$$E_f = \frac{mc^2}{\sqrt{1 - \frac{v_f^2}{c^2}}}$$

But the energy change (ΔE) is given by:

$$\Delta E = \underline{F} \cdot \underline{s} = F \Delta x$$ (since $\underline{F}$ in direction of x)

$$\therefore \quad \Delta E = 1.0 \times 10^6 \times 4 \times 10^{14} = 4 \times 10^{20} \text{ J}$$

Hence, $E_f - E_i = 4 \times 10^{20}$ J

So, $$mc^2 \left\{ \frac{1}{\sqrt{1 - \frac{v_f^2}{c^2}}} - \frac{1}{\sqrt{1 - (0.60)^2}} \right\} = 4.0 \times 10^{20}$$

$$\therefore \quad \frac{1}{\sqrt{1 - \frac{v_f^2}{c^2}}} - 1.25 = \frac{4.0 \times 10^{20}}{5.0 \times 10^3 \times (3.0 \times 10^8)^2}$$

$$= 0.89$$

$$\therefore \quad \frac{1}{\sqrt{1 - \frac{v_f^2}{c^2}}} = 2.14$$

whence,

$$v_f = 0.88c$$
$$= 2.6 \times 10^8 \text{ ms}^{-1}$$

(ii) We have, $$v_x' = \frac{v_x - V}{1 - \frac{V v_x}{c^2}}$$

Now we know, $v_x' = -0.88c$ (since rocket is moving in $-$ve x' direction)

So on substitution we have,