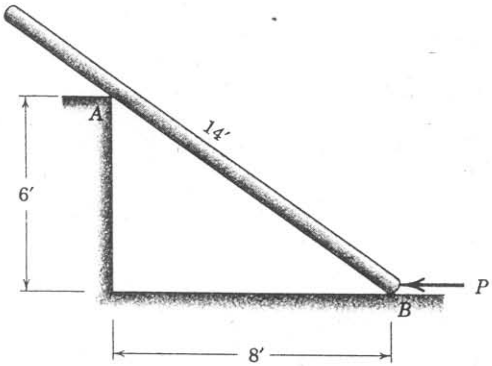
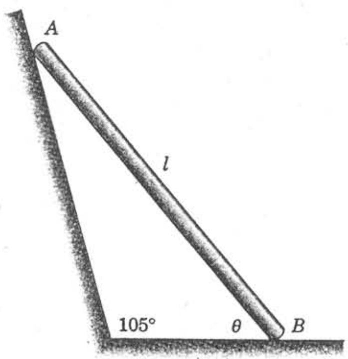
1 The uniform 14-ft pole weighs 150 lb and is supported as shown. Calculate the force P required to move the pole if the coefficient of static friction for each contact location is 0.40.



Problem 1

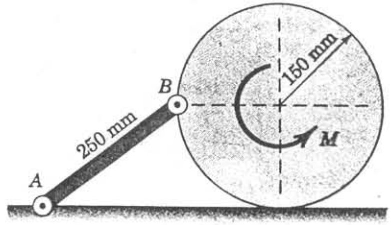
2 The uniform pole of length l and mass m is placed against the supporting surfaces shown. If the coefficient of static friction is $\mu_s = 0.25$ at both A and B, determine the maximum angle θ at which the pole can be placed before it begins to slip.

Ans. $\theta = 59.9°$



Problem 2

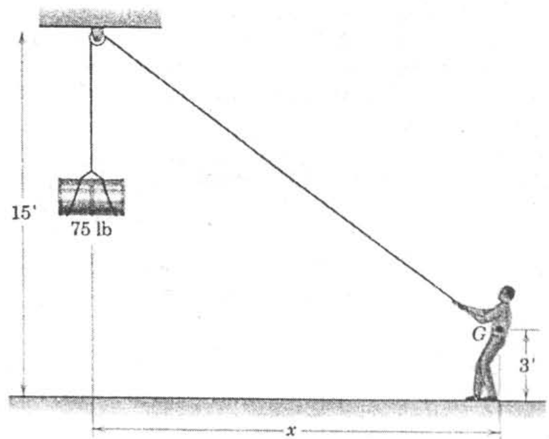
3 The strut AB of negligible mass is hinged to the horizontal surface at A and to the uniform 25-kg wheel at B. Determine the minimum couple M applied to the wheel which will cause it to slip if the coefficient of static friction between the wheel and the surface is 0.40.



Problem 3

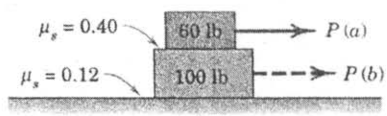
4 The 180-lb man with center of gravity G supports the 75-lb drum as shown. Find the greatest distance x at which the man can position himself without slipping if the coefficient of static friction between his shoes and the ground is 0.40.

Ans. $x = 10.52$ ft



Problem 4

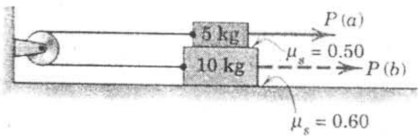
5 The force P is applied to (*a*) the 60-lb block and (*b*) the 100-lb block. For each case, determine the magnitude of P required to initiate motion.



Problem 5

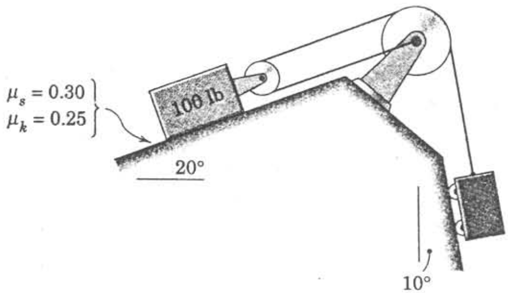
6 The system of two blocks, cable, and fixed pulley is initially at rest. Determine the horizontal force P necessary to cause motion when (*a*) P is applied to the 5-kg block and (*b*) P is applied to the 10-kg block. Determine the corresponding tension T in the cable for each case.

