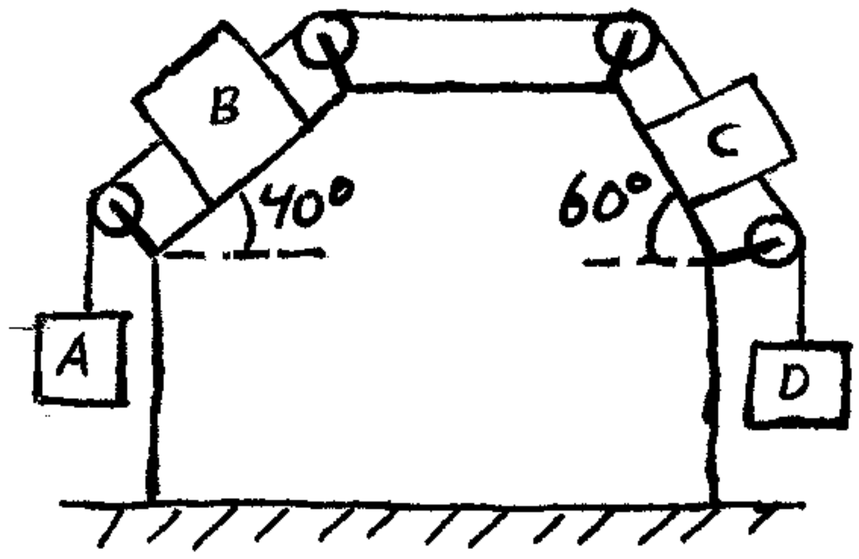
Oct. 1, 2020

This is a force and motion problem involving friction.

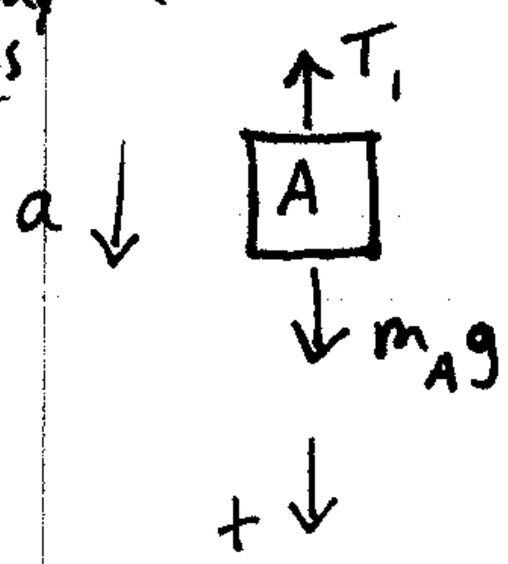


In the pulley system shown, $m_A = 10\,kg$, $m_B = 20\,kg$, $m_C = 8\,kg$, and $m_D = 5\,kg$. If the coefficient of kinetic friction between the blocks and the sliding surface is 0.15, what is the acceleration of block A and what is the tension in the different rope segments?

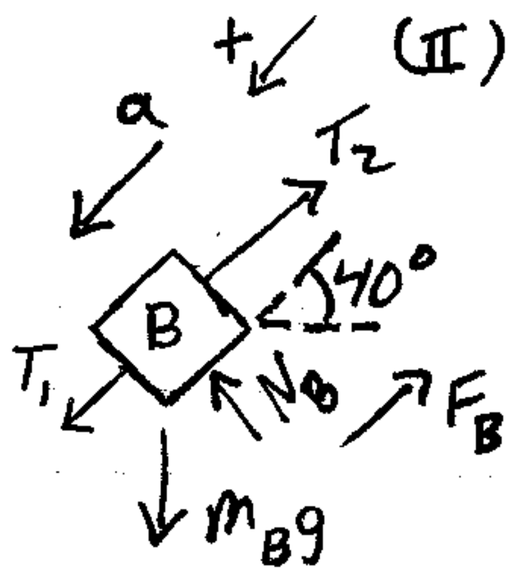
Solution:

Free-body diagrams

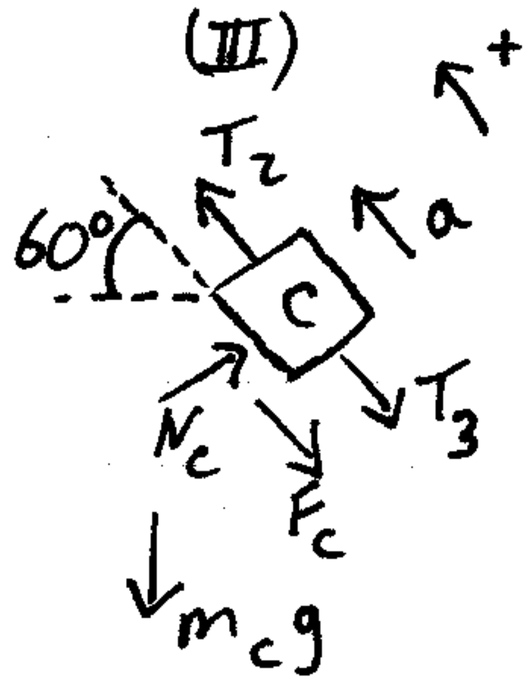
(I)



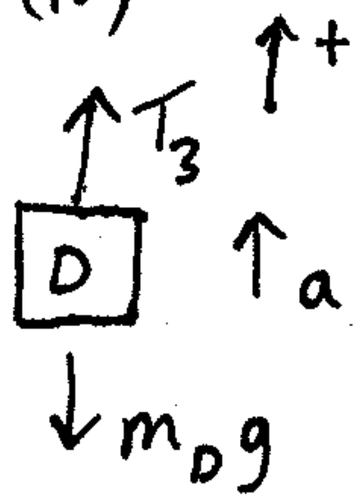
(II)



(III)



(IV)



(I) Apply Newton's second law:

$$m_A g - T_1 = m_A a \quad (1)$$

(II) Apply Newton's second law:

$$T_1 + m_B g \sin 40^\circ - F_B = m_B a \quad , \quad F_B = \mu_K N_B$$
$$\Rightarrow T_1 + m_B g \sin 40^\circ - 0.15 m_B g \cos 40^\circ = m_B a \quad (2) \quad , \quad N_B = m_B g \cos 40^\circ$$
$$\mu_K = 0.15$$

(III) Apply Newton's second law:

$$T_2 - m_c g \sin 60^\circ - F_c - T_3 = m_c a$$
$$\Rightarrow T_2 - m_c g \sin 60^\circ - 0.15 m_c g \cos 60^\circ = m_c a \quad (3) \quad , \quad F_c = \mu_K N_c$$
$$N_c = m_c g \cos 60^\circ$$
$$\mu_K = 0.15$$

(IV) Apply Newton's second law:

$$T_3 - m_D g = m_D a \quad (4)$$

Solve equations (1)-(4):

$$a = 1.83 \, m/s^2$$

$$T_1 = 79.7 \, N \quad \text{(answer)}$$

$$T_2 = 146.57 \, N$$

$$T_3 = 58.15 \, N$$