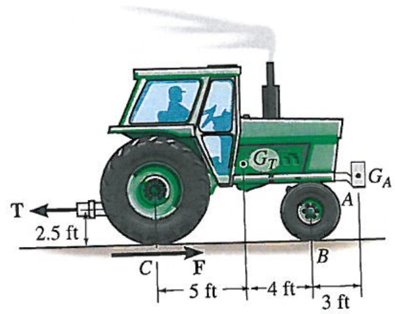
8–2.

The tractor exerts a towing force $T = 400$ lb. Determine the normal reactions at each of the two front and two rear tires and the tractive frictional force $\mathbf{F}$ on each rear tire needed to pull the load forward at constant velocity. The tractor has a weight of 7500 lb and a center of gravity located at G_T. An additional weight of 600 lb is added to its front having a center of gravity at G_A. Take $\mu_s = 0.4$. The front wheels are free to roll.



SOLUTION

Equations of Equilibrium:

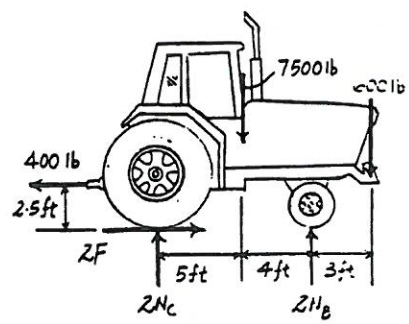
$\circlearrowleft + \Sigma M_C = 0 \qquad 2N_B(9) + 400(2.5) - 7500(5) - 600(12) = 0$

$N_B = 2427.78 \text{ lb} = 2.43 \text{ kip}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \qquad 2N_C + 2(2427.78) - 7500 - 600 = 0$

$N_C = 1622.22 \text{ lb} = 1.62 \text{ kip}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0; \qquad 2F - 400 = 0 \qquad F = 200 \text{ lb}$ **Ans.**

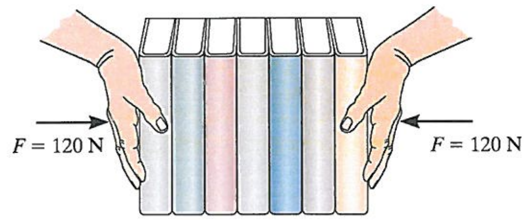


Friction: The maximum friction force that can be developed between each of the rear tires and the ground is $F_{max} = \mu_s N_C = 0.4(1622.22) = 648.89$ lb. Since $F_{max} > F = 200$ lb, the rear tires will not slip. Hence the tractor is capable of towing the 400 lb load.

Ans:
$N_B = 2.43$ kip
$N_C = 1.62$ kip
$F = 200$ lb

8–21.

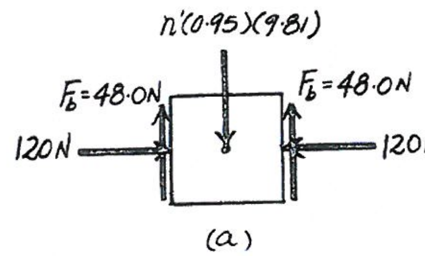
A man attempts to support a stack of books horizontally by applying a compressive force of $F = 120$ N to the ends of the stack with his hands. If each book has a mass of 0.95 kg, determine the greatest number of books that can be supported in the stack. The coefficient of static friction between the man's hands and a book is $(\mu_s)_h = 0.6$ and between any two books $(\mu_s)_b = 0.4$.



