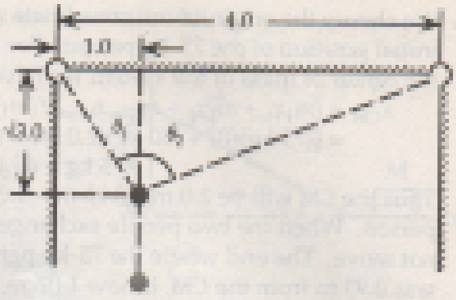
65. From the result of Problem 45, the angle between the two final directions will be 90° for an elastic collision. We take the initial direction of the cue ball to be parallel to the side of the table. The angles for the two balls after the collision are

$\tan \theta_1 = 1.0/\sqrt{3.0}$, which gives $\theta_1 = 30°$;

$\tan \theta_2 = (4.0 - 1.0)/\sqrt{3.0}$, which gives $\theta_2 = 60°$.

Because their sum is 90°, **this will be a "scratch shot".**



66. In the reference frame of the capsule before the push, we take the positive direction in the direction the capsule will move.

(a) Momentum conservation gives us

$m v_{\text{astronaut}} + M v_{\text{satellite}} = m v_{\text{astronaut}}' + M v_{\text{satellite}}'$;

$0 + 0 = (140\ \text{kg})(-2.50\ \text{m/s}) + (1800\ \text{kg}) v_{\text{satellite}}'$, which gives $v_{\text{satellite}}' =$ **0.194 m/s.**

(b) We find the force on the satellite from

$F_{\text{satellite}} = \Delta p_{\text{satellite}}/\Delta t = m_{\text{satellite}}\, \Delta v_{\text{satellite}}/\Delta t$

$= (1800\ \text{kg})(0.194\ \text{m/s} - 0)/(0.500\ \text{s}) =$ **700 N.**

There will be an equal but opposite force on the astronaut.

67. For each of the elastic collisions with a step, conservation of kinetic energy means that the velocity reverses direction but has the same magnitude. Thus the golf ball always rebounds to the height from which it started. Thus, after five bounces, the bounce height will be **4.00 m.**

68. For the elastic collision of the two balls, we use momentum conservation:

$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$;

$m v_1 + 0 = m(-v_1/4) + m_2 v_2'$, or $m_2 v_2' = 5 m v_1/4$.

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

$v_1 - 0 = -(v_1' - v_2')$; $v_1 = v_2' - (-v_1/4)$, or $v_2' = 3v_1/4$.

Combining these two equations, we get **$m_2 = 5m/3$.**

69. On the horizontal surface, the normal force on a car is $F_N = mg$. We find the speed of a car immediately after the collision by using the work-energy principle for the succeeding sliding motion:

$W_{fr} = \Delta KE$;

$-\mu_k m g d = 0 - \frac{1}{2} m v'^2$.

We use this to find the speeds of the cars after the collision:

$0.60(9.80\ \text{m/s}^2)(15\ \text{m}) = \frac{1}{2} v_A'^2$, which gives $v_A' = 13.3\ \text{m/s}$;

$0.60(9.80\ \text{m/s}^2)(30\ \text{m}) = \frac{1}{2} v_B'^2$, which gives $v_B' = 18.8\ \text{m/s}$.

For the collision, we use momentum conservation:

$m_A v_A + m_B v_B = m_A v_A' + m_B v_B'$;

$(2000\ \text{kg}) v_A + 0 = (2000\ \text{kg})(13.3\ \text{m/s}) + (1000\ \text{kg})(18.8\ \text{m/s})$, which gives $v_A = 22.7\ \text{m/s}$.

We find the speed of car A before the brakes were applied by using the work-energy principle for the preceding sliding motion:

$W_{fr} = \Delta KE$;

$-\mu_k m_A g d = \frac{1}{2} m_A v_A^2 - \frac{1}{2} m_A v_{A0}^2$;

$-0.60(9.80\ \text{m/s}^2)(15\ \text{m}) = \frac{1}{2}[(22.7\ \text{m/s})^2 - v_{A0}^2]$,

which gives $v_{A0} = 26.3\ \text{m/s} = 94.7\ \text{km/h} =$ **59 mi/h.**