Homework 7 Solutions PHYS 211 Dr. Amir

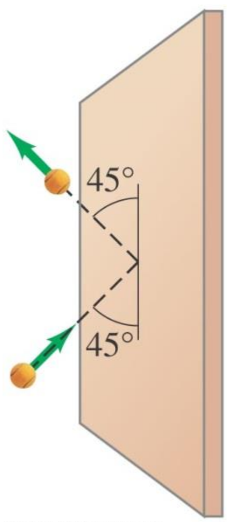
Chapter 9:

10. Consider the horizontal motion of the objects. The momentum in the horizontal direction will be conserved. Let A represent the car and B represent the load. The positive direction is the direction of the original motion of the car.

$$p_{\text{initial}} = p_{\text{final}} \quad \rightarrow \quad m_A v_A + m_B v_B = (m_A + m_B) v' \quad \rightarrow$$

$$v' = \frac{m_A v_A + m_B v_B}{m_A + m_B} = \frac{(9150\,\text{kg})(15.0\,\text{m/s}) + 0}{(9150\,\text{kg}) + (4350\,\text{kg})} = \boxed{10.2\,\text{m/s}}$$

25. (II) The impulse given the ball is the change in the ball's momentum. From the symmetry of the problem, the vertical momentum of the ball does not change, and so there is no vertical impulse. Call the direction AWAY from the wall the positive direction for momentum perpendicular to the wall.



$$\Delta p_{\perp} = mv_{\perp\,\text{final}} - mv_{\perp\,\text{initial}} = m\left(v\sin 45^{\circ} - -v\sin 45^{\circ}\right) = 2mv\sin 45^{\circ}$$

$$= 2\left(6.0\times 10^{-2}\,\text{km}\right)(25\,\text{m/s})\sin 45^{\circ} = \boxed{2.1\,\text{kg}\cdot\text{m/s, to the left}}$$

35. Let A represent the 0.450-kg puck, and let B represent the 0.900-kg puck. The initial direction of puck A is the positive direction. We have $v_A = 4.80\,\text{m/s}$ and $v_B = 0$. Use Eq. 9-8 to obtain a relationship between the velocities.

$$v_A - v_B = -(v'_A - v'_B) \quad \rightarrow \quad v'_B = v_A + v'_A$$

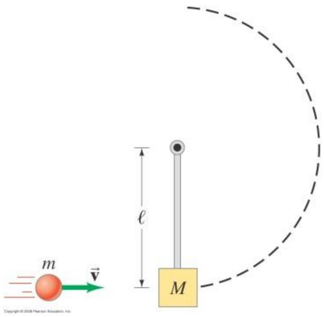
Substitute this relationship into the momentum conservation equation for the collision.

$$m_A v_A + m_B v_B = m_A v_A' + m_B v_B' \rightarrow m_A v_A = m_A v_A' + m_B (v_A + v_A') \rightarrow$$

$$v_A' = \frac{(m_A - m_B)}{(m_A + m_B)} v_A = \frac{-0.450 \text{ kg}}{1.350 \text{ kg}}(4.80 \text{ m/s}) = -1.60 \text{ m/s} = \boxed{1.60 \text{ m/s (west)}}$$

$$v_B' = v_A + v_A' = 4.80 \text{ m/s} - 1.60 \text{ m/s} = \boxed{3.20 \text{ m/s (east)}}$$

50.



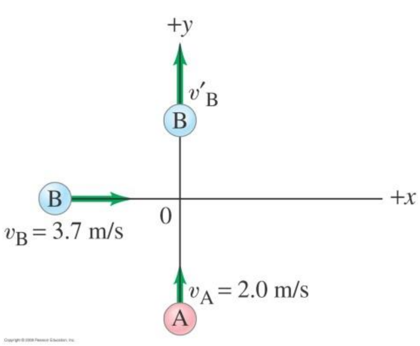
The swinging motion will conserve mechanical energy. Take the zero level for gravitational potential energy to be at the bottom of the arc. For the pendulum to swing exactly to the top of the arc, the potential energy at the top of the arc must be equal to the kinetic energy at the bottom.

$$K_{\text{bottom}} = U_{\text{top}} \rightarrow \tfrac{1}{2}(m+M)V_{\text{bottom}}^2 = (m+M)g(2L) \rightarrow V_{\text{bottom}} = 2\sqrt{gL}$$

Momentum will be conserved in the totally inelastic collision at the bottom of the arc. We assume that the pendulum does not move during the collision process.

$$p_{\text{initial}} = p_{\text{final}} \rightarrow mv = (m+M)V_{\text{bottom}} \rightarrow v = \frac{m+M}{m} = \boxed{2\frac{m+M}{m}\sqrt{gL}}$$

56.



