EXAMPLE PROBLEM 9-6

The wheels of the refrigerator of Fig. 9-14 are stuck and will not turn. The refrigerator weighs 600 N. Assume a coefficient of friction between the wheels and the floor of 0.6 and determine the force necessary to cause the refrigerator to just start to move (impending motion). Also determine the maximum height h at which the force can be applied without causing the refrigerator to tip over.

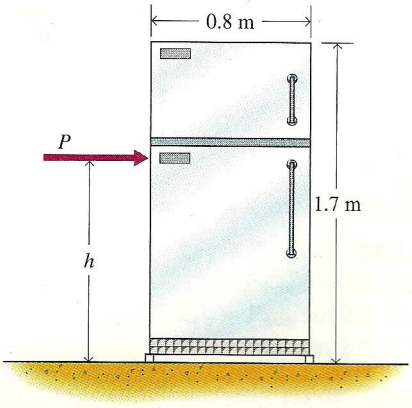

Fig. 9-14

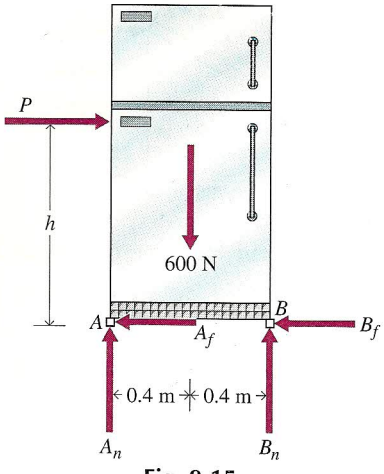

Fig. 9-15

SOLUTION

The free-body-diagram of the refrigerator is drawn in Fig. 9-15. The equilibrium equations

$$+\rightarrow \Sigma F_x = P - A_f - B_f = 0$$
$$+\uparrow \Sigma F_y = A_n + B_n - 600 = 0$$
$$\circlearrowleft +\Sigma M_B = (0.4)(600) - hP - 0.8\,A_n = 0$$

give

$$A_n + B_n = 600$$
$$P = A_f + B_f = 0.6(A_n + B_n) = 360 \text{ N} \qquad \text{Ans.}$$

and

$$h = \frac{240 - 0.8A_n}{360}$$

When $h = 0$, $A_n = B_n = 300$ N, and the wheels share the load of the weight equally. As h increases, A_s gets smaller. However, the force at A cannot be negative, so the condition for impending motion by tipping is $A_n = 0$. Thus,

$$h < \frac{240}{360} = 0.667 \text{ m} \qquad \text{Ans.}$$

At the point of impending tipping, none of the weight is carried by the wheels at A; it has all been shifted to the wheels at the right side of the refrigerator.

The condition that motion by slipping is impending means that $A_f = \mu_s A_n$ and $B_f = \mu_s B_n$.

For impending tipping, when all weight is being carried by the wheels at B, $0.4/h = \tan\phi = \mu_s = 0.60$ which verifies that $h = 0.667$ m.