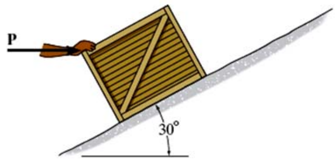
•**8–1.** Determine the minimum horizontal force P required to hold the crate from sliding down the plane. The crate has a mass of 50 kg and the coefficient of static friction between the crate and the plane is $\mu_s = 0.25$.



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.

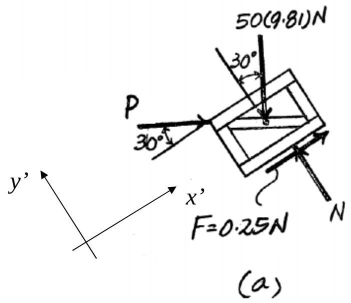
$\Sigma F_{y'} = 0;\ N - P\sin 30° - 50(9.81)\cos 30° = 0$

$\Sigma F_{x'} = 0;\ P\cos 30° + 0.25N - 50(9.81)\sin 30° = 0$

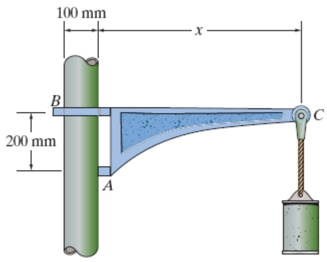
Solving

$P = 140\text{ N}$

$N = 494.94\text{ N}$ **Ans.**



*__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 $\mathbf{F}_A$ 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 $F_A = \mu_s N_A = 0.4 N_A$.

$$\sum F_y = 0;\quad F_A = mg$$

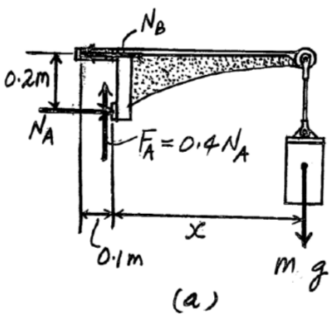
$$\sum M_B = 0;$$

$$F_A(0.1) + N_A(0.2) - mg(x + 0.1) = 0$$

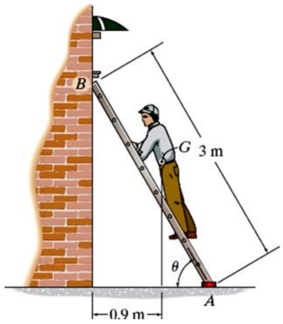
$$N_A(0.2) = F_A(x)$$

$$F_A < \mu_s N_A \quad N_A(0.2) < \mu_s N_A(x)$$

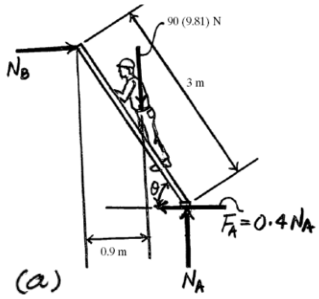
$$x > 0.2/\mu_s = 0.5\text{ m.}$$



•**8–5.** The 90-kg man climbs up the ladder and stops at the position shown after he senses that the ladder is on the verge of slipping. Determine the inclination θ of the ladder if the coefficient of static friction between the friction pad A and the ground is $\mu_s = 0.4$. Assume the wall at B is smooth. The center of gravity for the man is at G. Neglect the weight of the ladder.



Free – Body Diagram. Since the weight of the man tends to cause the friction pad A to slide to the right, the frictional force $\mathbf{F}_A$ must act to the left as indicated on the free – body diagram of the ladder, Fig. *a*. Here, the ladder is on the verge of slipping. Thus, $F_A = \mu_s N_A$.



Equations of Equilibrium.

