PROBLEM 8.2

Determine whether the block shown is in equilibrium and find the magnitude and direction of the friction force when $\theta = 30^\circ$ and $P = 30$ lb.

SOLUTION

Assume equilibrium:

\[ \sum F_x = 0: \quad F + (240 \text{ lb}) \sin 30^\circ - (30 \text{ lb}) \cos 30^\circ = 0 \]

\[ F = -94.019 \text{ lb} \quad \text{and} \quad F = 94.019 \text{ lb} \]

\[ \sum F_y = 0: \quad N - (240 \text{ lb}) \cos 30^\circ - (30 \text{ lb}) \sin 30^\circ = 0 \]

\[ N = +222.85 \text{ lb} \quad \text{and} \quad N = 222.85 \text{ lb} \]

Maximum friction force:

\[ F_m = \mu_s N \]

\[ = 0.35(222.85 \text{ lb}) \]

\[ = 77.998 \text{ lb} \]

Since $F$ is $\downarrow$ and $F > F_m$, Block moves down $\downarrow$

Actual friction force:

\[ F = F_k = \mu_k N = 0.25(222.85 \text{ lb}) \]

\[ F = 55.7 \text{ lb} \downarrow \]
**PROBLEM 8.12**

The coefficients of friction are $\mu_s = 0.40$ and $\mu_k = 0.30$ between all surfaces of contact. Determine the smallest force $P$ required to start the 30-kg block moving if cable $AB$ (a) is attached as shown, (b) is removed.

**SOLUTION**

(a) **Free body: 20-kg block**

\[
W_1 = (20 \text{ kg})(9.81 \text{ m/s}^2) = 196.2 \text{ N}
\]
\[
F_1 = \mu_s N_1 = 0.4(196.2 \text{ N}) = 78.48 \text{ N}
\]
\[\sum_F = 0: \quad T - F_1 = 0 \quad T = F_1 = 78.48 \text{ N}\]

Free body: 30-kg block

\[
W_2 = (30 \text{ kg})(9.81 \text{ m/s}^2) = 294.3 \text{ N}
\]
\[
N_2 = 196.2 \text{ N} + 294.3 \text{ N} = 490.5 \text{ N}
\]
\[
F_2 = \mu_k N_2 = 0.4(490.5 \text{ N}) = 196.2 \text{ N}
\]
\[\sum F = 0: \quad P - F_1 - F_2 = 0\]
\[P = 78.48 \text{ N} + 196.2 \text{ N} = 274.7 \text{ N}\]

(b) **Free body: Both blocks**

**Blocks move together**

\[
W = (50 \text{ kg})(9.81 \text{ m/s}^2) = 490.5 \text{ N}
\]
\[\sum F = 0: \quad P - F = 0\]
\[P = \mu_k N = 0.4(490.5 \text{ N}) = 196.2 \text{ N}\]

\[P = 196.2 \text{ N} \quad \blacktriangleleft\]
PROBLEM 8.16

A 120-lb cabinet is mounted on casters that can be locked to prevent their rotation. The coefficient of static friction between the floor and each caster is 0.30. Assuming that the casters at both A and B are locked, determine (a) the force $P$ required to move the cabinet to the right, (b) the largest allowable value of $h$ if the cabinet is not to tip over.

SOLUTION

FBD cabinet:

(a)

\[ \Sigma F_y = 0: \quad N_A + N_B - W = 0 \]
\[ N_A + N_B = W \]

Impending slip:

\[ F_A = \mu_s N_A \]
\[ F_B = \mu_s N_B \]

So

\[ F_A + F_B = \mu_s W \]

\[ \Sigma F_x = 0: \quad P - F_A - F_B = 0 \]
\[ P = F_A + F_B = \mu_s W \]
\[ P = 0.3(120 \text{ lb}) = 141.26 \text{ N} \]

(b) For tipping,

\[ N_A = F_A = 0 \]

\[ \Sigma M_B = 0: \quad hP - (12 \text{ in.})W = 0 \]
\[ h_{\text{max}} = (12 \text{ in.}) \frac{W}{P} = (12 \text{ in.}) \frac{1}{\mu_s} = \frac{12 \text{ in.}}{0.3} \]

\[ h_{\text{max}} = 40.0 \text{ in.} \]