Ans. (*a*) $P = 137.3$ N, $T = 112.8$ N
(*b*) $P = 137.3$ N, $T = 24.5$ N



Problem 6

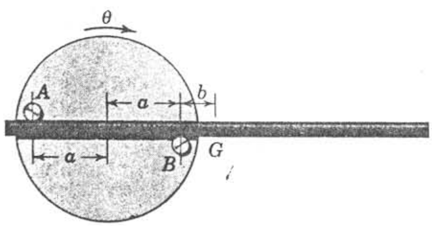
7 Determine the range of weights W for which the 100-lb block is in equilibrium. All wheels and pulleys have negligible friction.



Problem 7

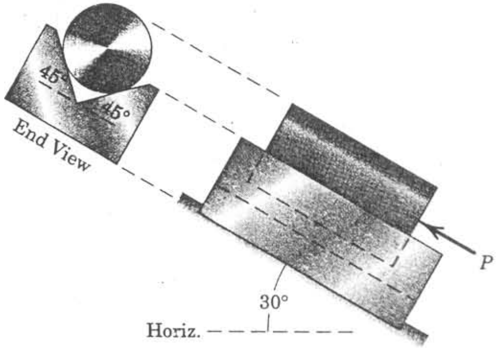
8 The uniform rod with center of mass at G is supported by the pegs A and B, which are fixed in the wheel. If the coefficient of friction between the rod and pegs is μ, determine the angle θ through which the wheel may be slowly turned about its horizontal axis through O, starting from the position shown, before the rod begins to slip. Neglect the diameter of the rod compared with the other dimensions.

Ans. $\theta = \tan^{-1}\left(\mu\frac{a+b}{a}\right)$



Problem 8

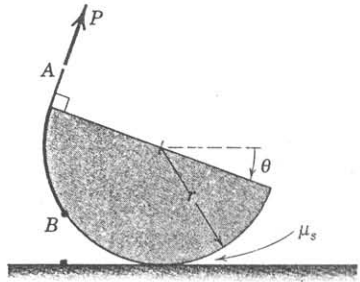
9 The 10-kg solid cylinder is resting in the inclined V-block. If the coefficient of static friction between the cylinder and the block is 0.50, determine (*a*) the friction force F acting on the cylinder at each side before force P is applied and (*b*) the value of P required to start sliding the cylinder up the incline.



Problem 9

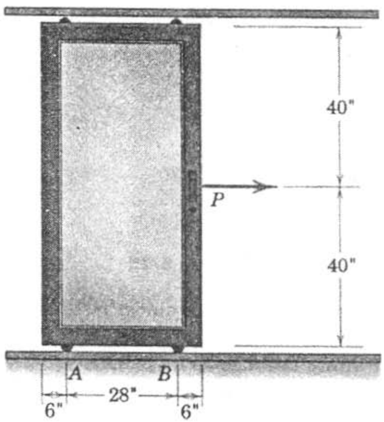
10 The homogeneous semicylinder rests on a horizontal surface and is subjected to the force P applied to a cord firmly attached to its periphery. The force P is slowly increased and kept normal to the flat surface of the semicylinder. If slipping is observed just as θ reaches 40°, determine the coefficient of static friction μ_s and the value of P when slipping occurs.

Ans. $\mu_s = 0.122$, $P = 0.1661mg$



Problem 10

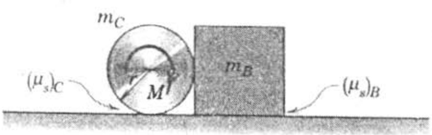
11 The sliding glass door rolls on the two small lower wheels A and B. Under normal conditions the upper wheels do not touch their horizontal guide. (*a*) Compute the force P required to slide the door at a steady speed if wheel A becomes "frozen" and does not turn in its bearing. (*b*) Rework the problem if wheel B becomes frozen instead of wheel A. The coefficient of kinetic friction between a frozen wheel and the supporting surface is 0.30, and the center of mass of the 140-lb door is at its geometric center. Neglect the small diameter of the wheels.



Problem 11

12 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, $(\mu_s)_B = 0.50$, $(\mu_s)_C = 0.40$, and $r = 0.2$ m. Friction between the cylinder C and the block B is negligible.