SOLUTION

Equations of Equilibrium and Friction: Let n' be the number of books that are on the verge of sliding together between the two books at the edge. Thus, $F_b = (\mu_s)_b N = 0.4(120) = 48.0$ N. From FBD (a),

$$+\uparrow \Sigma F_y = 0; \qquad 2(48.0) - n'(0.95)(9.81) = 0 \qquad n' = 10.30$$

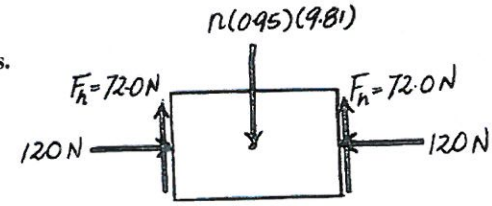


Let n be the number of books are on the verge of sliding together in the stack between the hands. Thus, $F_k = (\mu_s)_k N = 0.6(120) = 72.0$ N. From FBD (b),

$$+\uparrow \Sigma F_y = 0; \qquad 2(72.0) - n(0.95)(9.81) = 0 \qquad n = 15.45$$

Thus, the maximum number of books can be supported in stack is

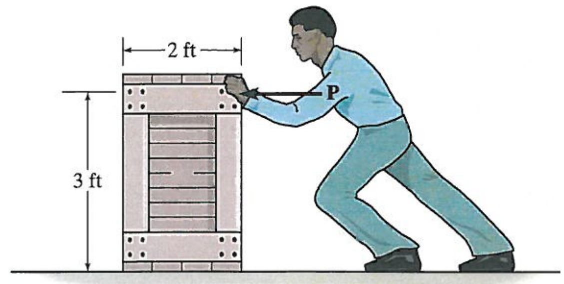
$$n = 10 + 2 = 12 \qquad \textbf{Ans.}$$



Ans:
$n = 12$

8–33.

The man having a weight of 200 lb pushes horizontally on the crate. If the coefficient of static friction between the 450-lb crate and the floor is $\mu_s = 0.3$ and between his shoes and the floor is $\mu'_s = 0.6$, determine if he can move the crate.



SOLUTION

Equations of Equilibrium. Referring to the *FBD* of the crate shown in Fig. *a*,

$$\overset{+}{\rightarrow}\Sigma F_x = 0; \quad F_C - P = 0 \qquad (1)$$

$$+\uparrow\Sigma F_y = 0; \quad N_C - 450 = 0 \quad N_C = 450 \text{ lb}$$

$$\circlearrowleft + \Sigma M_O = 0; \quad P(3) - 450(x) = 0 \qquad (2)$$

Also, from the *FBD* of the man, Fig. *b*,

$$\overset{+}{\rightarrow}\Sigma F_x = 0; \quad P - F_m = 0 \qquad (3)$$

$$+\uparrow\Sigma F_y = 0; \quad N_m - 200 = 0 \quad N_m = 200 \text{ lb}$$

Friction. Assuming that the crate slides before tipping. Thus

$$F_C = \mu_s N_C = 0.3(450) = 135 \text{ lb}$$

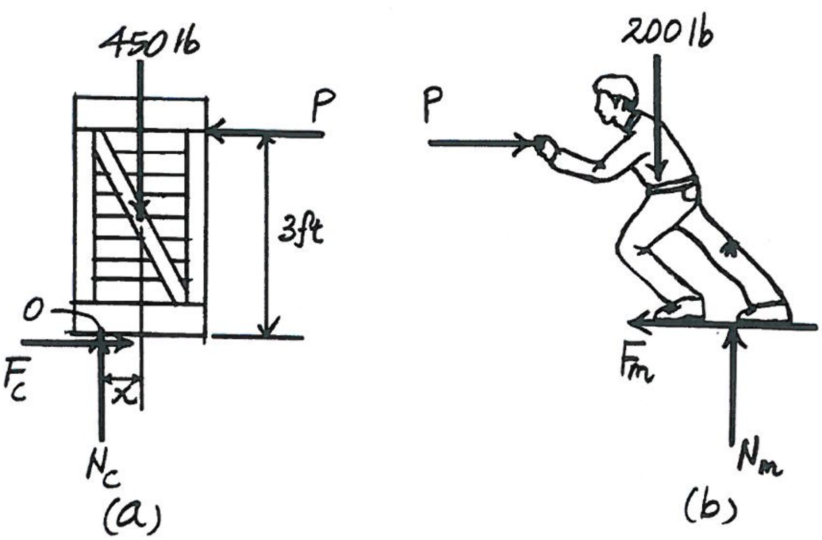
Using this result to solve Eqs. (1), (2) and (3)

$$F_m = P = 135 \text{ lb} \quad x = 0.9 \text{ ft}$$

Since $x < 1$ ft, the crate indeed slides before tipping as assumed.

