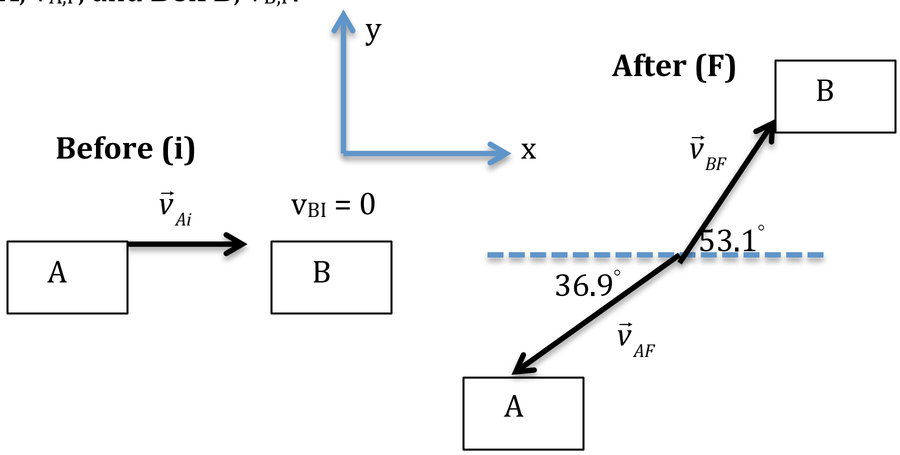
This problem illustrates that **conservation of momentum** is **vector problem**. Below **object A** (mass $m_A$ = 3kg) travels horizontally at $v_{Ai}$ = 2 m/s, **collides** with **object B** (mass $m_A$ = 2kg). **Object B** moves off at 53.1° above the horizontal, while **object B** moves off at 36.9° below the horizontal, as shown. Find the **final speed** of **Box A**, $v_{A,F}$, and **Box B**, $v_{B,F}$.




**SOLUTION** Use **conservation** of **momentum** in the x and y **components**.

**Initial momentum** $\vec{p}_{Ai} + \vec{p}_{Bi} = \vec{p}_{AF} + \vec{p}_{BF}$ **Final Momentum**

**X-component**: **Before** **After**

$$p_{Ai,x} + p_{Bi,x} = p_{AF,x} + p_{BF,x} \rightarrow m_A v_{Ai,x} + m_B v_{Bi,x} = m_A v_{AF,x} + m_B v_{BF,x}.$$

With $v_{Ai}$ = 2 m/s and $v_{Bi}$ = 0, $6kg \bullet m \bullet s^{-1} = -3kg \times v_{AF} \cos 53.1^0 + 2kg \times v_{BF} \cos 36.9^0 \rightarrow$

$6kg \bullet m \bullet s^{-1} = -1.8kg \times v_{AF} + 1.6kg \times v_{BF}$, [1]. Note the minus (–) sign

**y-component**: **Before** **After**

$$p_{Ai,y} + p_{Bi,y} = p_{AF,y} + p_{BF,y} \rightarrow m_A v_{Ai,y} + m_B v_{Bi,y} = m_A v_{AF,y} + m_B v_{BF,y}.$$

Since there's **zero** y-component initial momentum,

$0 = -3kg \times v_{AF} \sin 53.1^0 + 2kg \times v_{BF} \sin 36.9^0 \rightarrow 0 = -2.4kg \times v_{AF} + 1.2kg \times v_{BF}$

$v_{AF} = 0.5 \times v_{BF}$, [2]. To find $v_{A,F}$, and $v_{B,F}$ substitute equation [2] into [1]

$6kg \bullet m \bullet s^{-1} = -1.8kg \times (0.5 \times v_{BF}) + 1.6kg \times v_{BF} \rightarrow v_{BF} = 8.57 m \bullet s^{-1}$.

Resubstitute into [2], we obtain $v_{AF} = 4.28 m \bullet s^{-1}$.

Is this an **elastic collision**? Final (F) Initial (i)

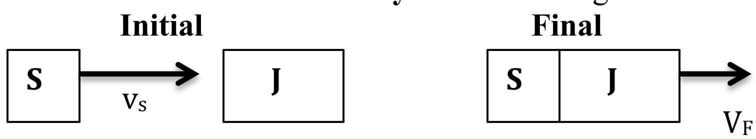
Change in Kinetic Energy, $\Delta K = K_F - K_i = \left(\frac{1}{2} m_A v_{AF}^2 + \frac{1}{2} m_B v_{BF}^2\right) - \left(\frac{1}{2} m_A v_{Ai}^2 + \frac{1}{2} m_B v_{Bi}^2\right)$

$K_{AF}$ $K_{BF}$ $K_{Ai}$ $K_{Bi}$

$$\Delta K = \left(\frac{1}{2}(3kg)\left(4.28\frac{m}{s}\right)^2 + \frac{1}{2}(2kg)\left(8.57\frac{m}{s}\right)^2\right) - \left(\frac{1}{2}(3kg)\left(2\frac{m}{s}\right)^2 + \frac{1}{2} m_B 0^2\right) = 95J.$$

There is an **increase** in **kinetic energy**. This is an inelastic collision.
An energy gain suggests that the collision induces a **collision**!

Here is a completely **inelastic collision**, where objects stick to gether. In the figure below, a 60 kg hockey player, named Sarawak skates at 15 m/s, and **collides** with a **stationary** player named Jesse, who weighs 70 kg. They stick together and slide along the ice at an **unknown final velocity**. Take +x as right.




**A) (2 points)** Use **conservation** of **momentum** to determine the Final velocity.

$$M_S v_s = \left(M_s + M_J\right)V_F \rightarrow V_F = \frac{60kg \times 15 m \bullet s^{-1}}{60kg + 70kg} = 6.92 m \bullet s^{-1}.$$

**B) Change** in **Kinetic Energy**: $\Delta K = \frac{1}{2}\left(M_s + M_J\right)V_F^2 - \frac{1}{2}\left(M_s v_s^2\right) = -3.6J$.

Final K Initial K

**Energy is lost!** Energy is transferred to the hockey players.

Below **object A** (mass $m_A$ = 2kg) travels horizontally at $v_{Ai}$ = 2 m/s, **collides** with **object B** (mass $m_A$ = 2kg). **Object B** moves off at 53.1° above the horizontal, while **object B** moves off at 36.9° also **above** the **horizontal**, as shown. Find the **final speed** of **Box A**, $v_{A,F}$, and **Box B**, $v_{B,F}$.