

While chopping down his father's cherry tree, George discovered that if he swung the axe with a speed of 27 m/s, it would embed itself 1.9 cm into the tree before coming to a stop.

- If the axe head had a mass of 2.5 kg, how much force was the tree exerting on the axe head upon impact?
- How much force did the axe exert back on the tree?

Solution:

$V_0 = 27 \frac{\text{m}}{\text{s}}$ – initial velocity of the axe;

$d = 1.9\text{cm} = 0.019\text{m}$ – distance that axe came before stop

$m = 2.5 \text{ kg}$ – mass of the axe;

The law of conservation of the total mechanical energy:

$$W_{\text{before hitting}} = W_{\text{after hitting}} \quad (1)$$

$$W_{\text{before hitting}} = W_k = \frac{mV^2}{2} \quad (2)$$

$$W_{\text{after hitting}} = W_{\text{work}} = Fd \quad (3)$$

(3)and(2)in(1):

$$\frac{mV^2}{2} = Fd$$

$$F = \frac{mV^2}{2d} = \frac{2.5\text{kg} \cdot \left(27 \frac{\text{m}}{\text{s}}\right)^2}{2 \cdot 0.019\text{m}} = 48000\text{N} = 48 \text{ kN}$$

Newton's third law: When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction to that of the first body:

$$F_{\text{axe} \rightarrow \text{tree}} = F_{\text{tree} \rightarrow \text{axe}} = 48\text{kN}$$

Answer: a) 48 kN b) 48 kN.