1. The force is the derivative of the momentum with respect to time.

$$\vec{\mathbf{F}} = \frac{d\vec{\mathbf{p}}}{dt} = \frac{d\left(4.8t^2\hat{\mathbf{i}} - 8.0\vec{\mathbf{j}} - 8.9t\,\vec{\mathbf{k}}\right)}{dt} = \left(9.6t\,\hat{\mathbf{i}} - 8.9\vec{\mathbf{k}}\right)\text{N}$$

2. (a) The impulse is the change in momentum. The direction of travel of the struck ball is the positive direction.

$\Delta p = m\Delta v = \left(4.5\times10^{-2}\,\text{kg}\right)\left(45\,\text{m/s} - 0\right) = 2.0\ \text{kg}\bullet\text{m/s}$, in the forward direction.

(b) The average force is the impulse divided by the interaction time.

$\overline{F} = \dfrac{\Delta p}{\Delta t} = \dfrac{2.0\ \text{kg}\bullet\text{m/s}}{3.5\times10^{-3}\,\text{s}} = 580\,\text{N}$, in the forward direction.

5. **IDENTIFY:** The x and y components of the momentum of the system of the two asteroids are separately conserved.

SET UP: The before and after diagrams are given in Figure and the choice of coordinates is indicated. Each asteroid has mass m.

EXECUTE: (a) $P_{1x} = P_{2x}$ gives $mv_{A1} = mv_{A2}\cos 30.0° + mv_{B2}\cos 45.0°$. $40.0\text{ m/s} = 0.866v_{A2} + 0.707v_{B2}$ and $0.707v_{B2} = 40.0\text{ m/s} - 0.866v_{A2}$.

$P_{2y} = P_{2y}$ gives $0 = mv_{A2}\sin 30.0° - mv_{B2}\sin 45.0°$ and $0.500v_{A2} = 0.707v_{B2}$.

Combining these two equations gives $0.500v_{A2} = 40.0\text{ m/s} - 0.866v_{A2}$ and $v_{A2} = 29.3\text{ m/s}$. Then

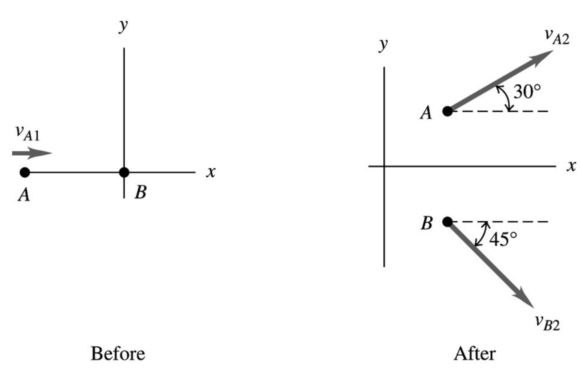
$$v_{B2} = \left(\frac{0.500}{0.707}\right)(29.3\text{ m/s}) = 20.7\text{ m/s}.$$

(b) $K_1 = \frac{1}{2}mv_{A1}^2$. $K_2 = \frac{1}{2}mv_{A2}^2 + \frac{1}{2}mv_{B2}^2$. $\dfrac{K_2}{K_1} = \dfrac{v_{A2}^2 + v_{B2}^2}{v_{A1}^2} = \dfrac{(29.3\text{ m/s})^2 + (20.7\text{ m/s})^2}{(40.0\text{ m/s})^2} = 0.804.$

$$\frac{\Delta K}{K_1} = \frac{K_2 - K_1}{K_1} = \frac{K_2}{K_1} - 1 = -0.196.$$

19.6% of the original kinetic energy is dissipated during the collision.

EVALUATE: We could use any directions we wish for the x and y coordinate directions, but the particular choice we have made is especially convenient.



6. **IDENTIFY:** Apply conservation of energy to the motion before and after the collision and apply conservation of momentum to the collision.

SET UP: Let v be the speed of the mass released at the rim just before it strikes the second mass. Let each object have mass m.

EXECUTE: Conservation of energy says $\frac{1}{2}mv^2 = mgR$; $v = \sqrt{2gR}$.

SET UP: This is speed v_1 for the collision. Let v_2 be the speed of the combined object just after the collision.

EXECUTE: Conservation of momentum applied to the collision gives $mv_1 = 2mv_2$ so $v_2 = v_1/2 = \sqrt{gR/2}$.

SET UP: Apply conservation of energy to the motion of the combined object after the collision. Let y_3 be the final height above the bottom of the bowl.

EXECUTE: $\frac{1}{2}(2m)v_2^2 = (2m)gy_3$.

$$y_3 = \frac{v_2^2}{2g} = \frac{1}{2g}\left(\frac{gR}{2}\right) = R/4.$$

EVALUATE: Mechanical energy is lost in the collision, so the final gravitational potential energy is less than the initial gravitational potential energy.

Answers

3. a) 7.5 m s^{-1} west b) *car:* 45 m s^{-1} west, *truck:* 5 m s^{-1} east
4. 1.33 m/s, 1.67 m/s