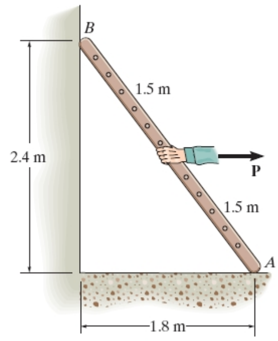
$+\uparrow\Sigma F_y = 0;$ $N_A - 90\,(9.81) = 0$ $N_A = 882.9\text{ N}$

$\circlearrowleft +\Sigma M_B = 0;$ $90\,(9.81)\,(3\cos\theta) - \mu_s(90)\,(9.81)\,(3\sin\theta) - 90\,(9.81)\,(0.9) = 0$

$3\cos\theta - 0.4\,(3)\sin\theta = 0.9$

$\theta = 52°$ **Ans.**

8–11. The uniform 10-kg ladder rests on the rough floor for which the coefficient of static friction is $\mu_s = 0.4$ 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.



Assume that the ladder slips at A :

$F_A = 0.4\,N_A$

$+\uparrow\Sigma F_y = 0;$ $N_A - 10\,(9.81) = 0$

$N_A = 98.1\text{ N}$

$F_A = 0.4\,(98.1) = 39.24\text{ N}$

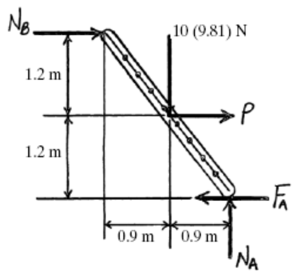
$\circlearrowleft +\Sigma M_B = 0;$ $P(1.2) - 98.1\,(0.9) + 98.1\,(1.8) - 39.24\,(2.4) = 0$

$P = 4.905\text{ N}$ **Ans**

$\xrightarrow{+}\Sigma F_x = 0;$ $N_B + 4.905 - 39.24 = 0$

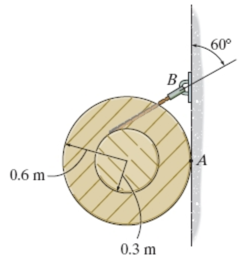
$N_B = 34.335\text{ N} > 0$ OK

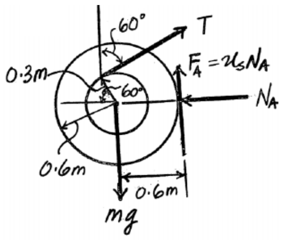
The ladder will remain in contact with the wall.



4

8–14. Determine the minimum coefficient of static friction between the uniform 50-kg spool and the wall so that the spool does not slip.





Equations of Equilibrium. Referring to Fig. a,

$$\curvearrowleft +\Sigma M_A = 0; \quad mg(0.6) - T\cos 60°(0.3\cos 60° + 0.6) - T\sin 60°(0.3\sin 60°) = 0$$

$$T = mg$$

$$\overset{+}{\rightarrow}\Sigma F_x = 0; \quad mg\sin 60° - N_A = 0 \qquad N_A = 0.8660\,mg$$

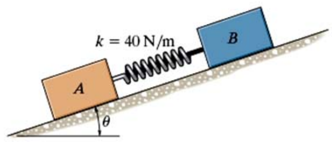
$$+\uparrow \Sigma F_y = 0; \quad \mu_s(0.8660mg) + mg\cos 60° - mg = 0$$

$$\mu_s = 0.577 \qquad \textbf{Ans.}$$

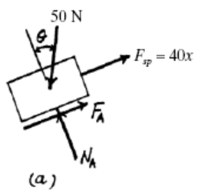
Note **Since μ_s is independent of the mass of the spool, it will not slip regardless of its mass provided $\mu_s > 0.577$.**

5

8–19. Two blocks A and B have a weight of 50 N and 30 N, respectively. They are resting on the incline for which the coefficients of static friction are $\mu_A = 0.15$ and $\mu_B = 0.25$. Determine the incline angle θ for which both blocks begin to slide. Also find the required stretch or compression in the connecting spring for this to occur. The spring has a stiffness of $k = 40$ N/m.



