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 $v_i$ 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:**

![Pictorial representation](image)

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

$$m_3 = m_{total} - m_1 - m_2 = 7.0 \times 10^7 \text{ kg}$$

To conserve momentum along the $x$-axis, we require

$$p_i = p_f$$

$$m_i v_{if} = m_1 v_{1f} + m_2 v_{2f} + m_3 v_{3f}$$

$$p_{3f} = m_{total} v_{i} - m_1 v_{1f} - m_2 v_{2f} = +1.02 \times 10^{11} \text{ kg m/s}$$

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:

$$v_{3f} = \frac{p_{3f}}{m_3} = \frac{1.02 \times 10^{13} \text{ kg m/s}}{7.0 \times 10^7 \text{ kg}} = 1.46 \times 10^7 \text{ m/s}$$