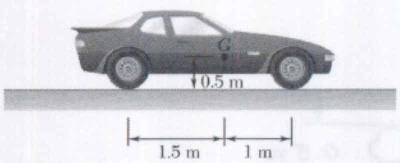
HW 7

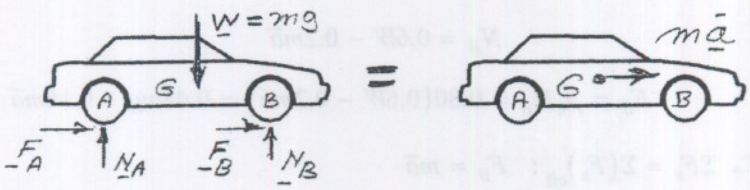
PROBLEM 16.5



Knowing that the coefficient of static friction between the tires and the road is 0.80 for the automobile shown, determine the maximum possible acceleration on a level road, assuming (*a*) four-wheel drive, (*b*) rear-wheel drive, (*c*) front-wheel drive.

SOLUTION

(*a*) *Four-wheel drive*:



$$+\uparrow \Sigma F_y = 0: \quad N_A + N_B - W = 0 \qquad N_A + N_B = W = mg$$

Thus:
$$F_A + F_B = \mu_k N_A + \mu_k N_B = \mu_k (N_A + N_B) = \mu_k W = 0.80mg$$

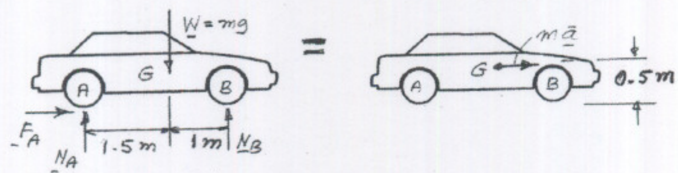
$$\xrightarrow{+} \Sigma F_x = \Sigma (F_x)_{\text{eff}}: \; F_A + F_B = m\bar{a}$$

$$0.80mg = m\bar{a}$$

$$\bar{a} = 0.80g = 0.80(9.81 \text{ m/s}^2) = 7.848 \text{ m/s}^2$$

$\bar{a} = 7.85 \text{ m/s}^2$ ◀

(*b*) *Rear-wheel drive*:



$$+\circlearrowleft \Sigma M_B = \Sigma (M_B)_{\text{eff}}: \; (1 \text{ m})W - (1.5 \text{ m})N_A = -(0.5 \text{ m})m\bar{a}$$

$$N_A = 0.4W + 0.2m\bar{a}$$

Thus:
$$F_A = \mu_k N_B = 0.80(0.4W + 0.2m\bar{a}) = 0.32mg + 0.16m\bar{a}$$

$$\xrightarrow{+} \Sigma F_x = \Sigma (F_x)_{\text{eff}}: \; F_A = m\bar{a}$$

$$0.32mg + 0.16m\bar{a} = m\bar{a}$$

$$0.32g = 0.84\bar{a}$$

$$\bar{a} = \frac{0.32}{0.84}(9.81 \text{ m/s}^2) = 3.7371 \text{ m/s}^2$$

or $\bar{a} = 3.74 \text{ m/s}^2$ ◀

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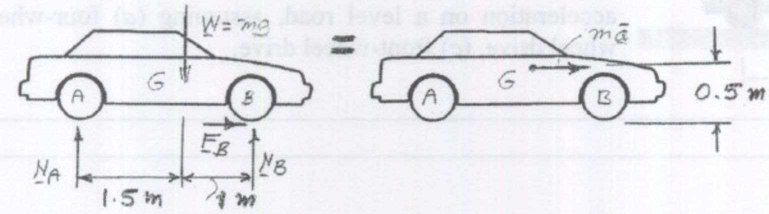
PROBLEM 16.5 CONTINUED

(c) *Front-wheel drive:*



$$+\circlearrowleft\ \Sigma M_A = \Sigma(M_A)_{\text{eff}}:\quad (2.5\text{ m})N_B - (1.5\text{ m})W = -(0.5\text{ m})m\bar{a}$$

$$N_B = 0.6W - 0.2m\bar{a}$$

Thus:
$$F_B = \mu_k N_B = 0.80(0.6W - 0.2m\bar{a}) = 0.48mg - 0.16m\bar{a}$$

$$\xrightarrow{+}\ \Sigma F_x = \Sigma(F_x)_{\text{eff}}:\quad F_B = m\bar{a}$$

$$0.48mg - 0.16m\bar{a} = m\bar{a}$$

$$0.48g = 1.16\bar{a}$$

$$\bar{a} = \frac{0.48}{1.16}\left(9.81\text{ m/s}^2\right) = 4.0593\text{ m/s}^2$$