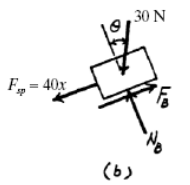
Equations of Equilibrium : Using the spring force formula, $F_{sp} = kx = 40x$. From FBD (a),



$$+\nearrow \Sigma F_{x'} = 0; \quad 40x + F_A - 50\sin\theta = 0 \qquad [1]$$

$$+\nwarrow \Sigma F_{y'} = 0; \quad N_A - 50\cos\theta = 0 \qquad [2]$$

From FBD (b),



$$+\nearrow \Sigma F_{x'} = 0; \quad F_B - 40x - 30\sin\theta = 0 \qquad [3]$$

$$+\nwarrow \Sigma F_{y'} = 0; \quad N_B - 30\cos\theta = 0 \qquad [4]$$

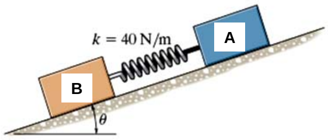
Friction : If block A and B are on the verge to move, slipping would have to occur at point A and B. Hence, $F_A = \mu_{sA}N_A = 0.15N_A$ and $F_B = \mu_{sB}N_B = 0.25N_B$. Substituting these values into Eqs. [1], [2], [3] and [4] and solving, we have

$$\theta = 10.62° \qquad x = 0.046 \text{ m} \qquad \textbf{Ans}$$

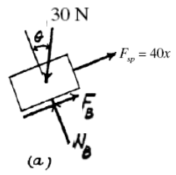
$$N_A = 49.14 \text{ N} \qquad N_B = 29.49 \text{ N}$$

6

8–19. Two blocks A and B have a weight of 50 N and 30 N, respectively. They are resting on the incline for which the coefficients of static friction are $\mu_A = 0.15$ and $\mu_B = 0.25$. Determine the incline angle θ for which both blocks begin to slide. Also find the required stretch or compression in the connecting spring for this to occur. The spring has a stiffness of $k = 40$ N/m.



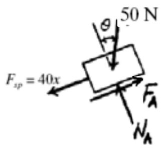
Equations of Equilibrium : Using the spring force formula, $F_{sp} = kx = 40x$. From FBD (a),



$$+\nearrow\Sigma F_{x'} = 0; \quad 40x + F_B - 30\sin\theta = 0 \qquad [1]$$

$$+\nwarrow\Sigma F_{y'} = 0; \quad N_B - 30\cos\theta = 0 \qquad [2]$$

From FBD (b),



$$+\nearrow\Sigma F_{x'} = 0; \quad F_A - 40x - 50\sin\theta = 0 \qquad [3]$$

$$+\nwarrow\Sigma F_{y'} = 0; \quad N_A - 50\cos\theta = 0 \qquad [4]$$

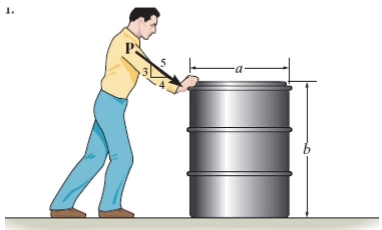
Friction : If block A and B are on the verge to move, slipping would have to occur at point A and B. Hence, $F_A = \mu_{sA}N_A = 0.15N_A$ and $F_B = \mu_{sB}N_B = 0.25N_B$. Substituting these values into Eqs. [1], [2], [3] and [4] and solving, we have

$\theta = 10.62°$ $\quad$ $x = -0.046$ m $\quad$ **Ans**

$N_A = 49.14$ N $\quad$ $N_B = 29.49$ N

7

***8–24.** The drum has a weight of 500 N and rests on the floor for which the coefficient of static friction is $\mu_s = 0.6$. If $a = 0.6$ m and $b = 0.9$ m, determine the smallest magnitude of the force P that will cause impending motion of the drum.

