4.3 Conservation of Momentum

The total momentum of a system is constant. In other words.

Total Momentum before = Total Momentum after

km/h

ex. A 1500 kg car is reversing at 65 ~~m/s~~ and crashes into a parked 2500 kg truck. What velocity does the crumpled combined mass have? (this is called an inelastic collision because the two masses do not bounce off one another)

65 km/h = 18.05 m/s

momentum before = momentum after

$m_1 v_{1o} + m_2 v_{2o} = m_1 v_{1f} + m_2 v_{2f}$

$(1500\text{kg})(-18.05\text{m/s}) + 0 =$ here $v_{1f} = v_{2f} = v_f$

$-27083.3\ \text{kg m/s} = v_f (m_1 + m_2)$

$\frac{-27083.3}{4000} = \frac{v_f (1500 + 2500)}{4000}$

$-6.8\text{m/s} = v_f$ or $v_f \approx -24$ km/h

In formal calculations, we usually denote initial conditions with a *0* and final conditions with an *f* and each mass with a 1 and a 2. Thus the conservation of momentum equation becomes.

$$m_1 v_{1o} + m_2 v_{2o} = m_1 v_{1f} + m_2 v_{2f}$$

ex. Two hockey players (90 kg and 105 kg) push each other from rest in opposite directions. If the heavier player moves backwards with a velocity of 3 m/s, what velocity will the 90 kg player have?

initial = final

no movement finitial = 0

$m_1 \vec{v}_{1f} + m_2 \vec{v}_{2f}$

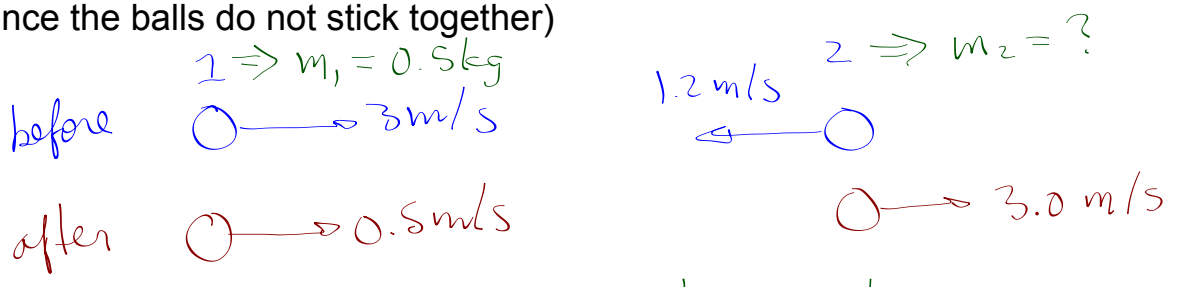
$0 = (105\text{kg})(3\text{m/s}) + (90\text{kg})\vec{v}_{2f}$

$0 = 315 + 90\,\vec{v}_{2f}$

$\frac{-315}{90} = \vec{v}_{2f}$

$-3.5\text{m/s} = \vec{v}_{2f}$

ex. Two balls collide. Initially, ball 1 travels to the right at 3.0 m/s and ball 2 moves left at 1.2 m/s. Ball 1 continues to the right at 0.50 m/s after the collision and ball 2 also moves to the right but with a velocity of 3.0 m/s. If ball 1 has a mass of 0.50 kg, what is the mass of ball 2? (this is known as elastic collision since the balls do not stick together)



$$m_1 v_{1_0} + m_2 v_{2_0} = m_1 v_{1f} + m_2 v_{2f}$$
$$(0.5)(3) + m_2(-1.2) = (0.5)(0.5) + m_2(3)$$
$$1.5 - 1.2m_2 = 0.25 + 3m_2$$
$$1.5 - 0.25 = 3m_2 + 1.2m_2$$
$$\frac{1.25}{4.2} = \frac{4.2m_2}{4.2}$$
$$\boxed{m_2 = 0.30 \text{ kg}}$$

ex. A 7500 kg rocket is travelling upward at 350 m/s when it drops its fuel booster. If the 5000 kg fuel booster is left behind and continues at 150 m/s, what is the final speed of the remaining portion of rocket?

momentum before = momentum after

$$m v_0 = m_1 \vec{v}_{1f} + m_2 \vec{v}_{2f}$$
$$(7500)(350) = (5000)(150) + (2500)\vec{v}_{2f}$$
$$2625000 = 750000 + 2500\vec{v}_{2f}$$
$$\frac{2625000 - 750000}{2500} = \frac{2500\vec{v}_{2f}}{2500}$$
$$\boxed{750 = \vec{v}_{2f}}$$

$7500 - 5000 = 2500$ kg

practice: handout