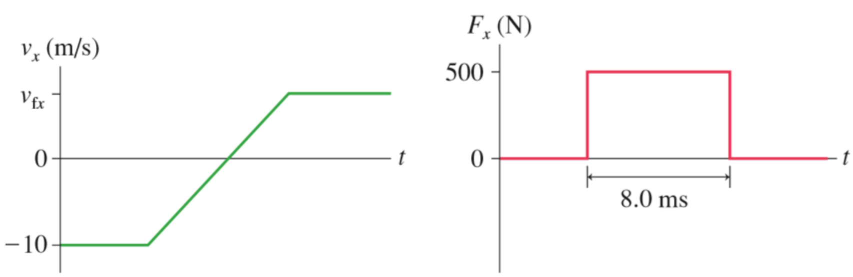
STEM Success Center

Phys 201: Chapter 9 Impulse and Momentum

Before we begin the problems, it helps to list your known's and unknowns/what we are solving for. This helps with organization by identifying the what the problem is asking for. Also, red represents the solution.

Section 9.2: Solving Impulse and Momentum Problems

12) A 250 g ball collides with a wall. The figure below shows the ball's velocity and the force exerted on the ball by the wall. What is v_{fx}, the ball's rebound velocity?



Known:

$m_b = 250kg = 0.25kg$

$v_{ix} = -\frac{10m}{s}$

$F_x = 500N \; for \; t = 8ms$

Find:

$v_{fx} = ?$

Given that a force is being applied to an object during a time interval, then find the impulse $(\boldsymbol{J_x})$.

$$J_x = \int_{t_i}^{t_f} ⟦F_x dt = 500 \int_{0s}^{8ms} dt = 500\left[t_f -⟧t_i\right| = 500\,[0.008ms - 0s] = 4N \cdot s$$

Now, use the impulse-momentum theorem ($\Delta P_x = J_x$) to solve for the final velocity.

$$\Delta P_x = J_x$$

$$P_{fx} - P_{ix} = J_x$$

$$m_b v_{fx} - m_b v_{ix} = J_x$$

$$m_b v_{fx} = J_x + m_b v_{ix}$$

$$v_{fx} = \frac{J_x}{m_b} + v_{ix}$$

$$v_{fx} = \frac{4N \cdot s}{0.25kg} + \left(-10\frac{m}{s}\right) = 16\frac{m}{s} - 10\frac{m}{s} = 6\frac{m}{s}$$

Section 9.3: Conservation of Momentum

16) A 10-m-long glider with a mass of 680 kg (including the passengers) is gliding horizontally through the air at 30 m/s when a 60 kg skydiver drops out by releasing his grip on the glider. What is the glider's velocity just after the skydiver lets go?

Known:

$m_S = 60kg$ (mass of skydiver)

$m_{G+S} = 680kg$ (mass of glider plus the mass of skydiver)

$m_G = m_{G+S} - m_S = 680kg - 60kg = 620kg$ (mass of glider)

$v_{G_i} = 30\frac{m}{s}$

$m_S = 60kg$

Note: turns out as the skydiver releases, the skydiver's final velocity will be the same as glider's initial velocity thus,

$v_{S_f} = v_{G_i}$

Find:

$v_{G_f} = ?$

Using the Law of Conservation of Momentum equation ($\boldsymbol{P_f} = \boldsymbol{P_i}$),

$$〚(m〛_G)v_{G_f} + 〚(m〛_S)v_{S_f}〚= (m〛_{G+S})v_{G_i}$$

Substitute v_{G_i} for v_{S_i} given that $v_{S_i} = v_{G_i}$, then solve for the gliders final velocity

$$〚(m〛_G)v_{G_f} + 〚(m〛_S)v_{G_i}〚= (m〛_{G+S})v_{G_i}$$

$$〚(m〛_G) v_{G_f} 〚= (m〛_{G+S}) v_{G_i} - 〚(m〛_S) v_{G_i}$$

$$v_{G_f} = \frac{〚(m〛_{G+S}) v_{G_i} - 〚(m〛_S) v_{G_i}}{m_G} = \frac{〚(m〛_{G+S}) - 〚(m〛_S)}{m_G} \cdot (v_{G_i}) = \frac{680kg - 60kg}{620kg} \cdot \left(30\frac{m}{s}\right)$$
$$= 30\frac{m}{s}$$

To check you answer, plug in the v_{G_f} and all other knowns to see whether if each side are equivalent.

Section 9.4: Inelastic Collisions

19) A 1500 kg car is rolling at 2.0 m/s. You would like to stop the car by firing a 10 kg blob of sticky clay at it. How fast should you fire the clay?

Known:

$m_{Car} = 1500kg$

$v_{car} = 2\frac{m}{s}$

$m_{clay} = 10kg$

Find:

$v_{clay} = ?$

Note: To stop the vehicle that has momentum, the clay needs momentum of the same magnitude to make car's momentum zero.