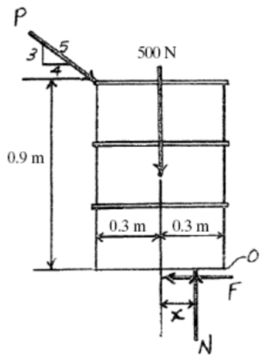


Assume that the drum tips :

$x = 0.3$ m

$$\circlearrowleft +\Sigma M_O = 0; \quad 500\,(0.3) + P\left(\frac{3}{5}\right)(0.6) - P\left(\frac{4}{5}\right)(0.9) = 0$$

$$P = 416.67 \text{ N}$$



$$\overset{+}{\rightarrow}\Sigma F_x = 0; \quad -F - 416.67\left(\frac{4}{5}\right) = 0$$

$$F = 333.33 \text{ kN}$$

$$+\uparrow\Sigma F_y = 0; \quad N - 500 - 416.67\left(\frac{3}{5}\right) = 0$$

$$N = 750 \text{ N}$$

$$F_{max} = 0.6\,(750) = 450 \text{ N} > 333.33 \text{ N} \qquad \text{OK}$$

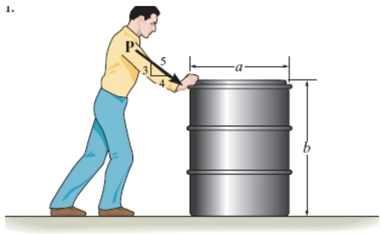
Drum tips as assumed,

$P = 416.67$ N $\quad$ **Ans**

8

1.

•8–25. The drum has a weight of 500 N and rests on the floor for which the coefficient of static friction is $\mu_s = 0.5$. If $a = 0.9$ m and $b = 1.2$ m, determine the smallest magnitude of the force P that will cause impending motion of the drum.



Assume that the drum slips :

$F = 0.5\,N$

$\overset{+}{\rightarrow}\Sigma F_x = 0; \quad -0.5\,N + P\left(\frac{4}{5}\right) = 0$

$+\uparrow\Sigma F_y = 0; \quad -P\left(\frac{3}{5}\right) - 500 + N = 0$

$P = 500\text{ N}$

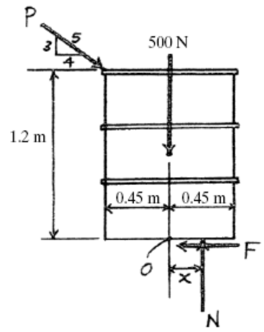
$N = 800\text{ N}$

$\circlearrowleft +\Sigma M_O = 0; \quad 800\,(x) + 500\left(\frac{3}{5}\right)(0.45) - 500\left(\frac{4}{5}\right)(1.2) = 0$

$x = 0.431\text{ m} < 0.45\text{ m} \qquad$ OK

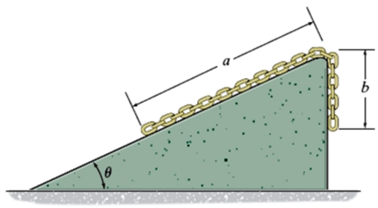
Drum slips as assumed,

$P = 500\text{ N}$ **Ans**



9

•8–37. If the coefficient of static friction between the chain and the inclined plane is $\mu_s = \tan\theta$, determine the overhang length b so that the chain is on the verge of slipping up the plane. The chain weighs w per unit length.



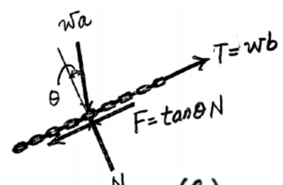
Free - Body Diagram. The tension developed in the chain at the end of the inclined plane is equal to the weight of the overhanging chain, i.e. $T = wb$. Since the chain is required to be on the verge of sliding up the plane, the frictional force **F** must act down the plane so that $F = \mu_s N = \tan\theta N$ as indicated on the free - body diagram of the chain shown in Fig. *a*.

Equations of Equilibrium.

$\nwarrow + \Sigma F_{y'} = 0; \quad N - wa\cos\theta = 0 \qquad N = wa\cos\theta$

$\nearrow + \Sigma F_{x'} = 0; \quad wb - wa\sin\theta - \tan\theta(wa\cos\theta) = 0$

$b = 2a\sin\theta$ **Ans.**



(a)

10