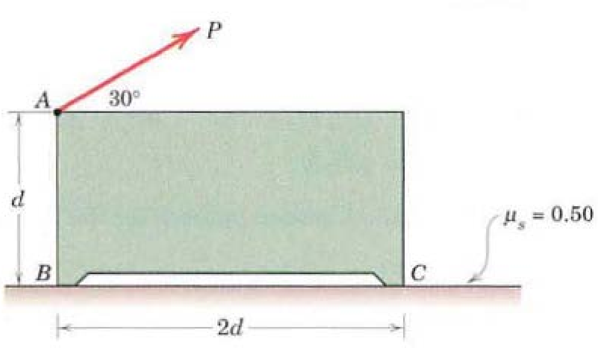
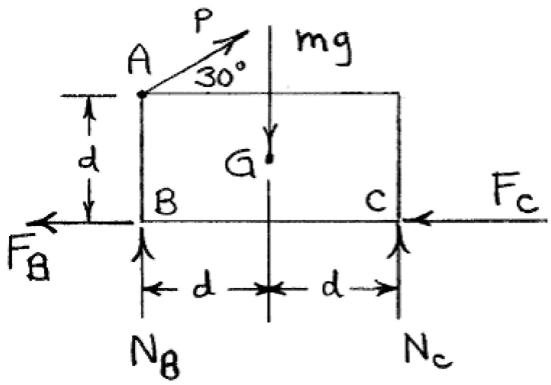
Problem 6

The magnitude of force P is slowly increased. Does the homogeneous box of mass m slip or tip first? State the value of P which would cause each occurrence. Neglect any effect of the size of the small feet.



Solution



Slips:

$$\Sigma F_x = 0: \quad -F_B - F_C + P\cos 30° = 0 \qquad (1)$$

$$\Sigma F_y = 0: \quad N_B + N_C + P\sin 30° - mg = 0 \qquad (2)$$

With $F_B = \mu_s N_B$ & $F_C = \mu_s N_C$, combine (1) & (2) to obtain $P = \dfrac{\mu_s mg}{\mu_s \sin 30° + \cos 30°}$

With $\mu_s = 0.5$, $P = P_{slip} = \underline{0.448 mg}$

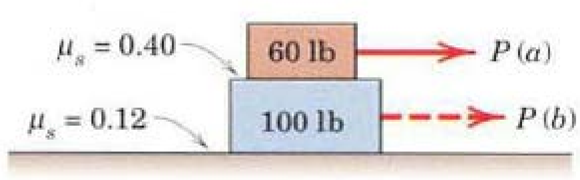
Tips ($N_B, F_B \to 0$):

$$\Sigma M_G = 0: \quad (P\cos 30°)d + (P\sin 30°)(2d) - mg(d) = 0$$

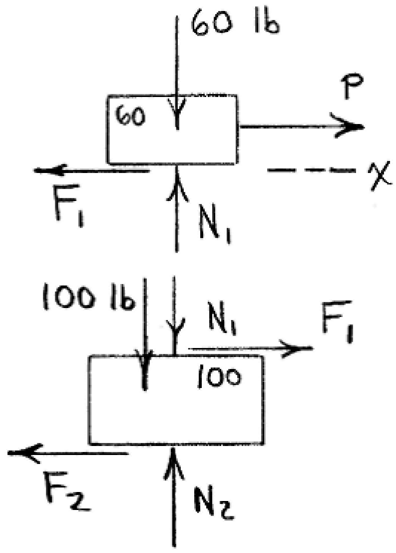
$$\Rightarrow P = \frac{mg}{\cos 30° + 2\sin 30°} = \underline{0.536 mg = P_{tip}}$$

Problem 7

The force P is app lied to (a) the 60-lb block and (b) the 100-lb block. For each case, determine the magnitude of P required to initiate motion.



