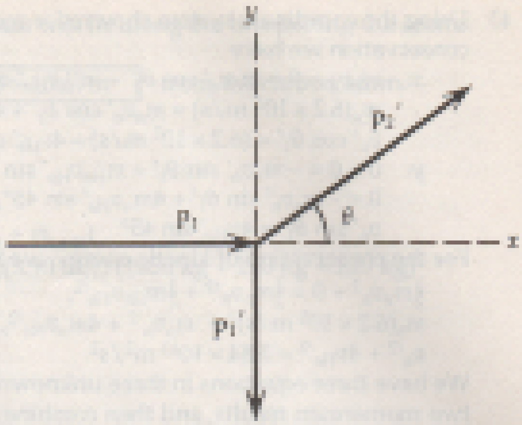
40. (*a*) Using the coordinate system shown, for momentum conservation we have



x-momentum: $mv + 0 = 0 + 2mv_2' \cos\theta$, or
$2v_2' \cos\theta = v$;
y-momentum: $0 + 0 = -mv_1' + 2mv_2' \sin\theta$, or
$2v_2' \sin\theta = v_1'$.

If we square and add these two equations, we get
$v^2 + v_1'^2 = 4v_2'^2$.

For the conservation of kinetic energy, we have
$\frac{1}{2}mv^2 + 0 = \frac{1}{2}mv_1'^2 + \frac{1}{2}(2m)v_2'^2$, or
$v^2 - v_1'^2 = 2v_2'^2$.

When we add this to the previous result, we get
$v^2 = 3v_2'^2$.

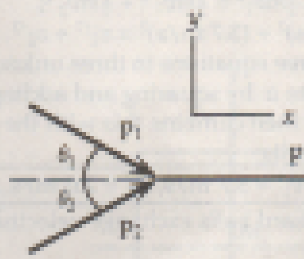
Using this in the x-momentum equation, we get
$\cos\theta = \sqrt{3}/2$, or $\theta =$ $\boxed{30°.}$

(*b*) From part (*a*) we have
$v_2' = v/\sqrt{3}$.

Using the energy result, we get
$v_1'^2 = v^2 - 2v_2'^2 = v^2 - 2v^2/3 = \frac{1}{3}v^2$, or $\boxed{v_1' = v/\sqrt{3}.}$

(*c*) The fraction of the kinetic energy transferred is
fraction $= KE_2/KE_1 = \frac{1}{2}(2m)v_2'^2/\frac{1}{2}mv^2 = m(v^2/3)/\frac{1}{2}mv^2 =$ $\boxed{\frac{2}{3}.}$

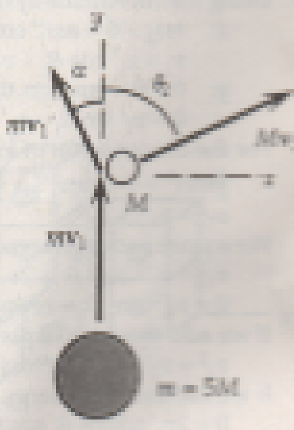
41. Using the coordinate system shown, for momentum conservation we have



y-momentum: $-mv \sin\theta_1 + mv \sin\theta_2 = 0$, or $\theta_1 = \theta_2$
x-momentum: $mv \cos\theta_1 + mv \cos\theta_2 = 2mv'$;
$2mv \cos\theta_1 = 2mv/3$;
$\cos\theta_1 = \frac{1}{3}$, or $\theta_1 = 70.5° = \theta_2$.

The angle between their initial directions is
$\phi = \theta_1 + \theta_2 = 2(70.5°) =$ $\boxed{141°.}$

42. Using the coordinate system shown, for momentum conservation we have



y-momentum: $mv_1 + 0 = mv_1' \cos\alpha + Mv_2' \cos\theta_2$;
$5M(12.0\ \text{m/s}) = 5Mv_1' \cos\alpha + Mv_2' \cos 80°$, or
$5v_1' \cos\alpha = -v_2' \cos 80° + 60.0\ \text{m/s}$.
x-momentum: $0 = -mv_1' \sin\alpha + Mv_2' \sin\theta_2$;
$0 = -5Mv_1' \sin\alpha + Mv_2' \sin 80°$, or
$5v_1' \sin\alpha = v_2' \sin 80°$.

For the conservation of kinetic energy, we have
$\frac{1}{2}mv_1^2 + 0 = \frac{1}{2}mv_1'^2 + \frac{1}{2}Mv_2'^2$;
$5M(12.0\ \text{m/s})^2 = 5Mv_1'^2 + Mv_2'^2$, or
$5v_1'^2 + v_2'^2 = 720\ \text{m}^2/\text{s}^2$.

We have three equations in three unknowns: α, v_1', v_2'. We eliminate α by squaring and adding the two momentum results, and then combine this with the energy equation, with the results:

(*a*) $v_2' =$ $\boxed{3.47\ \text{m/s.}}$
(*b*) $v_1' =$ $\boxed{11.9\ \text{m/s.}}$
(*c*) $\alpha =$ $\boxed{3.29°.}$