Write momentum conservation in the x and y directions, and kinetic energy conservation. Note that both masses are the same. We allow $\vec{\mathbf{v}}_A'$ to have both x and y components.

$$p_x: \quad mv_{\mathrm{B}} = mv'_{\mathrm{A}x} \quad \rightarrow \quad v_{\mathrm{B}} = v'_{\mathrm{A}x}$$
$$p_y: \quad mv_{\mathrm{A}} = mv'_{\mathrm{A}y} + mv'_{\mathrm{B}} \quad \rightarrow \quad v_{\mathrm{A}} = v'_{\mathrm{A}y} + v'_{\mathrm{B}}$$
$$K: \quad \tfrac{1}{2}mv_{\mathrm{A}}^2 + \tfrac{1}{2}mv_{\mathrm{B}}^2 = \tfrac{1}{2}mv'^2_{\mathrm{A}} + \tfrac{1}{2}mv'^2_{\mathrm{B}} \quad \rightarrow \quad v_{\mathrm{A}}^2 + v_{\mathrm{B}}^2 = v'^2_{\mathrm{A}} + v'^2_{\mathrm{B}}$$

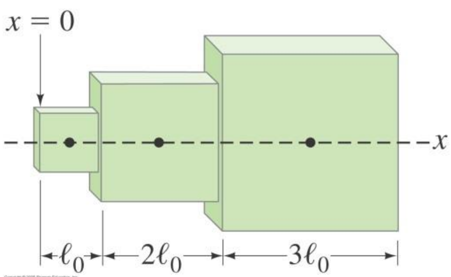
Substitute the results from the momentum equations into the kinetic energy equation.

$$\left(v'_{\mathrm{A}y} + v'_{\mathrm{B}}\right)^2 + \left(v'_{\mathrm{A}x}\right)^2 = v'^2_{\mathrm{A}} + v'^2_{\mathrm{B}} \quad \rightarrow \quad v'^2_{\mathrm{A}y} + 2v'^2_{\mathrm{A}y}v'_{\mathrm{B}} + v'^2_{\mathrm{B}} + v'^2_{\mathrm{A}y} = v'^2_{\mathrm{A}} + v'^2_{\mathrm{B}} \quad \rightarrow$$
$$v'^2_{\mathrm{A}} + 2v'^2_{\mathrm{A}y}v'_{\mathrm{B}} + v'^2_{\mathrm{B}} = v'^2_{\mathrm{A}} + v'^2_{\mathrm{B}} \quad \rightarrow \quad 2v'^2_{\mathrm{A}y}v'_{\mathrm{B}} = 0 \quad \rightarrow \quad v'_{\mathrm{A}y} = 0 \text{ or } v'_{\mathrm{B}} = 0$$

Since we are given that $v'_{\mathrm{B}} \neq 0$, we must have $v'_{\mathrm{A}y} = 0$. This means that the final direction of A is the $\boxed{x \text{ direction}}$. Put this result into the momentum equations to find the final speeds.

$$v'_{\mathrm{A}} = v'_{\mathrm{A}x} = v_{\mathrm{B}} = \boxed{3.7\,\mathrm{m/s}} \qquad v'_{\mathrm{B}} = v_{\mathrm{A}} = \boxed{2.0\,\mathrm{m/s}}$$

64.



By the symmetry of the problem, since the centers of the cubes are along a straight line, the vertical CM coordinate will be 0, and the depth CM coordinate will be 0. The only CM coordinate to calculate is the one along the straight line joining the centers. The mass of each cube will be the volume times the density, and so $m_1 = \rho\left(l_0\right)^3,\ m_2 = \rho\left(2l_0\right)^3,\ m_3 = \rho\left(3l_0\right)^3$. Measuring from the left edge of the smallest block, the locations of the CMs of the individual cubes are $x_1 = \tfrac{1}{2}l_0,\ x_2 = 2l_0,\ x_3 = 4.5l_0$. Use Eq. 9-10 to calculate the CM of the system.

$$x_{\mathrm{CM}} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3} = \frac{\rho l_0^3\left(\tfrac{1}{2}l_0\right) + 8\rho l_0^3\left(2l_0\right) + 27\rho l_0^3\left(4.5l_0\right)}{\rho l_0^3 + 8\rho l_0^3 + 27\rho l_0^3}$$
$$= \boxed{3.8l_0 \text{ from the left edge of the smallest cube}}$$