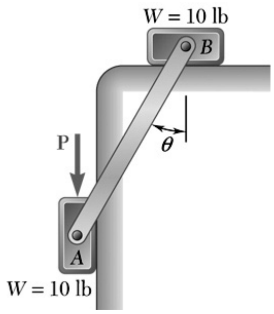
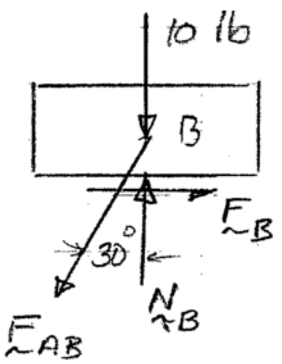


PROBLEM 8.141

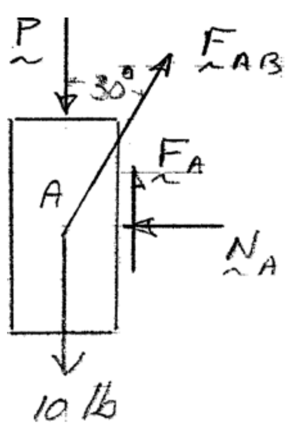
Two 10-lb blocks *A* and *B* are connected by a slender rod of negligible weight. The coefficient of static friction is 0.30 between all surfaces of contact, and the rod forms an angle $\theta = 30°$ with the vertical. (*a*) Show that the system is in equilibrium when $P = 0$. (*b*) Determine the largest value of *P* for which equilibrium is maintained.

SOLUTION

FBD block B:



FBD block A:



(*b*) For $P_{\max}$, motion impends at both surfaces

B: $\uparrow \Sigma F_y = 0{:}\quad N_B - 10\text{ lb} - F_{AB}\cos 30° = 0$

$$N_B = 10\text{ lb} + \frac{\sqrt{3}}{2}F_{AB} \qquad (1)$$

Impending motion: $F_B = \mu_s N_B = 0.3N_B$

$\longrightarrow \Sigma F_x = 0{:}\quad F_B - F_{AB}\sin 30° = 0$

$$F_{AB} = 2F_B = 0.6N_B \qquad (2)$$

Solving (1) and (2) $\quad N_B = 10\text{ lb} + \frac{\sqrt{3}}{2}(0.6N_B)$

$$= 20.8166\text{ lb}$$

Then $\quad F_{AB} = 0.6N_B = 12.4900\text{ lb}$

A: $\longrightarrow \Sigma F_x = 0{:}\quad F_{AB}\sin 30° - N_A = 0$

$$N_A = \frac{1}{2}F_{AB} = \frac{1}{2}(12.4900\text{ lb}) = 6.2450\text{ lb}$$

Impending motion: $F_A = \mu_s N_A = 0.3(6.2450\text{ lb}) = 1.8735\text{ lb}$

$\uparrow \Sigma F_y = 0{:}\quad F_A + F_{AB}\cos 30° - P - 10\text{ lb} = 0$

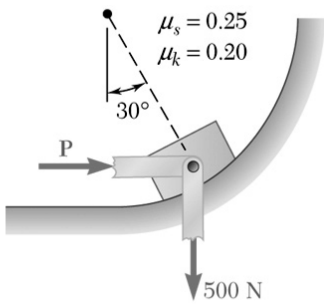
$$P = F_A + \frac{\sqrt{3}}{2}F_{AB} - 10\text{ lb}$$

$$= 1.8735\text{ lb} + \frac{\sqrt{3}}{2}(12.4900\text{ lb}) - 10\text{ lb} = 2.69\text{ lb}$$

$P = 2.69\text{ lb}$ ◀

(*a*) Since $P = 2.69$ lb to initiate motion,
equilibrium exists with $P = 0$ ◀

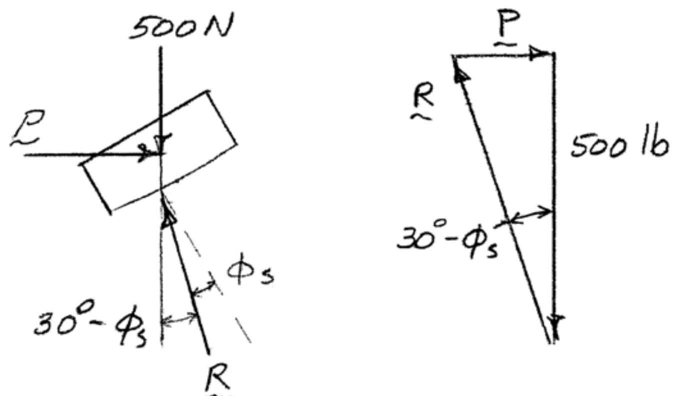
PROBLEM 8.142



Determine the range of values of P for which equilibrium of the block shown is maintained.

