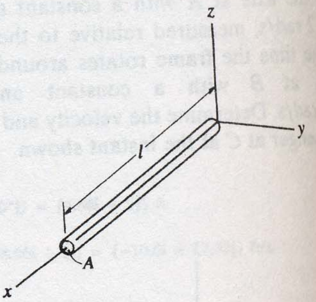
**17-1.** Determine the moment of inertia $I_y$ for the slender rod. The rod's density $\rho$ and cross-sectional area $A$ are constant. Express the result in terms of the rod's total mass $m$.




$$I_y = \int_M x^2\, dm$$

$$= \int_0^l x^2\, (\rho A\, dx)$$

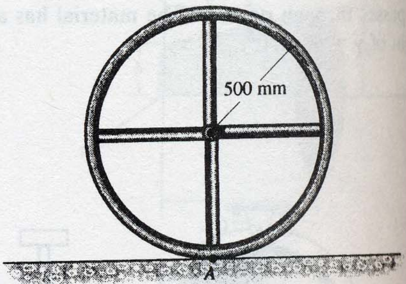
$$= \frac{1}{3}\rho A l^3$$

$$m = \rho A l$$

Thus,

$$I_y = \frac{1}{3} m l^2 \qquad \textbf{Ans}$$

**17-15.** The wheel consists of a thin ring having a mass of 10 kg and four spokes made from slender rods and each having a mass of 2 kg. Determine the wheel's moment of inertia about an axis perpendicular to the page and passing through point $A$.

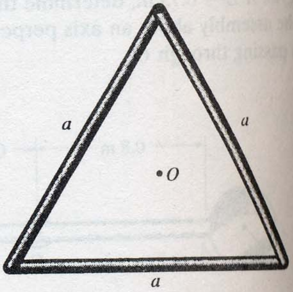



$$I_A = I_O + md^2$$

$$= \left[2\left[\frac{1}{12}(4)(1)^2\right] + 10(0.5)^2\right] + 18(0.5)^2$$

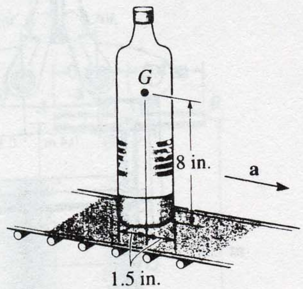
$$= 7.67 \text{ kg} \cdot \text{m}^2 \quad \textbf{Ans}$$

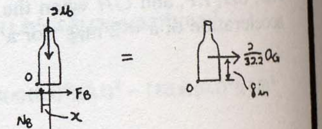
**17-17.** Each of the three rods has a mass $m$. Determine the moment of inertia of the assembly about an axis which is perpendicular to the page and passes through the center point $O$.




$$I_O = 3\left[\frac{1}{12}ma^2 + m\left(\frac{a\sin 60^\circ}{3}\right)^2\right] = \frac{1}{2}ma^2 \qquad \textbf{Ans}$$

**17-26.** The 2-lb bottle rests on the check-out conveyor at a grocery store. If the coefficient of static friction is $\mu_s = 0.2$, determine the largest acceleration the conveyor can have without causing the bottle to slip or tip. The center of gravity is at $G$.




$\overset{+}{\rightarrow} \Sigma F_x = m(a_G)_x; \quad F_B = \dfrac{2}{32.2} a_G$

$+\uparrow \Sigma F_y = m(a_G)_y; \quad N_B - 2 = 0$

$\curvearrowleft + \Sigma M_O = \Sigma (M_K)_O; \quad 2x = \dfrac{2}{32.2} a_G(8)$

Assume bottle is about to slip.

$N_B = 2 \text{ lb}, \quad F_B = 0.2(2) = 0.4 \text{ lb}$

$a_G = 6.44 \text{ ft/s}^2, \quad x = 1.6 \text{ in.} > 1.5 \text{ in.}$

Bottle will tip before slipping.

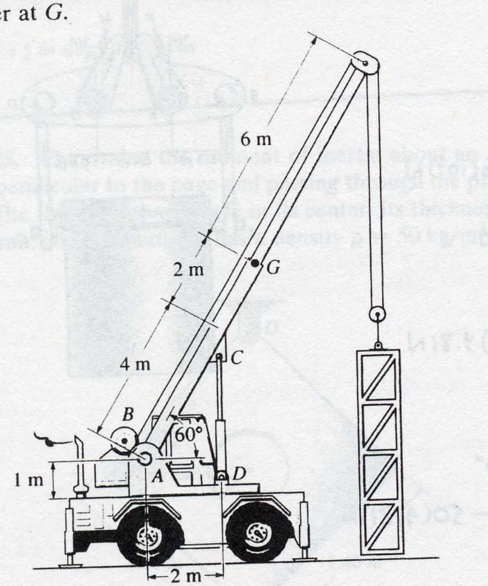
Set $x = 1.5$ in.