or $\bar{a} = 4.06\text{ m/s}^2 \longrightarrow$ ◀

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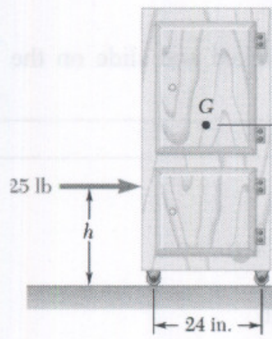
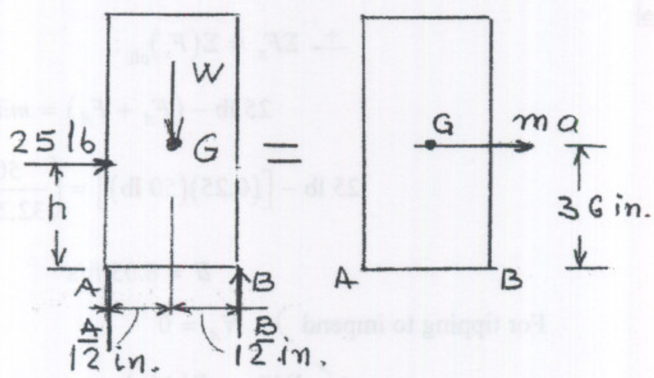


PROBLEM 16.7

A 50-lb cabinet is mounted on casters that allow it to move freely $(\mu = 0)$ on the floor. If a 25-lb force is applied as shown, determine (*a*) the acceleration of the cabinet, (*b*) the range of values of h for which the cabinet will not tip.

SOLUTION



(*a*) Acceleration

$$\xrightarrow{+} \Sigma F_x = \Sigma (F_x)_{\text{eff}}:$$

$$25 \text{ lb} = m\bar{a}$$

$$25 \text{ lb} = \frac{50 \text{ lb}}{32 \text{ ft/s}^2}\bar{a}$$

$\bar{a} = 16.10 \text{ ft/s}^2$ ◀

(*b*) For tipping to impend ↻; $A = 0$

$$+\circlearrowleft \Sigma M_B = \Sigma (M_B)_{\text{eff}}:$$

$$(25 \text{ lb})h - (50 \text{ lb})(12 \text{ in.}) = m\bar{a}(36 \text{ in.})$$

$$25h = 600 \cdot (25)(36) \qquad h = 60 \text{ in.}$$

For tipping to impend ↺; $B = 0$

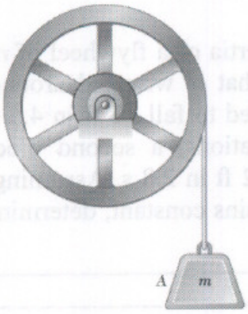
$$+\circlearrowleft \Sigma M_A = \Sigma (M_A)_{\text{eff}}:$$

$$(25 \text{ lb})h + (50 \text{ lb})(12 \text{ in.}) = m\bar{a}(36) \qquad \text{or} \qquad h = 12 \text{ in.}$$

cabinet will not tip for 12 in. ≤ h ≤ 60 in. ◀

HW7

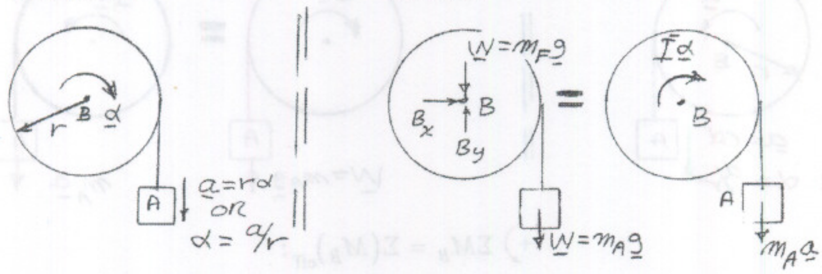
PROBLEM 16.27



The flywheel shown has a radius of 600 mm, a mass of 144 kg, and a radius of gyration of 450 mm. An 18-kg block A is attached to a wire that is wrapped around the flywheel, and the system is released from rest. Neglecting the effect of friction, determine (a) the acceleration of block A, (b) the speed of block A after it has moved 1.8 m.

