Chapter 8 Problems

1. A 60.0-kg person, running horizontally with a velocity of +3.80 m/s, jumps onto a 12.0-kg sled that is initially at rest. Ignoring the effects of friction during the collision, find the velocity of the sled and person as they move away.

Answer: The total momentum of the sled and person is conserved since no external force acts in the horizontal direction. $(m_p + m_s)v_f = m_p v_{0p}$ gives

$$v_f = \frac{m_p v_{0p}}{m_p + m_s} = 3.17 m/s.$$

The direction of v_f is the same as the direction of v_{0p}.

2. A 0.500-kg ball is dropped from rest at a point 1.20 m above the floor. The ball rebounds straight upward to a height of 0.700 m . What are the magnitude and direction of the impulse of the net force applied to the ball during the collision with the floor?

Answer: According to the impulse-momentum theorem,

$$(\sum \mathbf{F})\Delta t = m(\mathbf{v}_f - \mathbf{v}_0). \qquad (1)$$

Conservation of mechanical energy can be used to relate the velocities to the heights. If the floor is used to define the zero level for the heights, we have

$$mgh_0 = \frac{1}{2}mv_B^2$$

where h_0 is the height of the ball when it is dropped and v_B is the speed of the ball just before it strikes the ground. Solving for v_B gives

$$v_B = \sqrt{2gh_0}. \qquad (2)$$

Similary,

$$mgh_f = \frac{1}{2}mv_A^2$$

where h_f is the maximum height of the ball when it rebounds and v_A is the speed of the ball just after it rebounds from the ground. SOlving for v_A gives

$$v_A = \sqrt{2gh_f}. \qquad (3)$$

Substituting Eq. 2 and 3 into Eq. 1, where $\mathbf{v}_0 = -v_B$ and $\mathbf{v}_f = v_A$ gives

$$(\sum \mathbf{F})\Delta t = m\sqrt{2g}[+\sqrt{h_f} - (-\sqrt{h_0})] = +4.28Ns.$$

Since the impulse is positive, it is directed upwards.

3. A person stands in a stationary canoe and throws a 5.00-kg stone with a velcity of 8.00 m/s at an angle of 30.0° above the horizontal. The person and canoe have a combined mass of 105 kg. Ignoring air resistance and effects of the water, find the horizontal recoil velocity of the canoe.

Answer: The conservation of momentum applied in the horizontal direction gives

$$m_c v_c + m_s v_s \cos 30.0° = 0$$

so that

$$v_{fc} = \frac{-m_s v_{fs} \cos 30.0°}{m_c} = -0.330 m/s.$$

The magnitude of the velocity is 0.330 m/s. The minus sign indicates that the direction is opposite the horizontal velocity component of the stone.