Solution



(a) P applied to 60-lb block

(Note : $N_1 = 60$ lb & $N_2 = 160$ lb throughout)

Assume 60-lb block slips by itself $(F_1 = \mu_{s_1} N_1)$

$\sum F_x = 0: \quad P - \mu_{s_1} N = 0$

$P = \mu_{s_1} N_1 = 0.4(60) = 24$ lb

Check on 100-lb block :

$\sum F_x = 0: \quad 24 - F_2 = 0, \quad F_2 = 24$ lb

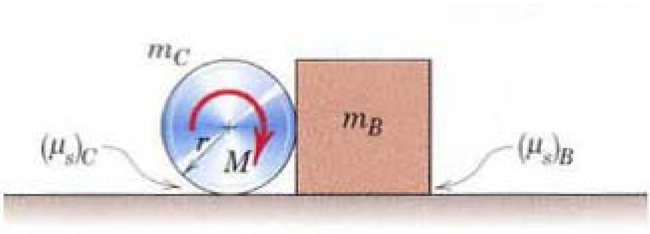
But $F_{2max} = \mu_{s_2} N_2 = 0.12(160) = 19.2$ lb

So the 60-lb does not slip by itself; rather, the two blocks move as a unit. In both cases (a) & (b),

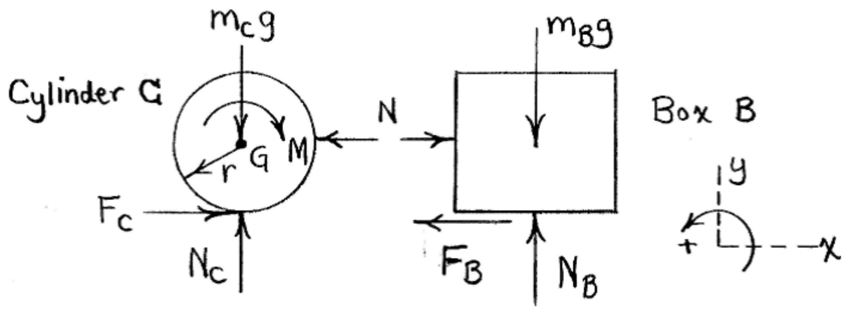
$P = \mu_{s_2} N_2 = 0.12(160) = \underline{19.2 \text{ lb}}$

Problem 8

A clockwise couple M is applied to the circular cylinder as shown. Determine the value of M required to initiate motion for the conditions m_B = 3 kg, m_c = 6 kg, $(\mu_s)_B$ = 0.5, $(\mu_s)_c$= 0.4, and r = 0.2 m. Friction between the cylinder C and the block B is negligible.



Solution



$F_B = (\mu_s)_B N_B$.

$$B \begin{cases} \Sigma F_x = 0 : & N - F_B = 0 \quad (1) \\ \Sigma F_y = 0 : & N_B - m_B g = 0 \quad (2) \end{cases}$$

So $N_B = m_B g$, $N = F_B = (\mu_s)_B m_B g$

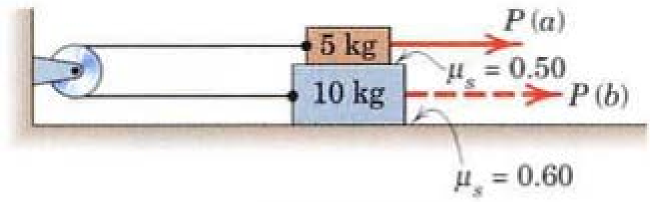
$$C \begin{cases} \Sigma F_x = 0 : & F_c - N = 0 \quad (3) \\ \Sigma F_y = 0 : & N_c - m_c g = 0 \quad (4) \\ \Sigma M_G = 0 : & F_c r - M = 0 \quad (5) \end{cases}$$

$$M = F_c r = N r = (\mu_s)_B m_B g r$$
$$= 0.5(3)(9.81)(0.2) = \underline{2.94 \text{ N}\cdot\text{m}}$$

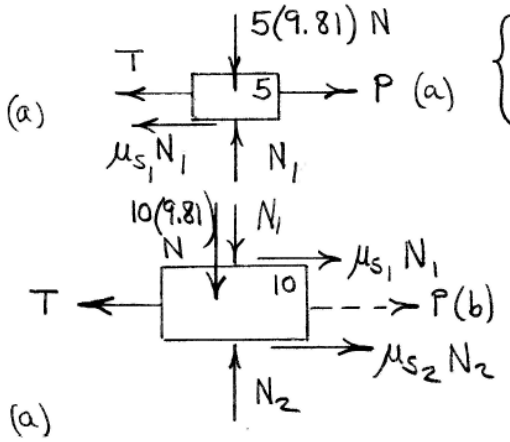
$$F_c = N = (\mu_s)_B m_B g = (0.5)(3)(9.81) = 14.72 \text{ N}$$
$$< (F_c)_{max} = (\mu_s)_c m_c g = (0.4)(6)(9.81) = 23.5 \text{ N}$$

Problem 9

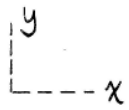
The system of two blocks, cable, and fixed pulley is initially at rest. Determine the horizontal force P necessary to cause mot ion when (a) P is applied to the 5-kg block and (b) P is applied to the 10 -kg block. Determine the corresponding tens ion T in the cable for each case.