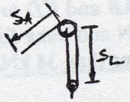
$N_B = 2 \text{ lb}, \quad a_G = 6.04 \text{ ft/s}^2$ **Ans**

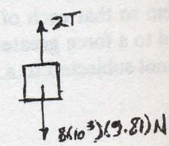
$F_B = 0.375 \text{ lb} < 0.4 \text{ lb}$ **(O.K!)**

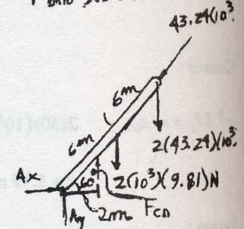
---

**17-27.** The assembly has a mass of 8 Mg and is hoisted using the boom and pulley system. If the winch at $B$ draws in the cable with an acceleration of 2 m/s$^2$, determine the compressive force in the hydraulic cylinder needed to support the boom. The boom has a mass of 2 Mg and mass center at $G$.




$s_B + 2s_L = l$

$a_B = -2a_L$

$2 = -2a_L$

$a_L = -1 \text{ m/s}^2$

Assembly:

$+\uparrow \Sigma F_y = m\,a_y; \quad 2T - 8(10^3)(9.81) = 8(10^3)(1)$

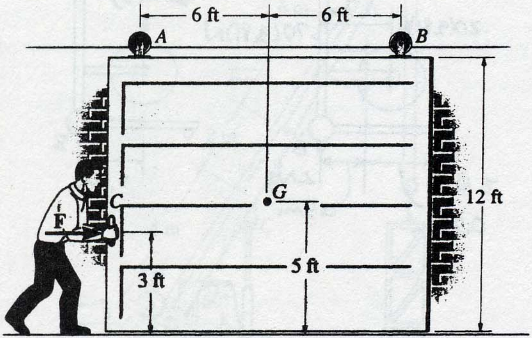
$T = 43.24 \text{ kN}$

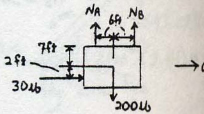
Boom:

$\curvearrowleft + \Sigma M_A = 0; \quad F_{CD}(2) - 2(10^3)(9.81)(6\cos 60°) - 2(43.24)(10^3)(12\cos 60°) = 0$

$F_{CD} = 289 \text{ kN}$ **Ans**

**17-31.** The door has a weight of 200 lb and a center of gravity at $G$. Determine how far the door moves in 2 s, starting from rest, if a man pushes on it at $C$ with a horizontal force $F = 30$ lb. Also, find the vertical reactions at the rollers $A$ and $B$.




$$\overset{+}{\rightarrow} \Sigma F_x = m(a_G)_x; \qquad 30 = \left(\frac{200}{32.2}\right)a_G$$

$$a_G = 4.83 \text{ ft/s}^2$$

$$\circlearrowleft + \Sigma M_A = \Sigma(M_k)_A; \qquad N_B(12) - 200(6) + 30(9) = \left(\frac{200}{32.2}\right)(4.83)(7)$$

$$N_B = 95.0 \text{ lb} \qquad \textbf{Ans}$$

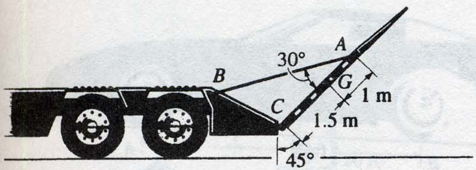
$$+\uparrow \Sigma F_y = m(a_G)_y; \qquad N_A + 95.0 - 200 = 0$$

$$N_A = 105 \text{ lb} \qquad \textbf{Ans}$$

$$(\overset{+}{\rightarrow}) \qquad s = s_0 + v_0 t + \frac{1}{2}a_G t^2$$

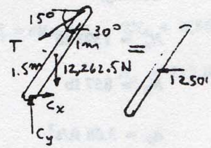
$$s = 0 + 0 + \frac{1}{2}(4.83)(2)^2 = 9.66 \text{ ft} \qquad \textbf{Ans}$$

**17-37.** The drop gate at the end of the trailer has a mass of 1.25 Mg and mass center at $G$. If it is supported by the cable $AB$ and hinge at $C$, determine the tension in the cable when the truck begins to accelerate at $5\ \text{m/s}^2$. Also, what are the horizontal and vertical components of reaction at the hinge $C$?