Ans. $M = 2.94$ N·m

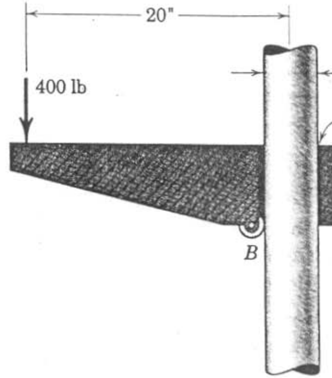


Problem 12

13 Repeat Prob. 12, except let $(\mu_s)_C = 0.20$. All other conditions of Prob. 12 remain the same.

14 The figure shows the design in section of a loaded bracket which is supported on the fixed shaft by the roller at B and by friction at the corner A. The coefficient of static friction is 0.40. Neglect the weight of the bracket and show that the bracket as designed will remain in place. Find the friction force F.

Ans. $F = 400$ lb



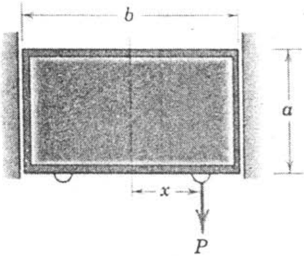
Problem 14

15 Determine the magnitude P of the horizontal force required to initiate motion of the block of mass m_0 for the cases (*a*) P is applied to the right and (*b*) P is applied to the left. Complete a general solution in each case, and then evaluate your expression for the values $\theta = 30°$, $m = m_0 = 3$ kg, $\mu_s = 0.60$, and $\mu_k = 0.50$.

Problem 15

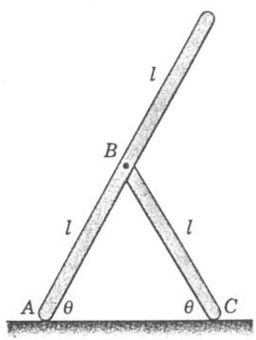
16 Find the maximum distance x from the horizontal centerline of the drawer at which the force P may be applied and still allow the drawer to be opened without binding at the corners. Neglect friction on the bottom of the drawer and take the coefficient of static friction at the corners to be μ_s.

Ans. $x = \dfrac{a}{2\mu_s}$



Problem 16

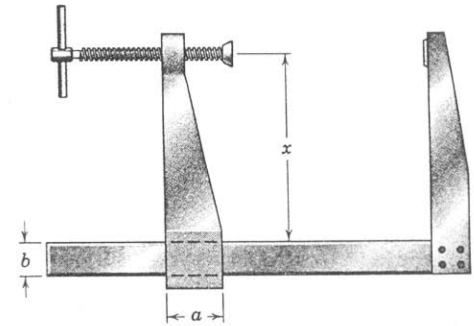
17 The two uniform slender bars constructed from the same stock material are freely pinned together at B. Determine the minimum angle θ at which slipping does not occur at either contact point A or C. The coefficient of static friction at both A and C is $\mu_s = 0.50$. Consider only motion in the vertical plane shown.



Problem 17

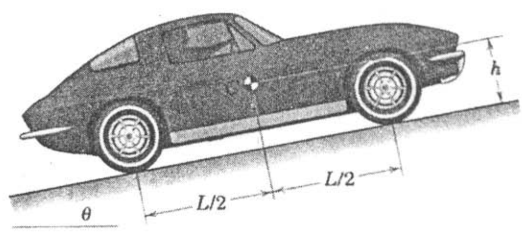
18 The movable left-hand jaw of the C-clamp can be slid along the frame to increase the capacity of the clamp. To prevent slipping of the jaw on the frame when the clamp is under load, the dimension x must exceed a certain minimum value. For given values of a and b and a static friction coefficient μ_s, specify this design minimum value of x to prevent slipping of the jaw.

Ans. $x = \dfrac{a - b\mu_s}{2\mu_s}$



Problem 18

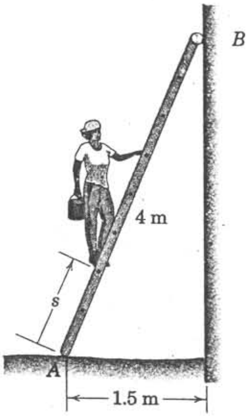
19 Two automobiles, both of which have the mass center located as shown midway between the front and rear axles, are identical except that one is front-wheel-drive and the other is rear-wheel-drive. The cars are driven at constant speed up ramps of various inclinations. From a theoretical design viewpoint, which car could climb the ramp of higher inclination angle θ? Justify your answer.



