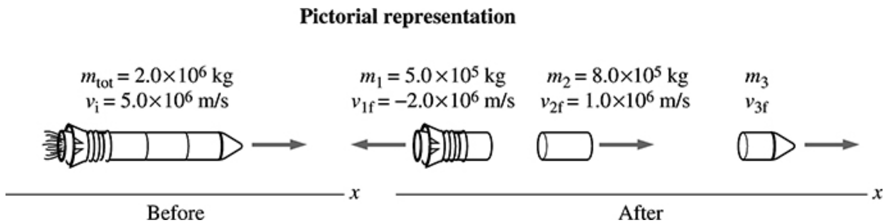
9.51. Model: This is an isolated system, so momentum is conserved in the explosion. Momentum is a *vector* quantity, so the direction of the initial velocity vector $\vec{v}_1$ establishes the direction of the momentum vector. The final momentum vector, after the explosion, must still point in the $+x$-direction. The two known pieces continue to move along this line and have no y-components of momentum. The missing third piece cannot have a y-component of momentum if momentum is to be conserved, so it must move along the x-axis—either straight forward or straight backward. We can use conservation laws to find out.

Visualize:



Solve: From the conservation of mass, the mass of piece 3 is

$$m_3 = m_{\text{total}} - m_1 - m_2 = 7.0\times10^5 \text{ kg}$$

To conserve momentum along the x-axis, we require

$$[p_i = m_{\text{total}}v_i] = [p_f = p_{1f} + p_{2f} + p_{3f} = m_1v_{1f} + m_2v_{2f} + p_{3f}]$$

$$\Rightarrow p_{3f} = m_{\text{total}}v_i - m_1v_{1f} - m_2v_{2f} = +1.02\times10^{13} \text{ kg m/s}$$

Because $p_{3f} > 0$, the third piece moves in the $+x$-direction, that is, straight forward. Because we know the mass m_3, we can find the velocity of the third piece as follows:

$$v_{3f} = \frac{p_{3f}}{m_3} = \frac{1.02\times10^{13} \text{ kg m/s}}{7.0\times10^5 \text{ kg}} = 1.46\times10^7 \text{ m/s}$$