SOLUTION

Kinematics *Kinetics*



$$+\circlearrowright \Sigma M_B = \Sigma (M_B)_{\text{eff}}:$$

$$(m_A g) r = \bar{I}\alpha + (m_A a) r$$

$$m_A g r = m_F k^2 \left(\frac{a}{r}\right) + m_A a r$$

$$a = \frac{m_A g}{m_A + m_F\left(\dfrac{k}{r}\right)^2}$$

(a)

$$a = \frac{(18\text{ kg})(9.81\text{ m/s}^2)}{18\text{ kg} + (144\text{ kg})\left(\dfrac{450\text{ mm}}{600\text{ mm}}\right)^2} = 1.7836\text{ m/s}^2$$

or $\mathbf{a}_A = 1.784\text{ m/s}^2 \downarrow$ ◄

(b)

$$V_A^2 + V_B^2 + 2as$$

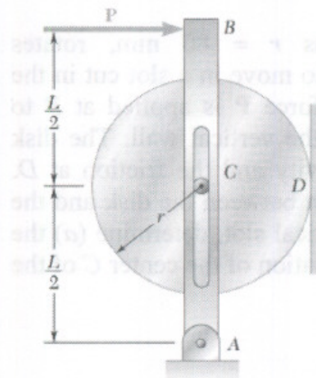
For $s = 1.8$ m

$$V_A^2 = 0 + 2(1.7836\text{ m/s}^2)(1.8\text{ m}) = 6.42096\text{ m}^2/\text{s}^2$$

$$V_A = 2.5339\text{ m/s}$$

or $V_A = 2.53\text{ m/s} \downarrow$ ◄

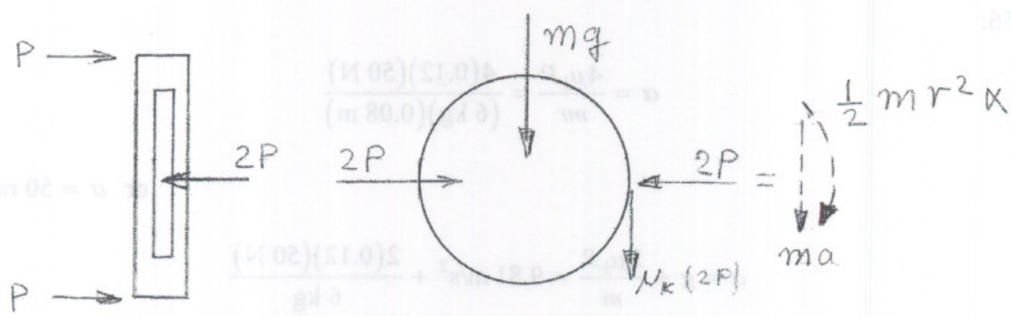
HW 7



PROBLEM 16.56

The uniform disk shown, of mass m and radius r, rotates counterclockwise. Its center C is constrained to move in a slot cut in the vertical member AB and a horizontal force **P** is applied at B to maintain contact at D between the disk and the vertical wall. The disk moves downward under the influence of gravity and the friction at D. Denoting by μ_k the coefficient of kinetic friction between the disk and the wall and neglecting friction in the vertical slot, determine (*a*) the angular acceleration of the disk, (*b*) the acceleration of the center C of the disk.

SOLUTION



$$+\circlearrowleft\ \Sigma M_G = \mu_k(2P)r = \frac{1}{2}mr^2\alpha$$

(*a*) $\alpha = \dfrac{4\mu_k P}{mr}$ ↺ ◀

(*b*) $+\downarrow\ \Sigma F_y = mg + \mu_k(2P) = ma$

$a = g + \dfrac{2\mu_k P}{m}$ ↓ ◀

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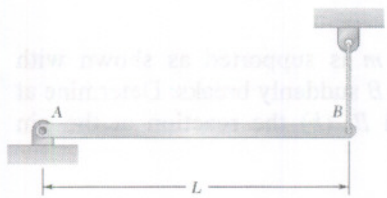
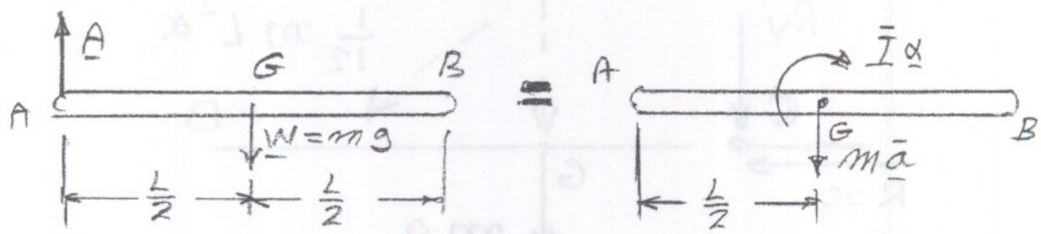
PROBLEM 16.79



A uniform rod of length L and mass m is supported as shown. If the cable attached at B suddenly breaks, determine (a) the acceleration of end B, (b) the reaction at the pin support.

