73. Let the velocity of the shell (of mass m_s) relative to the ground be $\vec{v}_s$, the recoiling velocity of the cannon (of mass m_c) be $\vec{v}_c$ (pointed in our $-x$ direction), and the velocity of the shell relative to the muzzle be $\vec{v}_s'$, where $\vec{v}_s\,' + \vec{v}_c = \vec{v}_s$. In component form, this becomes

$$\begin{aligned} v_s' \cos 39.0° - v_c &= v_{sx} \\ v_s' \sin 39.0° &= v_{sy} \end{aligned}$$

where $v_c = |\vec{v}_c|$. Conservation of linear momentum in the horizontal direction provides us with the additional relation $m_s v_{sx} = m_c v_c$. We solve these equations for the components of $\vec{v}_s$:

$$\begin{aligned} v_{sx} &= \frac{m_c v_s' \cos 39.0°}{m_s + m_c} = \frac{(1400\,\text{kg})(556\,\text{m/s})\cos 39.0°}{1400\,\text{kg} + 70.0\,\text{kg}} = 412\,\text{m/s} \\ v_{sy} &= v_s' \sin 39.0° = (556\,\text{m/s})(\sin 39.0°) = 350\,\text{m/s}\ . \end{aligned}$$

(a) The speed of the shell relative to the Earth is then

$$v_s = \sqrt{v_{sx}^2 + v_{sy}^2} = \sqrt{412^2 + 350^2} = 540\ \text{m/s}\ .$$

(b) The angle (relative to a stationary observer) at which the shell is fired is given by

$$\theta = \tan^{-1}\left(\frac{v_{sy}}{v_{sx}}\right) = \tan^{-1}\left(\frac{350}{412}\right) = 40.4°\ .$$