PHYS 2414 HW#8 SOLUTIONS

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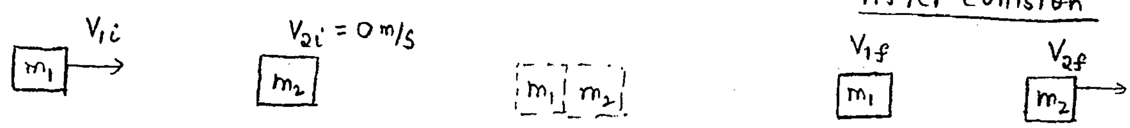
A ball of mass 0.340 kg moving east (+x direction) with a speed of 3.20 m/s collides head-on with a 0.200 kg ball at rest. If the collision is perfectly elastic, what will be the speed and direction of each ball after the collision?

ball originally at rest	4.03 m/s	---Select--- east
ball originally moving east	0.83 m/s	---Select--- east

Sol: Before collision — Collision — After collision



Since collision is perfectly elastic both momentum and kinetic energy are conserved. i.e

$$(\vec{P}_{tot})_{initial} = (\vec{P}_{tot})_{final}.$$

$$K_{initial} = K_{final}.$$

$\vec{P} = m\vec{v}$ $\left(kg\ m/s\right)$ depends on direction (vector)

$K = \frac{1}{2}mv^2$ (J) does not depend on direction of motion. (scalar)

Therefore,

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f} \quad \text{— (1)}$$

$$\frac{1}{2}m_1 v_{1i}^2 + \frac{1}{2}m_2 v_{2i}^2 = \frac{1}{2}m_1 v_{1f}^2 + \frac{1}{2}m_2 v_{2f}^2 \quad \text{— (2)}$$

{ Note: We can right away put $V_{2i} = 0$, which will simplify calculation. But we will do this algebra once keeping everything so that we can use it in other problems. }

Collect terms with mass m_1 on one side and terms with mass m_2 on other side in both equations.

$$m_1(V_{1i} - V_{1f}) = m_2(V_{2f} - V_{2i}) \quad — (3)$$

$$m_1(V_{1i}^2 - V_{1f}^2) = m_2(V_{2f}^2 - V_{2i}^2) \quad — (4)$$

divide (4) by (3) [This can be done excluding a rare case of $V_{1i} = V_{1f}$ and $V_{2i} = V_{2f}$.]

$$\frac{\cancel{m_1}(V_{1i}^2 - V_{1f}^2)}{\cancel{m_1}(V_{1i} - V_{1f})} = \frac{\cancel{m_2}(V_{2f}^2 - V_{2i}^2)}{\cancel{m_2}(V_{2f} - V_{2i})}$$

$$\Rightarrow \frac{\cancel{(V_{1i} - V_{1f})}(V_{1i} + V_{1f})}{\cancel{(V_{1i} - V_{1f})}} = \frac{\cancel{(V_{2f} - V_{2i})}(V_{2f} + V_{2i})}{\cancel{(V_{2f} - V_{2i})}}$$

using $a^2 - b^2 = (a+b)(a-b)$

$$\Rightarrow V_{1i} + V_{1f} = V_{2f} + V_{2i} \quad — (5)$$

Solve for V_{1f}

$$\boxed{V_{1f} = V_{2f} + V_{2i} - V_{1i}} \quad — (A)$$

Plug in V_{1f} in eq (1)

$$m_1 V_{1i} + m_2 V_{2i} = m_1(V_{2f} + V_{2i} - V_{1i}) + m_2 V_{2f}$$

$$m_1 V_{1i} + m_2 V_{2i} = \underline{\underline{m_1 V_{2f}}} + m_1 V_{2i} - m_1 V_{1i} + \underline{\underline{m_2 V_{2f}}}$$

Solving for V_{2f},

$$\underline{\underline{m_1 V_{2f}}} + \underline{\underline{m_2 V_{2f}}} = \underline{m_1 V_{1i}} + m_2 V_{2i} - m_1 V_{2i} + \underline{m_1 V_{1i}}$$

$$V_{2f}(m_1 + m_2) = 2 m_1 V_{1i} + (m_2 - m_1) V_{2i}$$

$$\boxed{V_{2f} = \frac{2 m_1 V_{1i} + (m_2 - m_1) V_{2i}}{(m_1 + m_2)}} \quad — (B)$$

Once we have number for V_{2f} we can plug-it back in (A) to get V_{1f}.