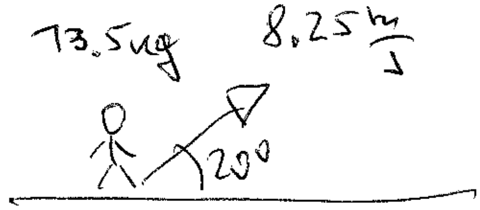
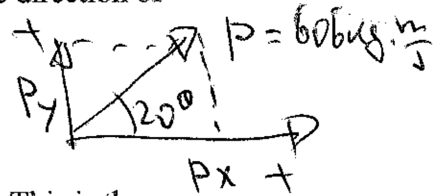
$|\vec{p}| = ?$

p direction $= ?$



42. **ORGANIZE AND PLAN** The magnitude of momentum depends on mass and the magnitude of velocity, or speed. The direction of momentum is the same as the direction of the velocity vector at any instant. We'll use $p = mv$ to get the magnitude of momentum. Since we're in two dimensions, we'll use vector-space notation to describe the direction of momentum. Let the x-axis be horizontal.



Known: $\theta = 20.°$ above the positive x-axis; $v = 8.25$ m/s; $m = 73.5$ kg.

SOLVE First, find the magnitude of momentum:

$$p = mv = (73.5 \text{ kg})(8.25 \text{ m/s}) = 606 \text{ kg}\cdot\text{m/s}$$

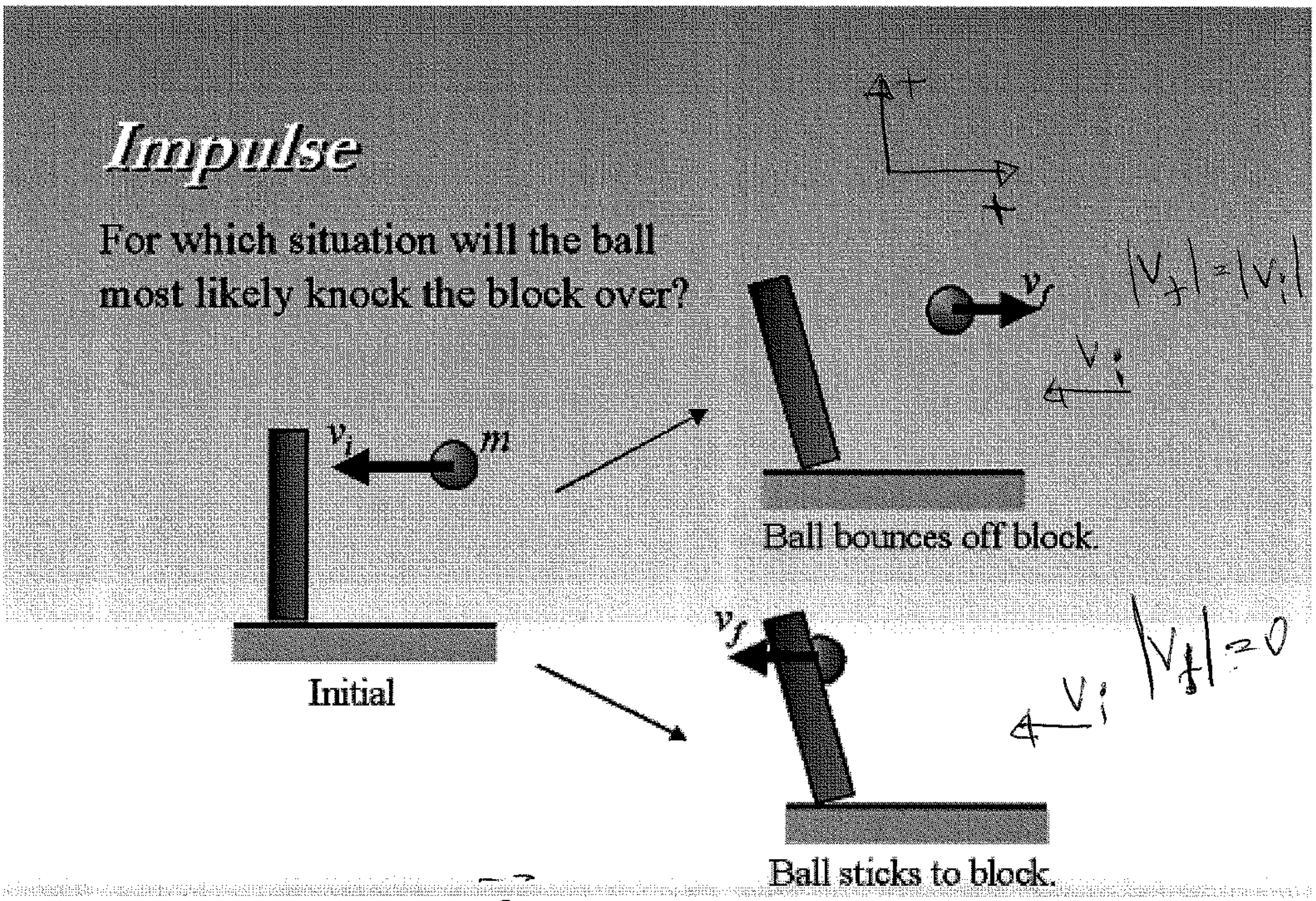
The long jumper leaves the ground at the angle of $20.°$ above horizontal. This is the direction of the velocity vector and hence the direction of the magnitude. Using this direction, we rewrite momentum as a vector:

$$\vec{p} = (mv\cos\theta) \text{ kg}\cdot\text{m/s}\hat{i} + (mv\sin\theta)\text{kg}\cdot\text{m/s}\hat{j}$$

REFLECT It doesn't matter which direction the long-jumper jumps; momentum is always equal to mass times speed in the direction of the jump.

$$\vec{p} = 569 \frac{\text{kg}\cdot\text{m}}{\text{s}}\cdot\hat{i} + 207\frac{\text{kg}\cdot\text{m}}{\text{s}}\cdot\hat{j}$$

$\vec{F} = \frac{\Delta \vec{p}}{\Delta t}$; $\vec{J} = \Delta t \vec{F} = \Delta \vec{p} = \vec{p}_f - \vec{p}_i$

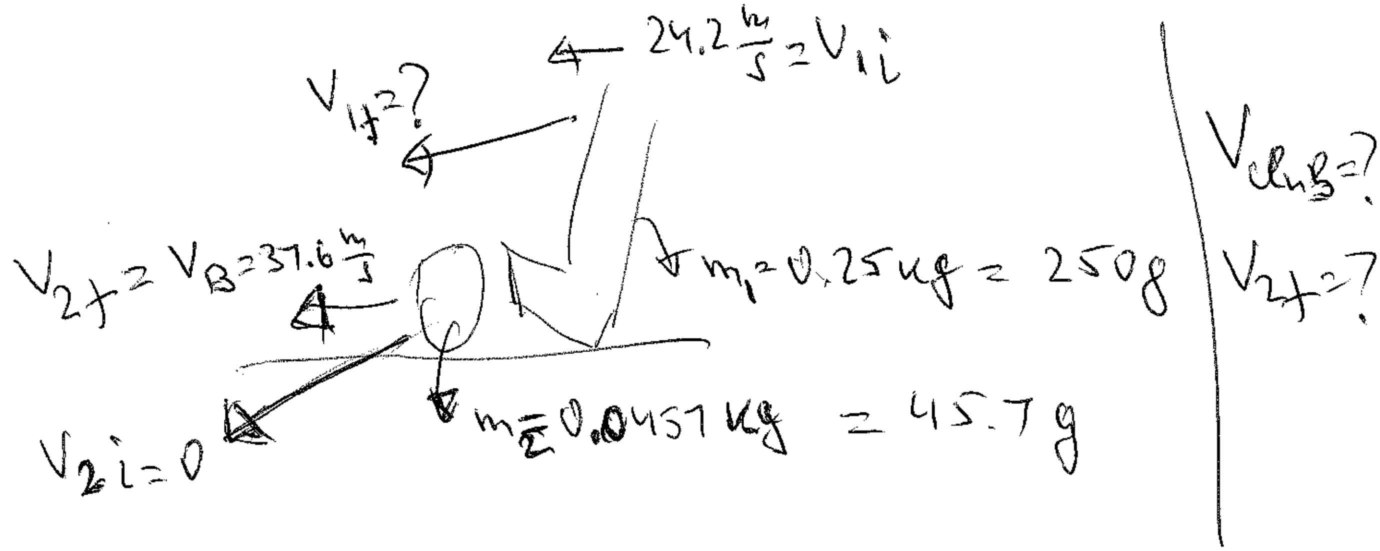


$J = \vec{F}_{avg} \cdot \Delta t = \Delta \vec{p} = m \cdot \Delta \vec{v}$

$\vec{F}_{avg} = \frac{m}{\Delta t} \cdot \Delta \vec{v}$

① $\Delta v = v_f - (-v_i) = 2v_i$

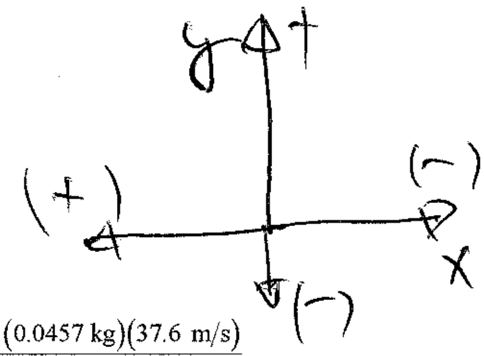
② $\Delta v = 0 - (-v_i) = v_i$



57. **ORGANIZE AND PLAN** Here momentum is conserved and both objects are moving after the collision. We'll assume that the club and the ball are moving in the same straight line just before and after the collision. We're to find the speed of the head of the golf club. We'll use $m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$ where subscript 1 refers to the club and subscript 2 refers to the ball. The club initially moves in the positive x-direction.

Known: $m_1 = 250.\text{g}$; $m_2 = 45.7$ g; $v_{1i} = 24.2$ m/s; $v_{2i} = 0$ m/s; $v_{2f} = 37.6$ m/s.

SOLVE First we convert mass to kilograms:



$$m_1 = 250.\text{g}\left(\frac{1\text{ kg}}{1000\ g}\right) = 0.250\text{ kg}$$

Likewise,

$$m_2 = 0.0457\text{ kg}$$