Solution



$$\begin{cases} \mu_{s_1} = 0.50 \\ \mu_{s_2} = 0.60 \end{cases}$$



From $\Sigma F_y = 0$,

$$\begin{cases} N_1 = 49.0 \text{ N} \\ N_2 = 147.2 \text{ N} \end{cases}$$

$$\Sigma F_x = 0: \begin{cases} P - T - 0.50(49.0) = 0 \\ -T + 0.50(49.0) + 0.60(147.2) = 0 \end{cases}$$

$T = 112.8$ N, $\underline{P = 137.3 \text{ N}}$

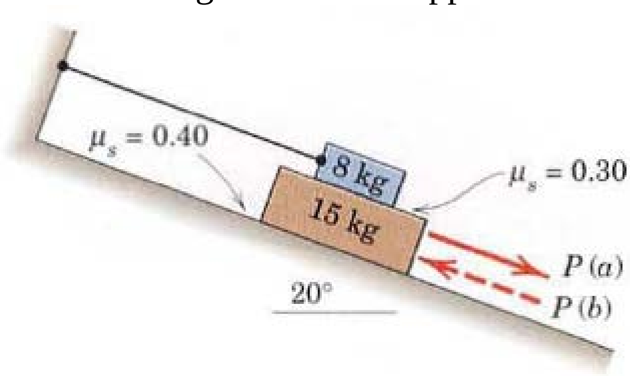
(b) Now P is applied to 10-kg block & we reverse all friction forces above:

$$\Sigma F_x = 0: \begin{cases} -T + 0.50(49.0) = 0 \\ -T - 0.50(49.0) - 0.60(147.2) + P = 0 \end{cases}$$

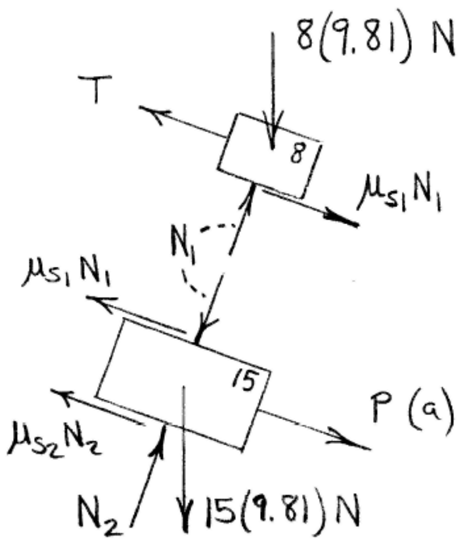
$\underline{T = 24.5 \text{ N}}$, $\underline{P = 137.3 \text{ N}}$

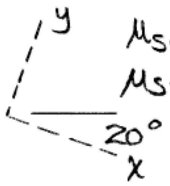
Problem 10

The two blocks are placed on the incline with the cab le taut. Determine the force P required to initiate motion of the 15-kg block if P is applied down the incline.



Solution





$\mu_{s_1} = 0.30$
$\mu_{s_2} = 0.40$

From $\Sigma F_y = 0$,

$$\begin{cases} N_1 = 73.7 \text{ N} \\ N_2 = 212 \text{ N} \end{cases}$$

(throughout)

$\Sigma F_x = 0$:

$$\left.\begin{aligned} &-T + 8(9.81)\sin 20^\circ + \mu_{s_1} N_1 = 0 \\ &-\mu_{s_1} N_1 - \mu_{s_2} N_2 + 15(9.81)\sin 20^\circ + P = 0 \end{aligned}\right\}$$

Solution : $\underline{P = 56.6 \text{ N},}$ $T = 49.0$ N