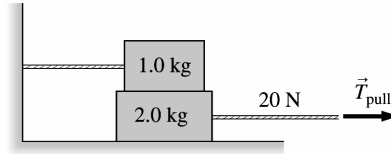


7.32. Model: The two blocks (1 and 2) are the systems of interest and will be treated as particles. The ropes are assumed to be massless, and the model of kinetic friction will be used.

Visualize:

Pictorial representation



Known

$$T_{\text{pull}} = 20 \text{ N}$$

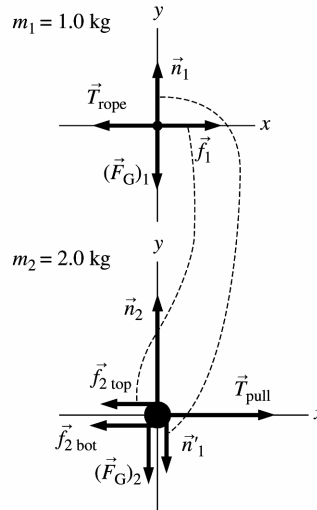
$$\mu_k = 0.40$$

$$m_1 = 1.0 \text{ kg}$$

$$m_2 = 2.0 \text{ kg}$$

Find

$$T_{\text{rope}} \quad a$$



Solve: (a) The separate free-body diagrams for the two blocks show that there are two action/reaction pairs. Notice how block 1 both pushes down on block 2 (force \vec{n}'_1) and exerts a retarding friction force $\vec{f}_{2 \text{ top}}$ on the top surface of block 2. Block 1 is in static equilibrium ($a_1 = 0 \text{ m/s}^2$) but block 2 is accelerating. Newton's second law for block 1 is

$$(F_{\text{net on 1}})_x = f_1 - T_{\text{rope}} = 0 \text{ N} \Rightarrow T_{\text{rope}} = f_1 \quad (F_{\text{net on 1}})_y = n_1 - m_1 g = 0 \text{ N} \Rightarrow n_1 = m_1 g$$

Although block 1 is stationary, there is a *kinetic* force of friction because there is motion between block 1 and block 2. The friction model means $f_1 = \mu_k n_1 = \mu_k m_1 g$. Substitute this result into the x -equation to get the tension in the rope:

$$T_{\text{rope}} = f_1 = \mu_k m_1 g = 3.92 \text{ N}$$

(b) Newton's second law for block 2 is

$$a_x = a = \frac{(F_{\text{net on 2}})_x}{m_2} = \frac{T_{\text{pull}} - f_{2 \text{ top}} - f_{2 \text{ bot}}}{m_2} \quad a_y = 0 \text{ m/s}^2 = \frac{(F_{\text{net on 2}})_y}{m_2} = \frac{n_2 - n'_1 - m_2 g}{m_2}$$

Forces \vec{n}_1 and \vec{n}'_1 are an action/reaction pair, so $n'_1 = n_1 = m_1 g$. Substituting into the y -equation gives $n_2 = (m_1 + m_2)g$. This is not surprising because the combined weight of both objects presses down on the surface. The kinetic friction on the bottom surface of block 2 is then

$$f_{2 \text{ bot}} = \mu_k n_2 = \mu_k (m_1 + m_2)g$$

The forces \vec{f}_1 and $\vec{f}_{2 \text{ top}}$ are an action/reaction pair, so $f_{2 \text{ top}} = f_1 = \mu_k m_1 g$. Inserting these friction results into the x -equation gives

$$a = \frac{(F_{\text{net on 2}})_x}{m_2} = \frac{T_{\text{pull}} - \mu_k m_1 g - \mu_k (m_1 + m_2) g}{m_2} = 2.16 \text{ m/s}^2$$