Also, since $F_m > (F_m)_{\max} = \mu_s' N_C = 0.6(200) = 120$ lb, the man slips.

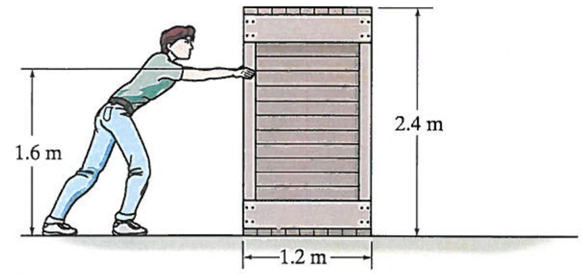
Thus **he is not able to move the crate.**



Ans:
No

8–50.

The uniform crate has a mass of 150 kg. If the coefficient of static friction between the crate and the floor is $\mu_s = 0.2$, determine the smallest mass of the man so he can move the crate. The coefficient of static friction between his shoes and the floor is $\mu'_s = 0.45$. Assume the man exerts only a horizontal force on the crate.



SOLUTION

Equations of Equilibrium. Referring to the *FBD* of the crate shown in Fig. *a*,

$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad P - F_C = 0$ **(1)**

$+\uparrow \Sigma F_y = 0; \quad N_C - 150(9.81) = 0 \quad N_C = 1471.5\text{ N}$

$\circlearrowleft + \Sigma M_O = 0; \quad 150(9.81)x - P(1.6) = 0$ **(2)**

Also, from the *FBD* of the man, Fig. *b*,

$+\uparrow \Sigma F_y = 0; \quad N_m - m(9.81) = 0 \quad N_m = 9.81\text{ m}$ **(3)**

$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad F_m - P = 0$ **(4)**

Friction. Assuming that the crate slips before tipping. Then

$$F_C = \mu_s N_C = 0.2(1471.5) = 294.3\text{ N}$$

Also, it is required that the man is on the verge of slipping. Then

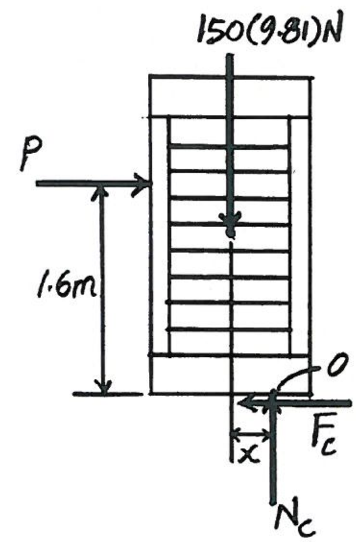
$$F_m = \mu'_s N_m = 0.45\, N_m \quad \textbf{(5)}$$

Solving Eqs. (1) to (5) using the result of $\mathbf{F}_C$,

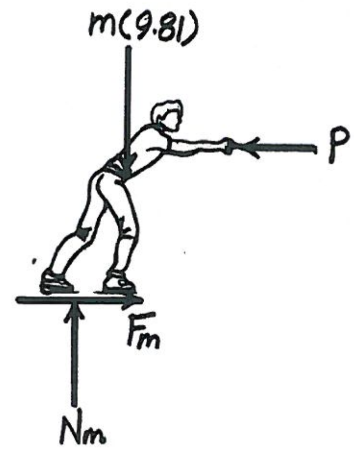
$$F_m = P = 294.3\text{ N} \quad x = 0.32\text{ m} \quad N_m = 654\text{ N}$$

$$m = 66.667\text{ kg} = 66.7\text{ kg} \quad \textbf{Ans.}$$

Since $x < 0.6$ m, the crate indeed slips before tipping as assumed.



(a)



(b)

Ans:
$m = 66.7$ kg