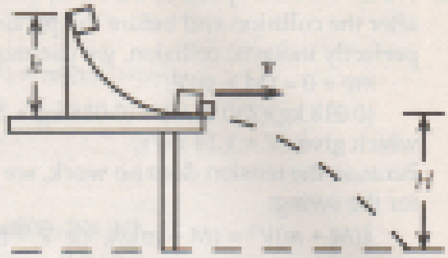
28. We find the speed after falling a height h from energy conservation:

$\frac{1}{2}Mv^2 = Mgh$, or $v = (2gh)^{1/2}$.



The speed of the first cube after sliding down the incline and just before the collision is

$v_1 = [2(9.80\ \text{m/s}^2)(0.20\ \text{m})]^{1/2} = 1.98\ \text{m/s}$.

For the elastic collision of the two cubes, we use momentum conservation:

$Mv_1 + mv_2 = Mv_1' + mv_2'$;

$M(1.98\ \text{m/s}) + \frac{1}{2}M(0) = Mv_1' + \frac{1}{2}Mv_2'$.

Because the collision is elastic, the relative speed does not change:

$v_1 - v_2 = -(v_1' - v_2')$, or $1.98\ \text{m/s} - 0 = v_2' - v_1'$.

Combining these two equations, we get

$v_1' = 0.660\ \text{m/s}$, and $v_2' = 2.64\ \text{m/s}$.

Because both cubes leave the table with a horizontal velocity, they will fall to the floor in the same time, which we find from

$H = \frac{1}{2}gt^2$;

$0.90\ \text{m} = \frac{1}{2}(9.80\ \text{m/s}^2)t^2$, which gives $t = 0.429\ \text{s}$.

Because the horizontal motion has constant velocity, we have

$x_1 = v_1't = (0.660\ \text{m/s})(0.429\ \text{s}) =$ **0.28 m**;

$x_2 = v_2't = (2.64\ \text{m/s})(0.429\ \text{s}) =$ **1.1 m**.

29. (*a*) For the elastic collision of the two masses, we use momentum conservation:

$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$;

$m_1v_1 + 0 = m_1v_1' + m_2v_2'$.

Because the collision is elastic, the relative speed does not change:

$v_1 - v_2 = -(v_1' - v_2')$, or $v_1 - 0 = v_2' - v_1'$.

If we multiply this equation by m_2 and subtract it from the momentum equation, we get

$(m_1 - m_2)v_1 = (m_1 + m_2)v_1'$, or $v_1' = [(m_1 - m_2)/(m_1 + m_2)]v_1$.

If we multiply the relative speed equation by m_1 and add it to the momentum equation, we get

$2m_1v_1 = (m_1 + m_2)v_2'$, or $v_2' = [2m_1/(m_1 + m_2)]v_1$.

(*b*) When $m_1 \ll m_2$ we have

$v_1' = [(m_1 - m_2)/(m_1 + m_2)]v_1 = [(-m_2)/(m_2)]v_1 = -v_1$;

$v_2' = [2m_1/(m_1 + m_2)]v_1 = [(2m_1/m_2)]v_1 = 0$; so

$v_1' = -v_1$, $v_2' = 0$; the small mass rebounds with the same speed; the large mass does not move.

An example is throwing a ping pong ball against a concrete block.

(*c*) When $m_1 \gg m_2$ we have

$v_1' = [(m_1 - m_2)/(m_1 + m_2)]v_1 = [(m_1)/(m_1)]v_1 = v_1$;

$v_2' = [2m_1/(m_1 + m_2)]v_1 = (2m_1/m_1)v_1 = 2v_1$; so

$v_1' = v_1$, $v_2' = 2v_1$; the large mass continues with the same speed; the small mass acquires a large velocity. An example is hitting a light stick with a bowling ball.

(*d*) When $m_1 = m_2$ we have

$v_1' = [(m_1 - m_2)/(m_1 + m_2)]v_1 = 0$;

$v_2' = [2m_1/(m_1 + m_2)]v_1 = (2m_1/2m_1)v_1 = v_1$; so

$v_1' = 0$, $v_2' = v_1$; the striking mass stops; the hit mass acquires the striking mass's velocity.

An example is one billiard ball hitting an identical one.