A hunter on a frozen, essentially frictionless pond uses a rifle that shoots 4.20-g bullets at 965m/s. The mass of the hunter (including his gun) is 72.5kg, and the hunter holds tight to the gun after firing it. Find the recoil velocity of the hunter if he fires the rifle (a) horizontally and (b) at 56.0° above the horizontal.

Solution.

According to the law of momentum conservation:

$$m_b\vec{\vartheta}_b + m_h\vec{\vartheta}_h = m_b\vec{\vartheta}'_b + m_h\vec{\vartheta}'_h\,, \qquad (1)$$

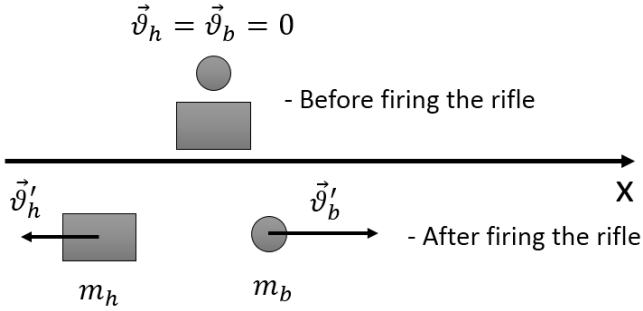
where m_b is the mass of the bullet, m_h is the mass of the hunter, $\vec{\vartheta}_b$ and $\vec{\vartheta}_h$ are velocities of the bullet and the hunter before firing the rifle, $\vec{\vartheta}'_b$ and $\vec{\vartheta}'_h$ are velocities of the bullet and the hunter after firing the rifle.

Taking into account, that $\vec{\vartheta}'_h = \vec{\vartheta}'_b = 0$, we receive:

$$0 = m_b\vec{\vartheta}'_b + m_h\vec{\vartheta}'_h\,. \qquad (2)$$

Let's rewrite (2) in scalar form.

Case (a):



$$0 = m_b\vartheta'_b - m_h\vartheta'_h$$

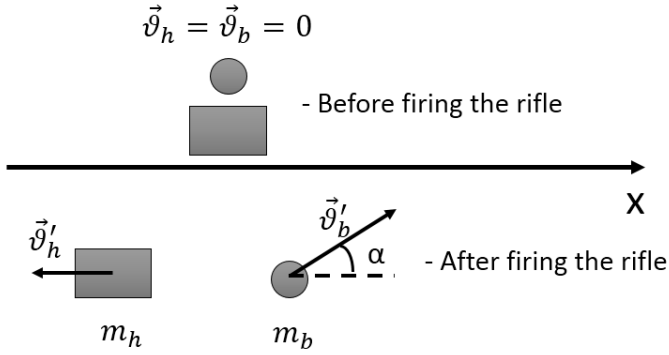
$$m_h\vartheta'_h = m_b\vartheta'_b$$

$$\vartheta'_h = \frac{m_b\vartheta'_b}{m_h}$$

$$\vartheta'_h = \frac{4.20\cdot 10^{-3}\cdot 965}{72.5} = 0.0559 \text{ (m/s)} =$$

$$= 55.9\ (mm/s)$$

Case (b):



$$0 = m_b\vartheta'_b cos\alpha - m_h\vartheta'_h$$

$$m_h\vartheta'_h = m_b\vartheta'_b cos\alpha$$

$$\vartheta'_h = \frac{m_b\vartheta'_b}{m_h} cos\alpha$$

$$\vartheta'_h = \frac{4.20\cdot 10^{-3}\cdot 965}{72.5}\cdot 0.5592 =$$

$$= 0.031 \text{ (m/s)} = 31 \text{ (mm/s)}$$

Answer: $(a)\ \vartheta'_h = 55.9$ mm/s; (b) $\vartheta'_h = 31$ mm/s.