Problem 19

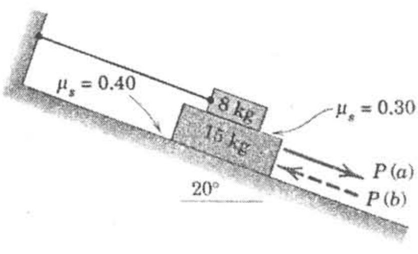
20 Determine the distance s to which the 90-kg painter can climb without causing the 4-m ladder to slip at its lower end A. The top of the 15-kg ladder has a small roller, and at the ground the coefficient of static friction is 0.25. The mass center of the painter is directly above her feet.

Ans. $s = 2.55$ m



Problem 20

21 The two blocks are placed on the incline with the cable taut. (*a*) Determine the force P required to initiate motion of the 15-kg block if P is applied down the incline. (*b*) If P is applied up the incline and slowly increased from zero, determine the value of P which will cause motion and describe that motion.

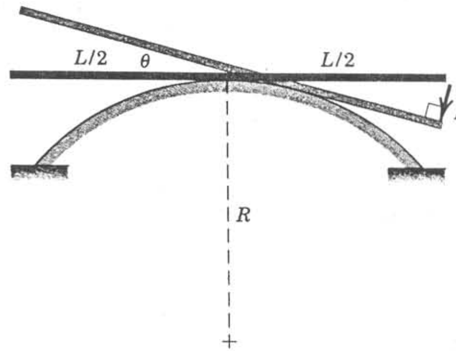


Problem 21

22 Repeat Prob. 21 but with $\mu_s = 0.50$ between the blocks. All other conditions remain the same.

Ans. (*a*) $P = 71.4$ N, (*b*) $P = 162.0$ N

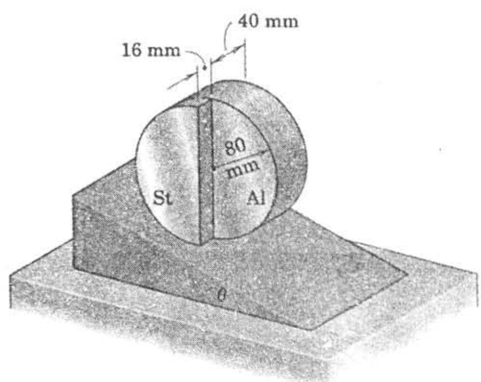
23 The uniform slender rod of mass m and length L is initially at rest in a centered horizontal position on the fixed circular surface of radius $R = 0.6L$. If a force P normal to the bar is gradually applied to its end until the bar begins to slip at the angle $\theta = 20°$, determine the coefficient of static friction μ_s.



Problem 23

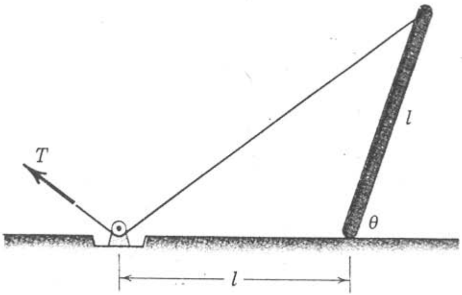
24 The body is constructed of an aluminum cylinder with an attached half-cylinder of steel. Determine the ramp angle θ for which the body will remain in equilibrium when released in the position shown where the diametral section of the steel half-cylinder is vertical. Also calculate the necessary minimum coefficient of static friction μ_s.

Ans. $\theta = 8.98°$, $\mu_s = 0.158$



Problem 24

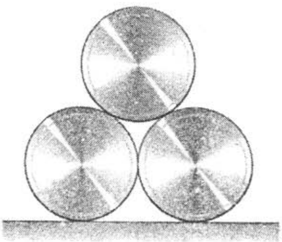
25 The uniform slender rod is slowly lowered from the upright position ($\theta = 90°$) by means of the cord attached to its upper end and passing under the small fixed pulley. If the rod is observed to slip at its lower end when $\theta = 40°$, determine the coefficient of static friction at the horizontal surface.



Problem 25

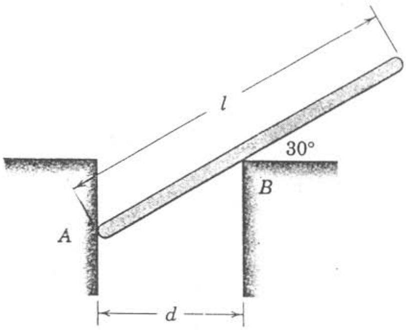
26 The three identical rollers are stacked on a horizontal surface as shown. If the coefficient of static friction μ_s is the same for all pairs of contacting surfaces, find the minimum value of μ_s for which the rollers will not slip.