SOLUTION

FBD block (Impending motion down):

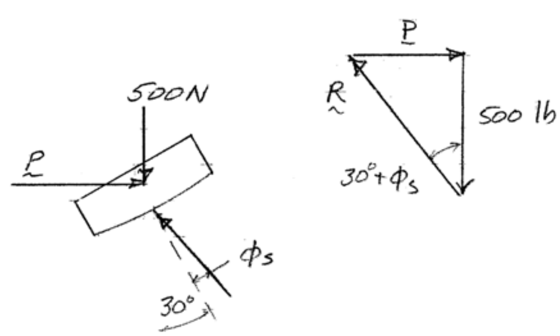


$$\phi_s = \tan^{-1}\mu_s = \tan^{-1}0.25$$

$$P = (500 \text{ lb})\tan\left(30° - \tan^{-1}0.25\right)$$

$$= 143.03 \text{ lb}$$

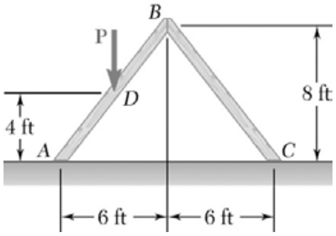
(Impending motion up):



$$P = (500 \text{ lb})\tan\left(30° + \tan^{-1}0.25\right)$$

$$= 483.46 \text{ lb}$$

Equilibrium for $143.0 \text{ lb} \le P \le 483 \text{ lb}$ ◀

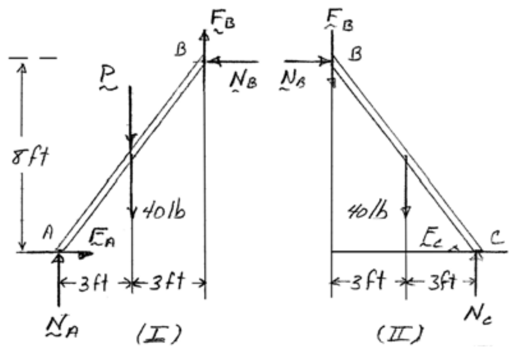


PROBLEM 8.143

Two identical uniform boards, each of weight 40 lb, are temporarily leaned against each other as shown. Knowing that the coefficient of static friction between all surfaces is 0.40, determine (*a*) the largest magnitude of the force **P** for which equilibrium will be maintained, (*b*) the surface at which motion will impend.

SOLUTION

Board FBDs:



Assume impending motion at *C*, so

$$F_C = \mu_s N_C$$

$$= 0.4 N_C$$

FBD II:

$$\circlearrowleft \Sigma M_B = 0: \quad (6\text{ ft})N_C - (8\text{ ft})F_C - (3\text{ ft})(40\text{ lb}) = 0$$

$$\left[6\text{ ft} - 0.4(8\text{ ft})\right]N_C = (3\text{ ft})(40\text{ lb})$$

or

$$N_C = 42.857\text{ lb}$$

and

$$F_C = 0.4N_C = 17.143\text{ lb}$$

$$\rightarrow \Sigma F_x = 0: \quad N_B - F_C = 0$$

$$N_B = F_C = 17.143\text{ lb}$$

$$\uparrow \Sigma F_y = 0: \quad -F_B - 40\text{ lb} + N_C = 0$$

$$F_B = N_C - 40\text{ lb} = 2.857\text{ lb}$$

Check for motion at *B*:

$$\frac{F_B}{N_B} = \frac{2.857\text{ lb}}{17.143\text{ lb}} = 0.167 < \mu_s, \quad \text{OK, no motion.}$$

PROBLEM 8.143 CONTINUED

FBD I:

$$\circlearrowleft \Sigma M_A = 0: \quad (8\text{ ft})N_B + (6\text{ ft})F_B - (3\text{ ft})(P + 40\text{ lb}) = 0$$

$$P = \frac{(8\text{ ft})(17.143\text{ lb}) + (6\text{ ft})(2.857\text{ lb})}{3\text{ ft}} - 40\text{ lb} = 11.429\text{ lb}$$

Check for slip at A (unlikely because of P)

$$\rightarrow \Sigma F_x = 0: \quad F_A - N_B = 0 \qquad \text{or} \qquad F_A = N_B = 17.143\text{ lb}$$

$$\uparrow \Sigma F_y = 0: \quad N_A - P - 40\text{ lb} + F_B = 0 \qquad \text{or} \qquad N_A = 11.429\text{ lb} + 40\text{ lb} - 2.857\text{ lb}$$

$$= 48.572\text{ lb}$$

Then $\dfrac{F_A}{N_A} = \dfrac{17.143\text{ lb}}{48.572\text{ lb}} = 0.353 < \mu_s,$ OK, no slip $\Rightarrow$ assumption is correct

Therefore,

(*a*) $P_{\text{max}} = 11.43\text{ lb}$ ◀

(*b*) Motion impends at C ◀