

This is a problem involving systems of particles.

A cannon of mass 1400 kg fires a ball of mass 60 kg in the horizontal direction with a velocity of 53 m/s relative to the cannon. What is the velocity of the cannon and ball relative to the Earth?

Solution:

There is conservation of linear momentum in horizontal direction, for the system, which is the cannon + ball.

$$P_i = P_f$$

$$P_i = 0 \text{ (initial linear momentum of system)}$$

$$\begin{array}{l} \text{Final} \\ \text{linear} \\ \text{momentum} \\ \text{of system} \end{array} \rightarrow P_f = M V + m (v_b + V) \quad \begin{array}{l} \text{velocity} \\ \text{of} \\ \text{ball} \\ \text{relative to} \\ \text{Earth} \end{array} \quad \begin{array}{l} M = 1400 \text{ kg (mass of} \\ \text{cannon)} \\ m = 60 \text{ kg (mass of} \\ \text{ball)} \\ V = \text{velocity of} \\ \text{cannon (relative to} \\ \text{Earth)} \\ v_b = \text{velocity of ball} \\ \text{relative to cannon} \\ = 53 \text{ m/s} \rightarrow \end{array}$$

So,

$$0 = 1400V + 60(53 + V)$$

$$V = -2.2 \text{ m/s}$$

The velocity of cannon relative to Earth is 2.2 m/s ← (answer)

The velocity of ball relative to Earth is 53 m/s - 2.2 m/s = 50.8 m/s → (answer)