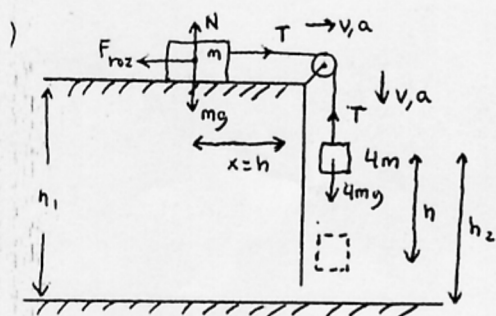




$$a) E_{tot, \text{inic}} = E_{tot, \text{fin}} + W_{roz}$$

$$mgh_1 + 4mgh_2 = (mgh_1 + \frac{1}{2}mv^2) + (4mgh_2 - h) + \frac{1}{2}4mv^2 + W_{roz}$$

$$W_{roz} = 4mgh - (\frac{1}{2}mv^2 + \frac{1}{2}4mv^2) = 0,5mgh$$

$$E_{k, \text{fin, sist}} = 3,5mgh$$

$$b) W_{roz} = F_{roz} \cdot x = \mu_c N h = \mu_c mgh, \quad \mu_c = \frac{W_{roz}}{mgh} = \frac{0,5mgh}{mgh} = 0,5$$

$$c) \begin{cases} T - F_{roz} = ma \rightarrow T - \mu_c mg = ma \\ 4mg - T = 4ma \rightarrow 4mg - T = 4ma \end{cases} \quad (*) \rightarrow a = \frac{4 - \mu_c}{5} g = \frac{4 - 0,5}{5} g = 0,7g = 6,87 \text{ m/s}^2$$

$$(*) \Rightarrow T = 4m(g - a) = 4m(g - 0,7g) = 1,2mg$$

$$3) a) E_k = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 + \frac{1}{2} m_3 v_3^2$$

$$v_1^2 = \vec{v}_1 \cdot \vec{v}_1 = 2, \quad v_2^2 = \vec{v}_2 \cdot \vec{v}_2 = 10, \quad v_3^2 = \vec{v}_3 \cdot \vec{v}_3 = 3 \quad \left\{ E_k = \frac{1}{2} 2 \times 2 + \frac{1}{2} 3 \times 10 + \frac{1}{2} 5 \times 3 = 24,5 \text{ J} \right.$$

$$b) E_{k, \text{cm}} = \frac{1}{2} M_{\text{tot}} v_{\text{cm}}^2$$

$$\vec{v}_{\text{cm}} = \frac{\sum m_i \vec{v}_i}{M_{\text{tot}}} = \frac{m_1 \vec{v}_1 + m_2 \vec{v}_2 + m_3 \vec{v}_3}{M_{\text{tot}}} = \frac{2(\vec{i} - \vec{j}) + 3(3\vec{j} - \vec{k}) + 5(\vec{i} + \vec{j} + \vec{k})}{10} = \frac{7}{10} \vec{i} + \frac{12}{10} \vec{j} + \frac{2}{10} \vec{k}$$

$$E_{k, \text{cm}} = \frac{1}{2} (2+3+5) \left[\left(\frac{7}{10} \right)^2 + \left(\frac{12}{10} \right)^2 + \left(\frac{2}{10} \right)^2 \right] = 9,85 \text{ J}$$

$$c) E_k = \frac{1}{2} M_{\text{tot}} v_{\text{cm}}^2 + E'_{k, \text{rel}} \quad (*)$$

$$E'_{k, \text{rel}} = \frac{1}{2} m_1 v_1'^2 + \frac{1}{2} m_2 v_2'^2 + \frac{1}{2} m_3 v_3'^2$$

$$\vec{v}_1' = \vec{v}_1 - \vec{v}_{\text{cm}} = \frac{1}{10} (3\vec{i} - 22\vec{j} - 2\vec{k}); \quad v_1'^2 = 4,97$$

$$\vec{v}_2' = \vec{v}_2 - \vec{v}_{\text{cm}} = \frac{1}{10} (-7\vec{i} + 18\vec{j} - 12\vec{k}); \quad v_2'^2 = 5,17$$

$$\vec{v}_3' = \vec{v}_3 - \vec{v}_{\text{cm}} = \frac{1}{10} (3\vec{i} - 2\vec{j} + 8\vec{k}); \quad v_3'^2 = 0,77$$

$$\Rightarrow E'_{k, \text{rel}} = 14,65 \text{ J}$$

$$(*) \text{ se cumple pues } 24,5 = 9,85 + 14,65$$