Ans. $\mu_s = 0.268$



Problem 26

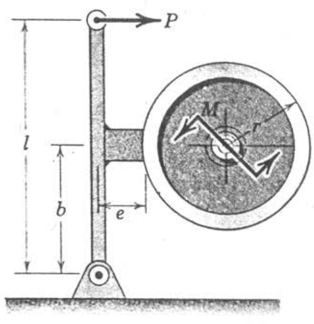
27 The uniform slender bar of length l is placed in the opening of width d at the 30° angle shown. For what range of l/d will the bar remain in static equilibrium? The coefficient of static friction at A and B is $\mu_s = 0.40$.



Problem 27

28 The single-lever block brake prevents rotation of the flywheel under a counterclockwise torque M. Find the force P required to prevent rotation if the coefficient of static friction is μ_s. Explain what would happen if the geometry permitted b to equal $\mu_s e$.

Ans. $P = \dfrac{M}{rl}\left(\dfrac{b}{\mu_s} - e\right)$



Problem 28

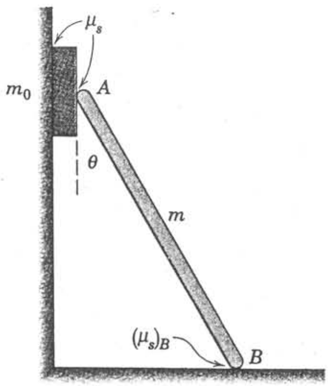
29 A block of mass m_0 is placed between the vertical wall and the upper end A of the uniform slender bar of mass m. If the coefficient of static friction is μ_s between the block and the wall and also between the block and the bar, determine a general expression for the minimum value θ_{min} of the angle θ for which the block will remain in equilibrium. Evaluate your expression for the conditions $\mu_s = 0.5$ and

(a) $\dfrac{m}{m_0} = 0.1$,

(b) $\dfrac{m}{m_0} = 1$, and

(c) $\dfrac{m}{m_0} = 10$.

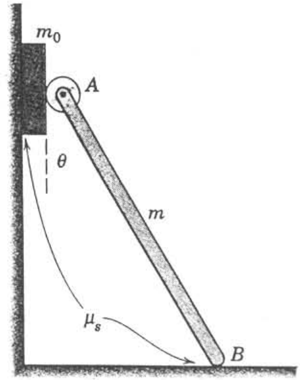
For each case, state the minimum coefficient of static friction $(\mu_s)_B$ necessary to prevent slippage at B.



Problem 29

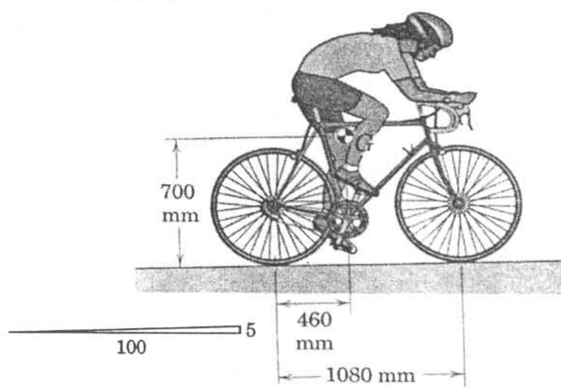
30 A block of mass m_0 is placed between the vertical wall and the small ideal roller at the upper end A of the uniform slender bar of mass m. The lower end B of the bar rests on the horizontal surface. If the coefficient of static friction is μ_s at B and also between the block and the wall, determine a general expression for the minimum value θ_{min} of θ for which the block will remain in equilibrium. Evaluate your expression for $\mu_s = 0.5$ and $\dfrac{m}{m_0} = 10$. For these conditions, check for possible slipping at B.

Ans. $\theta_{min} = \tan^{-1}\left(\dfrac{2m_0}{\mu_s m}\right)$, $\theta_{min} = 21.8°$



Problem 30

31 A woman pedals her bicycle up a 5-percent grade on a slippery road at a steady speed. The woman and bicycle have a combined mass of 82 kg with mass center at G. If the rear wheel is on the verge of slipping, determine the coefficient of friction μ_s between the rear tire and the road. If the coefficient of friction were doubled, what would be the friction force F acting on the rear wheel? (Why may we neglect friction under the front wheel?)



Problem 31