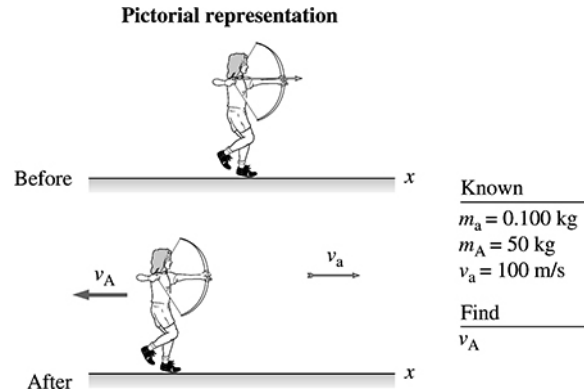


9.20. Model: We will define our system to be archer + arrow. The force of the archer (A) on the arrow (a) is equal to the force of the arrow on the archer. These are internal forces within the system. The archer is standing on frictionless ice, and the normal force by ice on the system balances the weight force. Thus $\vec{F}_{\text{ext}} = \vec{0}$ on the system, and momentum is conserved.

Visualize:



The initial momentum p_{ix} of the system is zero, because the archer and the arrow are at rest. The final momentum p_{ix} must also be zero.

Solve: We have $M_A v_A + m_a v_a = 0 \text{ kg m/s}$. Therefore,

$$v_A = \frac{-m_a v_a}{m_A} = \frac{-(0.100 \text{ kg})(100 \text{ m/s})}{50 \text{ kg}} = -0.20 \text{ m/s}$$

The archer's recoil *speed* is 0.20 m/s.

Assess: It is the total final momentum that is zero, although the individual momenta are nonzero. Since the arrow has forward momentum, the archer will have backward momentum.