For conservation of momentum, $\vec{p}_i = \vec{p}_f$

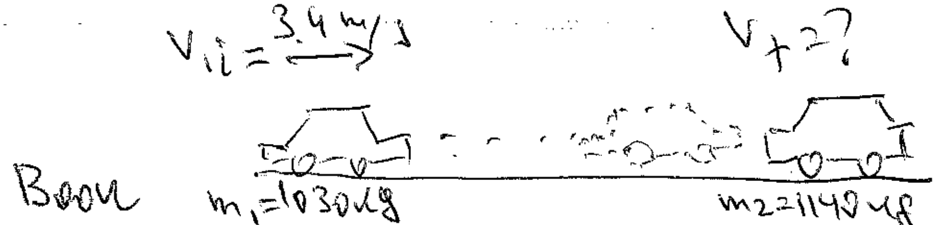
$$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$$

$$v_{1f} = \frac{m_1v_{1i} + m_2v_{2i} - m_2v_{2f}}{m_1} = \frac{(0.250\text{ kg})(24.2\text{ m/s}) + 0\text{ kg}\cdot\text{m/s} - (0.0457\text{ kg})(37.6\text{ m/s})}{0.250\text{ kg}}$$

$$v_f = 17.3\text{ m/s}$$

The club head is moving at 17.3m/s in its original direction.

REFLECT When a golfer swings the club, the club head "follows through" after colliding with the ball and ends up over the golfer's shoulder, so the positive final direction of the club head is reasonable. Only part of the head's momentum is imparted to the ball.



59. **ORGANIZE AND PLAN** This is a perfectly inelastic collision. Since we have only one final speed, v_f, we can use $m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$ to find that final speed.

Known: $m_1 = 1030$ kg; $m_2 = 1140$ kg; $v_{1i} = 3.4$ m/s; $v_{2i} = 0$ m/s.

SOLVE For a perfectly inelastic collision,

$$m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$$

Isolating v_{1f},

$$v_f = \frac{m_1v_1 + m_2v_2}{m_1 + m_2} = \frac{(1030\text{ kg})(3.4\text{ m/s}) + 0\text{ kg}\cdot\text{m/s}}{1030\text{ kg} + 1140\text{ kg}} = 1.6\text{ m/s}$$

REFLECT The combined mass travels in the same (positive) direction as the incoming object, which is reasonable. Notice the similarity between the formula for v_f and the formula we learned for center of mass. These are both weighted averages (see pages 137–138 in the text).