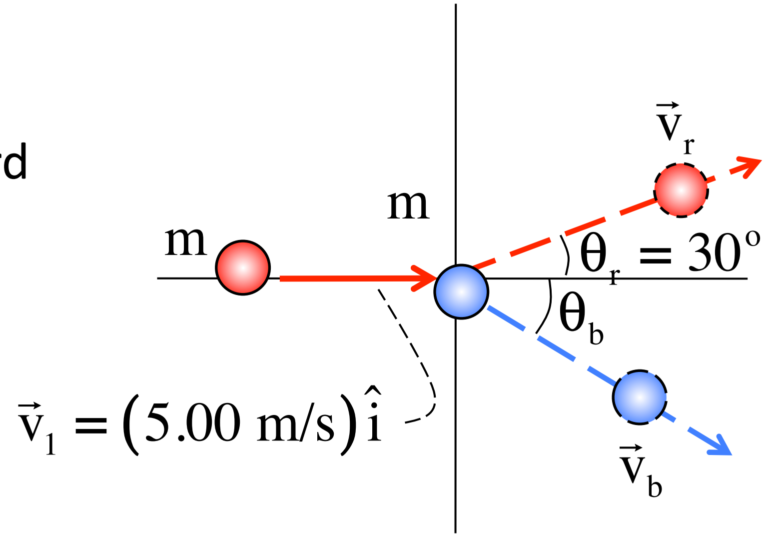
Problem 9.33



A billiard ball of mass "m" hits a stationary billiard ball a glancing blow in an assumed "elastic collision." As a consequence, its velocity magnitude becomes $\vec{v}_r = (4.33 \text{ m/s}) \measuredangle 30^o$.

Determine the blue ball's final velocity.

This is another classic *conservation of momentum* problem. Using that, we can write:

$$\sum p_{1,x} + \cancelto{0}{\sum F_{external,x} \Delta t_{throughCollision}} = \sum p_{2,x}$$

$$\Rightarrow \quad m_r v_1 = m_r v_r \cos\theta_r + m_b v_b \cos\theta_b$$

$$\Rightarrow \quad \cancel{m}(5.00 \text{ m/s}) = \cancel{m}(4.33 \text{ m/s})\cos 30^o \cancel{+} m v_b \cos\theta_b$$

$$\Rightarrow \quad v_b \cos\theta_b = (5.00 \text{ m/s}) - (4.33 \text{ m/s})\cos 30^o$$

$$\Rightarrow \quad v_b \cos\theta_b = 1.25 \text{ m/s}$$

With velocity signs unembedded to make the "v" terms magnitudes in the y-part of the *conservation of momentum*, we can write:

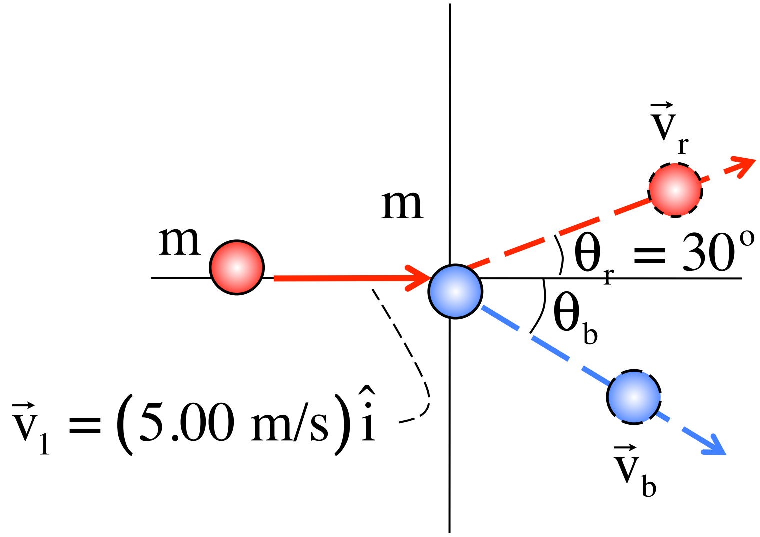
$$\cancelto{0}{\sum p_{1,y}} + \sum \cancelto{0}{F_{external,x}\Delta t_{throughCollision}} = \sum p_{2,y}$$

$$\Rightarrow \quad 0 = m_r v_r \sin\theta_r - m_b v_b \sin\theta_b$$

$$\Rightarrow \quad \cancel{m} v_b \sin\theta_b = \cancel{m}(4.33 \text{ m/s})\sin 30^\circ$$

$$\Rightarrow \quad v_b \sin\theta_b = (4.33 \text{ m/s})\sin 30^\circ$$

$$\Rightarrow \quad v_b \sin\theta_b = 2.17 \text{ m/s}$$



Using the “dividing the two expressions” trick, we get:

$$\frac{v_b \sin\theta_b}{v_b \cos\theta_b} = \frac{(2.17 \text{ m/s})}{(1.25 \text{ m/s})}$$

$$\Rightarrow \quad \tan\theta_b = 1.74$$

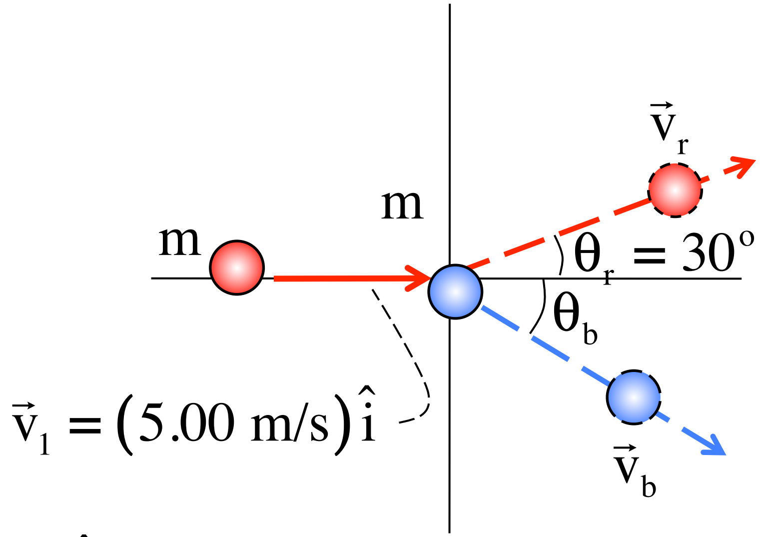
$$\Rightarrow \quad \theta_b = 60^\circ$$

This gives us a velocity magnitude of:

$$v_b \sin 60^\circ = 2.17 \text{ m/s}$$

$$\Rightarrow \quad v_b = 2.50 \text{ m/s}$$

Putting this information into a unit vector notation, we get:



$$\vec{v}_b = (2.50 \text{ m/s}) \measuredangle -60^{\circ}$$

$$= \left[(2.50 \text{ m/s})\cos 60^{\circ}\right]\hat{i} - \left[(2.50 \text{ m/s})\sin 60^{\circ}\right]\hat{j}$$

$$= (1.25 \text{ m/s})\hat{i} - (2.17 \text{ m/s})\hat{j}$$