At the intersection of Texas Avenue and University Drive, a blue, subcompact car with mass 950 kg traveling east on University collides with a maroon pickup truck with mass 1900 kg that is traveling north on Texas and ran a red light (Fig. 8.34). The two vehicles stick together as a result of the collision and, after the collision, the wreckage is sliding at 16.0 m/s in the direction 24.0° east of north. Calculate the speed of each vehicle before the collision. The collision occurs during a heavy rainstorm; you can ignore friction forces between the vehicles and the wet road.

\[ \text{Car: } m = 950 \text{ kg} \]
\[ \text{Initial velocity east } \rightarrow \]
\[ \text{Pickup: } m = 1900 \text{ kg} \]
\[ \text{Initial velocity north } \uparrow \]

**Identify:** Since friction forces from the road are ignored, the \( x \) and \( y \) components of momentum are conserved.

**Set Up:** Let object \( A \) be the subcompact and object \( B \) be the truck. After the collision the two objects move together with velocity \( \vec{v}_2 \). Use the \( x \) and \( y \) coordinates given in the problem. \( v_{A_fy} = v_{B_fy} = 0 \).

\[ v_{2x} = (16.0 \text{ m/s}) \sin 24.0^\circ = 6.5 \text{ m/s}; \quad v_{2y} = (16.0 \text{ m/s}) \cos 24.0^\circ = 14.6 \text{ m/s}. \]

**Execute:** \( P_{x_i} = P_{2x} \) gives \( m_A v_{A_{fx}} = (m_A + m_B) v_{2x} \).

\[ v_{A_{fx}} = \left( \frac{m_A + m_B}{m_A} \right) v_{2x} = \left( \frac{950 \text{ kg} + 1900 \text{ kg}}{950 \text{ kg}} \right) (6.5 \text{ m/s}) = 19.5 \text{ m/s}. \]

\[ P_{y_i} = P_{2y} \] gives \( m_A v_{A_{fy}} = (m_A + m_B) v_{2y} \).

\[ v_{A_{fy}} = \left( \frac{m_A + m_B}{m_A} \right) v_{2y} = \left( \frac{950 \text{ kg} + 1900 \text{ kg}}{1900 \text{ kg}} \right) (14.6 \text{ m/s}) = 21.9 \text{ m/s}. \]

Before the collision the subcompact car has speed 19.5 m/s and the truck has speed 21.9 m/s.

**Evaluate:** Each component of momentum is independently conserved.
8.39 A 0.150-kg glider is moving to the right on a frictionless, horizontal air track with a speed of 0.80 m/s. It has a head-on collision with a 0.300-kg glider that is moving to the left with a speed of 2.20 m/s. Find the final velocity (magnitude and direction) of each glider if the collision is elastic.

**IDENTIFY:** No net external horizontal force so $F_x$ is conserved. Elastic collision so $K_1 = K_2$ and can use Eq. 8.27.

**SET UP:**

\[
\begin{align*}
M_A &= 0.150 \text{ kg} \\
M_B &= 0.300 \text{ kg}
\end{align*}
\]

\[
\begin{align*}
v_{A1} &= 0.80 \text{ m/s} \\
v_{B1} &= 2.20 \text{ m/s}
\end{align*}
\]

**Figure 8.46**

**EXECUTE:** From conservation of $x$-component of momentum:

\[
\frac{M_A v_{A1x} + M_B v_{B1x}}{M_A v_{A1x} - M_B v_{B1x}} = \frac{M_A v_{A2x} + M_B v_{B2x}}{M_A v_{A2x} - M_B v_{B2x}}
\]

\[
(0.150 \text{ kg})(0.80 \text{ m/s}) - (0.300 \text{ kg})(2.20 \text{ m/s}) = (0.150 \text{ kg})v_{A2x} + (0.300 \text{ kg})v_{B2x}
\]

\[-3.60 \text{ m/s} = v_{A2x} + 2v_{B2x} \]

From the relative velocity equation for an elastic collision Eq. 8.27:

\[
v_{B2x} = v_{A2x} = \frac{-(v_{B1x} - v_{A1x})}{3} = \frac{-(2.20 \text{ m/s} - 0.80 \text{ m/s})}{3} = +0.30 \text{ m/s}
\]

Adding the two equations gives $-0.60 \text{ m/s} = 3v_{B2x}$ and $v_{B2x} = -0.20 \text{ m/s}$. Then

\[
v_{A2x} = v_{B2x} = 3.00 \text{ m/s} = -3.20 \text{ m/s}
\]

The 0.150 kg glider (A) is moving to the left at 3.20 m/s and the 0.300 kg glider (B) is moving to the left at 0.20 m/s.

8.36 **A Ballistic Pendulum.** A 12.0-g rifle bullet is fired with a speed of 380 m/s into a ballistic pendulum with mass 6.00 kg, suspended from a cord 70.0 cm long (see Example 8.8 in Section 8.3). Compute a) the vertical height through which the pendulum rises; b) the initial kinetic energy of the bullet; c) the kinetic energy of the bullet and pendulum immediately after the bullet becomes embedded in the pendulum.

**IDENTIFY:** Apply conservation of momentum to the collision and conservation of energy to the motion after the collision. After the collision the kinetic energy of the combined object is converted to gravitational potential energy.

**SET UP:** Immediately after the collision the combined object has speed $V$. Let $h$ be the vertical height through which the pendulum rises.

**EXECUTE:** (a) Conservation of momentum applied to the collision gives

\[
(12.0 \times 10^{-3} \text{ kg})(380 \text{ m/s}) = (6.00 \text{ kg} + 12.0 \times 10^{-3} \text{ kg})V \quad \text{and} \quad V = 0.758 \text{ m/s}
\]

Conservation of energy applied to the motion after the collision gives $\frac{1}{2}m_{tot}V^2 = m_{tot}gh$ and

\[
h = \frac{V^2}{2g} = \frac{(0.758 \text{ m/s})^2}{2(9.80 \text{ m/s}^2)} = 0.0293 \text{ m} = 2.93 \text{ cm}
\]

(b) $K = \frac{1}{2}m_Bv_B^2 = \frac{1}{2}(12.0 \times 10^{-3} \text{ kg})(380 \text{ m/s})^2 = 866 \text{ J}$.

(c) $K = \frac{1}{2}m_{tot}V^2 = \frac{1}{2}(6.00 \text{ kg} + 12.0 \times 10^{-3} \text{ kg})(0.758 \text{ m/s})^2 = 1.73 \text{ J}$.

**EVALUATE:** Most of the initial kinetic energy of the bullet is dissipated in the collision.