

45. Objects with masses $m_1 = 10.0$ kg and $m_2 = 5.00$ kg are connected by a light string that passes over a frictionless pulley as in Figure P4.30. If, when the system starts from rest, m_2 falls 1.00 m in 1.20 s, determine the coefficient of kinetic friction between m_1 and the table.

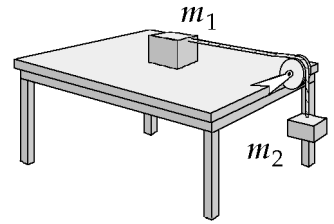
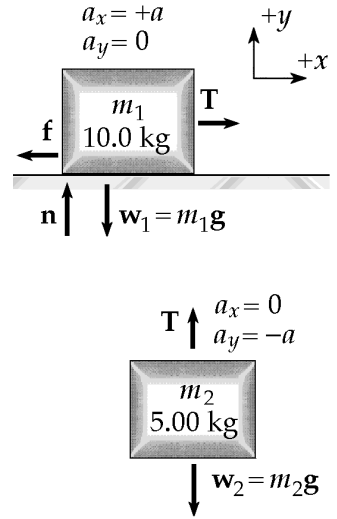


Figure P4.30

Solution The free-body diagrams of the two objects in this system are shown at the right. Note that the accelerations of the two objects have the same magnitude, a , with the acceleration of m_1 directed horizontally to the right and the acceleration of m_2 directed vertically downward.



Since m_2 is observed to drop downward 1.00 m in 1.20 s when the system is released, the magnitude of the acceleration is found using $\Delta y = v_{iy}t + \frac{1}{2}a_yt^2$ as

$$-1.00 \text{ m} = 0 + \frac{1}{2}(-a)(1.20 \text{ s})^2 \quad \text{so} \quad a = 1.39 \text{ m/s}^2$$

The weights of the objects are $w_1 = m_1g = 98.0$ N and $w_2 = m_2g = 49.0$ N. Applying Newton's second law to m_2 gives us the tension T in the cord:

$$\begin{aligned} \sum F_y = m_2a_y : \quad & +T - w_2 = m_2(-a) \\ T = 49.0 \text{ N} + (5.00 \text{ kg})(-1.39 \text{ m/s}^2) &= 42.1 \text{ N} \end{aligned}$$

Now, consider the vertical forces acting on m_1 :

$$\sum F_y = m_1a_y : \quad +n - w_1 = 0 \quad \text{so} \quad n = w_1 = 98.0 \text{ N}$$

Finally, considering the horizontal forces acting on m_1 ,

$$\begin{aligned} \sum F_x = m_1a_x : \quad & +T - f = m_1(+a) \\ f = T - m_1a &= 42.1 \text{ N} - (10.0 \text{ kg})(1.39 \text{ m/s}^2) \end{aligned}$$

so the friction force is $f = 28.2$ N. The coefficient of kinetic friction between m_1 and the table is therefore

$$\mu_k = \frac{f}{n} = \frac{28.2 \text{ N}}{98.0 \text{ N}} = 0.287$$

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