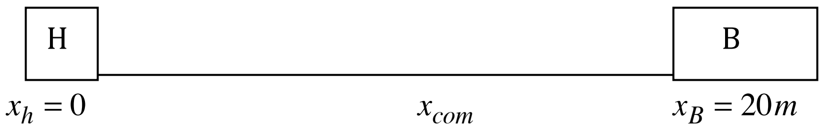
PHYS 1211, QUIZ 8, November 17, 2017 max grade 15 out of 10

1) In the diagram below, a 64 kg hunter gets a rope around a 320 kg polar bear. They are **stationary**, 20 m apart, on **frictionless level ice**.



A) (1 point) Calculate the **center-of-mass** (**com**) position.

$$x_{com} = \frac{M_h x_h + M_B x_B}{M_h + M_B} = \frac{64kg \times 0m + 320kg \times 20m}{64kg + 320kg} = 16.7m$$

B) (1 point) What is the **initial com velocity**, $\mathbf{v_{com,i}}$?

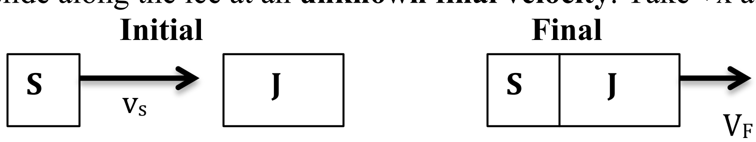
Note that $v_{com} = \frac{M_h v_{h,0} + M_B v_{B,0}}{M_h + M_B} = 0$, since initially **both** are at **rest**.

C) (1 point) The hunter pulls the polar bear to him until they are at the same location. Calculate the **distance** and **direction** that the **bear** moves from its **initial position**.
The hunter and the bear will be at the initial center-of-mass, $x_{com} = 16.7$m. So the bear must move 3.3m from its **initial position**.

D) (1 point) What **law** of **physics** was used in part **C**? Explain in **no more** than **three sentences**.

We use Newton's second law for system of particles, $\vec{F}_{ext}^{Net} = M\vec{a}_{com}$. The bear and hunter are on ice, so they are effectively isolated, and there is no external force, so the **initially** at **rest** com will **remain** at **rest**, and x_{com} remains the same.

2) 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.

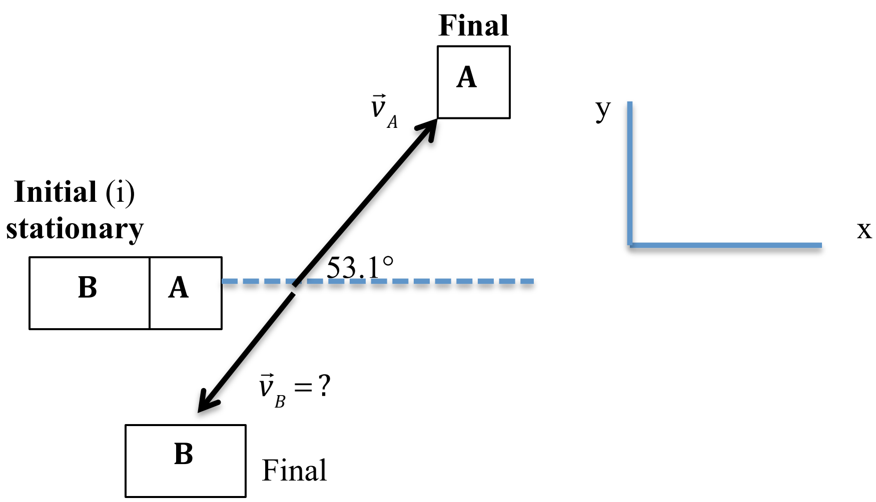
$$M_S v_s = \left(M_s + M_J\right) V_F \rightarrow V_F = \frac{60kg \times 15m \bullet s^{-1}}{60kg + 70kg} = 6.92m \bullet s^{-1}.$$

B) (2 points) Calculate the **initial** center-of-mass (COM) velocity, $\vec{v}_{com,i}$ then calculate the **final** COM velocity, $\vec{v}_{com,f}$.

Initial, use formula $v_{com,i} = \frac{M_s v_s}{M_s + M_J} = 6.92\frac{m}{s}$. Final, after the collision they stick together, and move with velocity, $V_F = 6.92$ m/s, so the **com velocity** are the **same**.

C) (1 point) In no more than **two sentences** explain why the velocities are the **same**.
Just like problem 1, skaters are on ice so the constitute an isolated system with **zero external force**. This means that the com acceleration is zero, $a_{com} = 0$, and the com velocity, v_{com}, must remain constant.

3) In the figure below, an object with two connected components, A (m_A = 3 kg), and B (m_B = 5 kg) is at **rest** in **outer space**. It then **explodes**, and component **A moves** off at a **speed** of v_A = 3.4 m/s at 53.1° **above** the **horizontal**. Component **B moves** off **below** the **horizontal** as shown.



A) (3 points) Calculate the x and y **components** of the **velocity** and **momentum** of **component A**, **after** the **explosion**, and then expressed them in **unit vector form**.

x-component: $v_{A,x} = v_A \cos 53.1 = 2.04 m \bullet s^{-1} \rightarrow p_{A,x} = m_A v_{A,x} = 6.12 kg \bullet m \bullet s^{-1}$.

y-component: $v_{A,y} = v_A \sin 53.1 = 2.72 m \bullet s^{-1} \rightarrow p_{A,y} = m_A v_{A,y} = 8.16 kg \bullet m \bullet s^{-1}$.

Vector form: $\vec{v} = 2.04 m \bullet s^{-1} \hat{i} + 2.72 m \bullet s^{-1} \hat{j} \rightarrow \vec{p} = 6.12 kg \bullet m \bullet s^{-1} \hat{i} + 8.16 kg \bullet m \bullet s^{-1} \hat{j}$.

B) (3 points) Use **conservation** of **momentum** to find the **velocity** and **momentum** of **component B**, **after** the **explosion**, and then expressed them in **unit vector form**.

Initial (both at rest) $0 = \vec{P}_A + \vec{P}_B$ **Final**

x-component: $p_{A,x} + p_{B,x} = 0 \rightarrow p_{B,x} = -p_{A,x} = -6.12 kg \bullet m \bullet s^{-1}$

y-component: $p_{A,y} + p_{B,y} = 0 \rightarrow p_{B,y} = -p_{A,y} = -8.16 kg \bullet m \bullet s^{-1}$

$\vec{p}_B = -6.12 kg \bullet m \bullet s^{-1} \hat{i} - 8.16 kg \bullet m \bullet s^{-1} \hat{j}$,

$$\vec{v}_B = \frac{\vec{p}_B}{m_B} = -1.224 m \bullet s^{-1} \hat{i} - 1.632 m \bullet s^{-1} \hat{j}$$