\(8-1.\) Determine the minimum horizontal force \(P\) required to hold the crate from sliding down the plane. The crate has a mass of 50 kg and the coefficient of static friction between the crate and the plane is \(\mu_s = 0.25\).

Free Body Diagram: When the crate is on the verge of sliding down the plane, the frictional force \(F\) will act up the plane as indicated on the free-body diagram of the crate shown in Fig. a.

Equations of Equilibrium:

\[
\begin{align*}
\sum F_y &= 0; \quad N - P \sin 30^\circ - 50(9.81) \cos 30^\circ = 0 \\
\sum F_x &= 0; \quad P \cos 30^\circ + 25(N - 50(9.81) \sin 30^\circ) = 0
\end{align*}
\]

Solving

\[
\begin{align*}
P &= 140 \text{ N} \\
N &= 494.94 \text{ N}
\end{align*}
\]

*8–4. If the coefficient of static friction at \( A \) is \( \mu_s = 0.4 \) and the collar at \( B \) is smooth so it only exerts a horizontal force on the pipe, determine the minimum distance \( x \) so that the bracket can support the cylinder of any mass without slipping. Neglect the mass of the bracket. \( x \text{ mS} = 0.4 \)

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*8–4. If the coefficient of static friction at \( A \) is \( \mu_s = 0.4 \) and the collar at \( B \) is smooth so it only exerts a horizontal force on the pipe, determine the minimum distance \( x \) so that the bracket can support the cylinder of any mass without slipping. Neglect the mass of the bracket.

**Free Body Diagram.** The weight of cylinder tends to cause the bracket to slide downward. Thus, the frictional force \( F_A \) must act upwards as indicated in the free-body diagram shown in Fig. a. Here the bracket is required to be on the verge of slipping so that 

\[
F_A = \mu_s N_A = 0.4 N_A.
\]

**Equations of Equilibrium.**

\[ + \sum F_y = 0; \quad 0.4 N_A - mg = 0 \]
\[ + \sum N_B = 0; \quad 2.5mg(0.2) + 0.4(2.5m)g(0.1) - m(g)x + 0.1 = 0 \]

**Ans.**

\( x = 0.5 \text{ m} \)

**Note:** Since \( x \) is independent of the mass of the cylinder, the bracket will not slip regardless of the mass of the cylinder provided \( x > 0.5 \text{ m} \).
8–9. If the coefficient of static friction at all contacting surfaces is \( \mu_s \), determine the inclination \( \theta \) at which the identical blocks, each of weight \( W \), begin to slide.

Free-Body Diagram. Here, we will assume that the impending motion of the upper block is down the plane while the impending motion of the lower block is up the plane. Thus, the frictional force \( F' \) acting on the upper block acts up the plane while the friction forces \( F \) and \( F' \) acting on the lower block act down the plane as indicated on the free-body diagram of the upper and lower blocks shown in Figs. a and b, respectively. Since both blocks are required to be on the verge of slipping, then \( F = \mu_s N \) and \( F' = \mu_s N' \).

Equations of Equilibrium. Referring to Fig. a,
\[
\sum F_y = 0, \quad N - W \cos \theta = 0 \\
\sum F_x = 0, \quad T + \mu_s (W \cos \theta) - W \sin \theta = 0 \\
N = W \cos \theta \\
T = W \sin \theta - \mu_s W \cos \theta
\]

Using these results and referring to Fig. b,
\[
\sum F_y = 0, \quad N' - W \cos \theta - W \cos \theta = 0 \\
\sum F_x = 0, \quad 2(W \sin \theta - \mu_s W \cos \theta) - \mu_s W \cos \theta - \mu_s (2W \cos \theta) - W \sin \theta = 0 \\
N' = 2W \cos \theta \\
\sin \theta - 5 \mu_s \cos \theta = 0 \\
\theta = \tan^{-1} 5 \mu_s
\]

Ans.

Since the analysis yields a positive \( \theta \), the above assumption is correct.
8–10. The uniform 20-lb ladder rests on the rough floor for which the coefficient of static friction is \( \mu_s = 0.8 \) and against the smooth wall at \( B \). Determine the horizontal force \( P \) the man must exert on the ladder in order to cause it to move. \( mS = 0 \)

Assume that the ladder tips about \( A \):

- \( N_A = 0 \);
- \( \Sigma F_x = 0 \): \( P - F_x = 0 \)
- \( \Sigma F_y = 0 \): \( -20 + N_A = 0 \)
- \( N_A = 20 \text{ lb} \)
- \( \Sigma M_A = 0 \): \( 20 \times 3 - P \times 4 = 0 \)
- \( P = 15 \text{ lb} \)

Thus

\( F_x = 15 \text{ lb} \)

\( (F_x)_{\text{max}} = 0.8 \times 20 = 16 \text{ lb} > 15 \text{ lb} \) OK

Ladder tips as assumed.

\( P = 15 \text{ lb} \) Ans