Use the Law of Conservation of Momentum ($\boldsymbol{P_f} = \boldsymbol{P_i}$) to solve for the clay's velocity

$$P_f = P_i$$

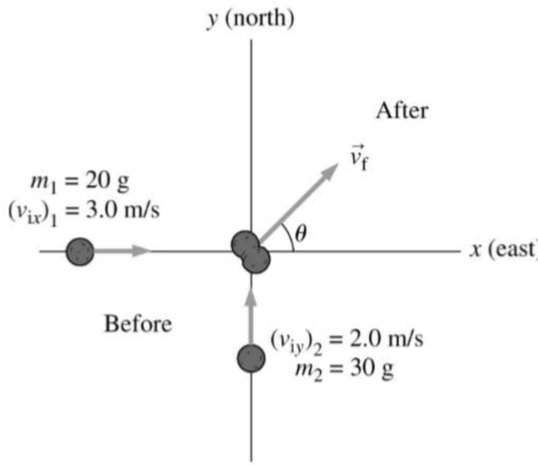
$$m_{clay} v_{clay} = m_{car} v_{car}$$

$$v_f = \frac{m_{car}}{m_{clay}}(v_{car}) = \frac{1500kg}{10kg} \cdot \left(2\frac{m}{s}\right) = 150kg \cdot \left(2\frac{m}{s}\right) = 300\frac{m}{s}$$

To check your answer, see if the momentum of the clay is same as the momentum of the car.

Section 9.6: Momentum in Two Dimensions

25) A 20 g ball of clay traveling east at 3.0 m/s collides with a 30 g ball of clay traveling north at 2.0 m/s. What are the speed and the direction of the resulting 50 g ball of clay?



<u>Known:</u>

$m_1 = 20g = 0.020kg$

$(v_{ix})_1 = 3\frac{m}{s}$

$m_2 = 30g = 0.030kg$

$(v_{iy})_2 = 2\frac{m}{s}$

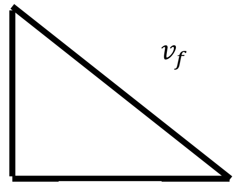
<u>Find:</u>

v_f=?

θ =?

Use the Law of Conservation of Momentum ($\boldsymbol{P_f} = \boldsymbol{P_i}$) to solve for the clay's velocity

$$P_f = P_i$$



X-direction: $m_1(v_{ix})_1 + m_2(v_{ix})_2 = (m_1 + m_2)v_{fx}$

Rewrite v_{fx} in terms of v_f using trigonometry.

$$\cos(\theta) = \frac{v_{fx}}{v_f} \rightarrow v_{fx} = v_f \cos(\theta)$$

$$\rightarrow m_1(v_{ix})_1 + m_2(v_{ix})_2 = (m_1 + m_2)v_f \cos(\theta)$$

$$\rightarrow v_f \cos(\theta) = \frac{m_1(v_{ix})_1 + m_2(v_{ix})_2}{(m_1 + m_2)}$$

$$v_f \cos(\theta) = 1.2\frac{m}{s}$$

Y-direction: $m_1(v_{iy})_1 + m_2(v_{iy})_2 = (m_1 + m_2)v_{fy}$

Rewrite v_{fy} in terms of v_f using trigonometry.

$$\sin(\theta) = \frac{v_{fy}}{v_f} \rightarrow v_{fy} = v_f \sin(\theta)$$

$$\rightarrow m_1(v_{iy})_1 + m_2(v_{iy})_2 = (m_1 + m_2)v_f \sin(\theta)$$

$$\rightarrow v_f \sin(\theta) = \frac{m_1(v_{iy})_1 + m_2(v_{iy})_2}{(m_1 + m_2)}$$

$$v_f \sin(\theta) = 1.2\frac{m}{s}$$

Use the Pythagorean theorem **($\boldsymbol{c^2 = a^2 + b^2}$)** to find v_f, thus

$$v_f^2 = v_{fx}^2 + v_{fy}^2$$

Substitute v_{fx} and v_{fy} (which was found above):

$$\rightarrow v_f = \sqrt{(v_f \cos(\theta))^2 + (v_f \sin(\theta))^2}$$

$$v_f = \sqrt{\left(1.2\frac{m}{s}\right)^2 + \left(1.2\frac{m}{s}\right)^2} \approx 1.69\frac{m}{s}$$

$$\tan(\theta) = \frac{v_{fy}}{v_{fx}}$$

$$\rightarrow \theta = \tan^{-1}\left(\frac{v_{fy}}{v_{fx}}\right)$$

$$\theta = \tan^{-1}\left(\frac{1.2\frac{m}{s}}{1.2\frac{m}{s}}\right) = 45°$$

The clay has a velocity of 1.69 m/s heading northeast at a 45-degree angle.