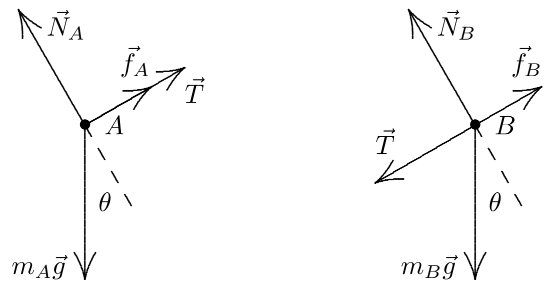
23. The free-body diagrams for the two blocks are shown below. T is the magnitude of the tension force of the string, $\vec{N}_A$ is the normal force on block A (the leading block), $\vec{N}_B$ is the the normal force on block B, $\vec{f}_A$ is kinetic friction force on block A, $\vec{f}_B$ is kinetic friction force on block B. Also, m_A is the mass of block A (where $m_A = W_A/g$ and $W_A = 3.6$ N), and m_B is the mass of block B (where $m_B = W_B/g$ and $W_B = 7.2$ N). The angle of the incline is $\theta = 30°$.



For each block we take $+x$ downhill (which is toward the lower-left in these diagrams) and $+y$ in the direction of the normal force. Applying Newton's second law to the x and y directions of first block A and next block B, we arrive at four equations:

$$\begin{aligned} W_A \sin\theta - f_A - T &= m_A\, a \\ N_A - W_A \cos\theta &= 0 \\ W_B \sin\theta - f_B + T &= m_B\, a \\ N_B - W_B \cos\theta &= 0\ . \end{aligned}$$

which, when combined with Eq. 6-2 ($f_A = \mu_{k\,A} N_A$ where $\mu_{k\,A} = 0.10$ and $f_B = \mu_{k\,B} N_B$ where $\mu_{k\,B} = 0.20$), fully describe the dynamics of the system so long as the blocks have the same acceleration and $T > 0$.

(a) These equations lead to an acceleration equal to

$$a = g\left(\sin\theta - \left(\frac{\mu_{k\,A} W_A + \mu_{k\,B} W_B}{W_A + W_B}\right)\cos\theta\right) = 3.5\ \mathrm{m/s^2}\ .$$

(b) We solve the above equations for the tension and obtain

$$T = \left(\frac{W_A\, W_B}{W_A + W_B}\right)(\mu_{k\,B} - \mu_{k\,A})\cos\theta = 0.21\ \mathrm{N}\ .$$

Simply returning the value for a found in part (a) into one of the above equations is certainly fine, and probably easier than solving for T algebraically as we have done, but the algebraic form does illustrate the $\mu_{k\,B} - \mu_{k\,A}$ factor which aids in the understanding of the next part.

(c) Reversing the blocks is equivalent to switching the labels (so A is now the block of weight 7.2 N and $\mu_{k\,A}$ is now the 0.20 value). We see from our algebraic result in part (b) that this gives a negative value for T, which is impossible. We conclude that the above set of four equations are not valid in this circumstance (specifically, a for one block is not equal to a for the other block). The blocks move independently of each other.