of the other lump was < -3, 0, -5 > m/s.

What was the the total momentum of the lumps just before the impact?

$\vec{p}_{total}$ = [ ] kg · m/s.

What is the momentum of the stuck-together lump just after the collision?

$\vec{p}$ = [ ] kg · m/s.

What is the velocity of the stuck-together lump just after the collision?

$\vec{v}_f$ = [ ] m/s.

Part A

$$\vec{P}_{sys} = \vec{P}_1 + \vec{P}_2$$

$$= V_1 m_1 + V_2 m_2$$

$$= \langle 0.15, 0.075, -0.075 \rangle + \langle -0.075, 0, -0.125 \rangle$$

$$= \langle 0.075, 0.075, -0.2 \rangle \, kg \tfrac{m}{s}$$

Part B

$$\vec{P} = \langle 0.075, 0.075, -0.2 \rangle \, kg \tfrac{m}{s}$$

Part C

$$\vec{V}_f = \frac{\vec{P}}{m_1 + m_2}$$

$$= \frac{\vec{P}}{0.05}$$

$$= \langle 1.5, 1.5, -4 \rangle \, kg \tfrac{m}{s}$$

A car of mass 3000 kg collides with a truck of mass 4400 kg, and just after the collision the car and truck slide along, stuck together. The car's velocity just before the collision was < 37, 0, 0 > m/s, and the truck's velocity just before the collision was < -11, 0, 22 > m/s.

(a) What is the velocity of the stuck-together car and truck just after the collision?

[ ] m/s

(b) In your analysis in part (a), why can you neglect the effect of the force of the road on the car and truck?

- ○ Short collision time, negligible impulse compared to large impulse acting between car and truck.
- ○ The road doesn't exert forces on the car or truck and doesn't affect the vehicles.

$$\vec{P}_{sys} = \vec{P}_{car} + \vec{P}_{truck}$$

$$= \vec{V}_{car} m_{car} + \vec{V}_{truck} m_{truck}$$

$$= \langle 111000, 0, 0 \rangle + \langle -48400, 0, 96800 \rangle$$

$$= \langle 62600, 0, 96800 \rangle \, kg\frac{m}{s}$$

$$\vec{V}_{both} = \frac{\vec{P}_{sys}}{m_{both}}$$

$$= \frac{\vec{P}_{sys}}{m_{car} + m_{truck}}$$

$$= \frac{\vec{P}_{sys}}{7400}$$

$$= \langle 8.459, 0, 13.081 \rangle \frac{m}{s}$$