SOLUTION

$$\omega = 0 \qquad \bar{a} = \frac{L}{2}\alpha$$



$$+\circlearrowright \Sigma M_A = \Sigma(M_A)_{\text{eff}}: \quad W\frac{L}{2} = \bar{I}\alpha + m\bar{a}\frac{L}{2}$$

$$mg\frac{L}{2} = \frac{1}{12}mL^2\alpha + m\left(\frac{L}{2}\alpha\right)\frac{L}{2}$$

$$mg\frac{L}{2} = \frac{1}{3}mL^2\alpha \qquad \alpha = \frac{3}{2}\frac{g}{L} \circlearrowright$$

$$+\uparrow \Sigma F_y = \Sigma(F_y)_{\text{eff}}: \quad A - mg = -m\bar{a} = -m\frac{L}{2}\alpha$$

$$A - mg = -m\left(\frac{L}{2}\right)\left(\frac{3}{2}\frac{g}{L}\right)$$

$$A - mg = -\frac{3}{4}mg$$

$$A = \frac{1}{4}mg; \qquad \mathbf{A} = \frac{1}{4}mg \uparrow \blacktriangleleft$$

$$\mathbf{a}_B = \mathbf{a}_A + \mathbf{a}_{B/A} = 0 + L\alpha \downarrow$$

$$\mathbf{a}_B = L\left(\frac{3}{2}\frac{g}{L}\right) = \frac{3}{2}g \downarrow; \qquad \mathbf{a}_B = \frac{3}{2}g \downarrow \blacktriangleleft$$

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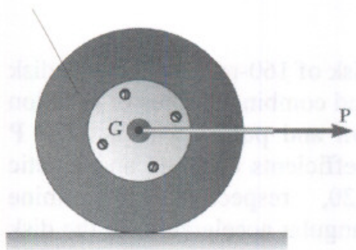
PROBLEM 16.93



A drum of 80-mm radius is attached to a disk of 160-mm radius. The disk and drum have a combined mass of 5 kg and combined radius of gyration of 120 mm. A cord is attached as shown and pulled with a force **P** of magnitude 20 N. Knowing that the coefficients of static and kinetic friction are $\mu_s = 0.25$ and $\mu_k = 0.20$, respectively, determine (*a*) whether or not the disk slides, (*b*) the angular acceleration of the disk and the acceleration of *G*.

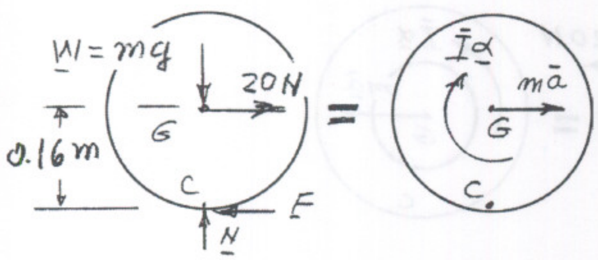
SOLUTION

Assume disk rolls:

$$\bar{a} = r\alpha = (0.16\text{ m})\alpha$$

$$\bar{I} = m\bar{k}^2 = (5\text{ kg})(0.12\text{ m})^2$$

$$= 0.072\text{ kg}\cdot\text{m}^2$$



$$+\circlearrowright\ \Sigma M_C = \Sigma(M_C)_{\text{eff}}:\ (20\text{ N})(0.16\text{ m}) = (m\bar{a})r + \bar{I}\alpha$$

$$3.2\text{ N}\cdot\text{m} = (5\text{ kg})(0.16\text{ m})^2\alpha + (0.072\text{ kg}\cdot\text{m}^2)\alpha$$

$$\alpha = 16\text{ rad/s}^2$$

or $\alpha = 16\text{ rad/s}^2 \circlearrowright$ ◀

$$\bar{a} = r\alpha = (0.16\text{ m})(16\text{ rad/s}^2) = 2.56\text{ m/s}^2$$

or $\mathbf{a} = 2.56\text{ m/s}^2 \longrightarrow$ ◀

$$\xrightarrow{+}\ \Sigma F_x = \Sigma(F_x)_{\text{eff}}:\ -F + 20\text{ N} = m\bar{a}$$

$$-F + 20\text{ N} = (5\text{ kg})(2.56\text{ m/s}^2)$$

$$F = 7.2\text{ N}$$

$$+\uparrow\ \Sigma F_y = \Sigma(F_y)_{\text{eff}}:\ N - mg = 0 \quad N = (5\text{ kg})(9.81\text{ m/s}^2)$$

$$= 49.05\text{ N}$$

$$F_m = \mu_s N = 0.25(49.05\text{ N}) = 12.2625\text{ N}$$

Since $F < F_m$, *disk rolls with no sliding* ◀