$$\circlearrowleft +\Sigma M_C = \Sigma(M_k)_C; \qquad T\sin 30°(2.5) - 12\,262.5(1.5\cos 45°) = 1250(5)(1.5\sin 45°)$$

$$T = 15\,708.4\ \text{N} = 15.7\ \text{kN} \qquad \textbf{Ans}$$



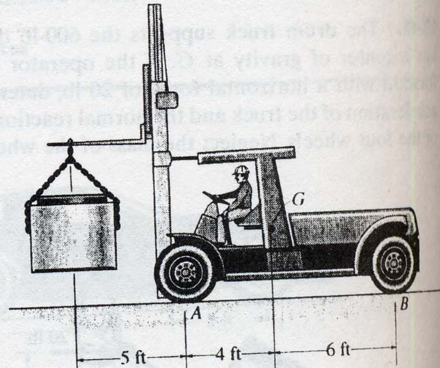

$$\overset{+}{\leftarrow}\Sigma F_x = m(a_G)_x; \qquad -C_x + 15\,708.4\cos 15° = 1250(5)$$

$$C_x = 8.92\ \text{kN} \qquad \textbf{Ans}$$

$$+\uparrow \Sigma F_y = m(a_G)_y; \qquad C_y - 12\,262.5 - 15\,708.4\sin 15° = 0$$

$$C_y = 16.3\ \text{kN} \qquad \textbf{Ans}$$

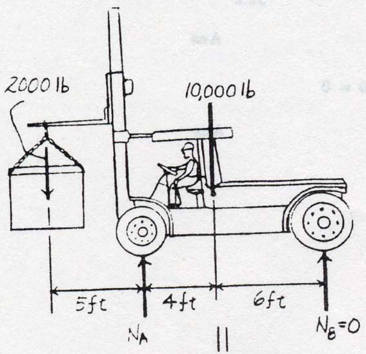
**17-43.** The forklift and operator have a combined weight of 10 000 lb and center of mass at $G$. If the forklift is used to lift the 2000-lb concrete pipe, determine the maximum vertical acceleration it can give to the pipe so that it does not tip forward on its front wheels.

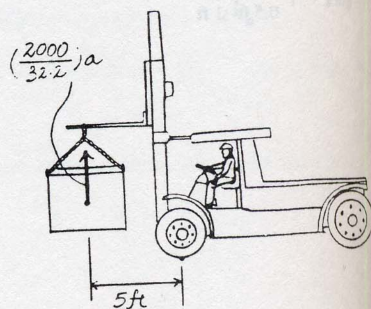



It is required that $N_B = 0$.

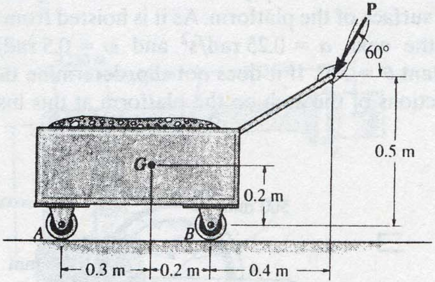
$$\circlearrowleft + \Sigma M_A = \Sigma (M_k)_A; \quad 2000(5) - 10000(4) = -\left[\left(\frac{2000}{32.2}\right)a\right](5)$$

$$a = 96.6 \text{ ft/s}^2$$ **Ans**



**17-47.** The handcart has a mass of 200 kg and center of mass at $G$. Determine the normal reactions at each of the two wheels at $A$ and the two wheels at $B$ if a force of $P = 50$ N is applied to the handle. Neglect the mass of the wheels.

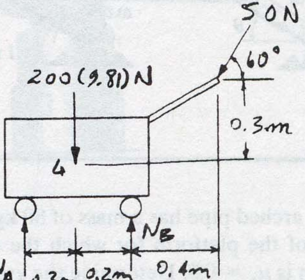



$\leftarrow \Sigma F_x = m(a_G)_x;$ $\quad 50\cos 60° = 200 a_G$

$+\uparrow \Sigma F_y = m(a_G)_y;$ $\quad N_A + N_B - 200(9.81) - 50\sin 60° = 0$

$\circlearrowleft + \Sigma M_G = 0;$ $\quad -N_A(0.3) + N_B(0.2) + 50\cos 60°(0.3) - 50\sin 60°(0.6) = 0$

$a_G = 0.125 \text{ m/s}^2;$ $\quad N_A = 765.2 \text{ N};$ $\quad N_B = 1240 \text{ N}$




At each wheel,

$N_A' = \dfrac{N_A}{2} = 383 \text{ N}$ **Ans**

$N_B' = \dfrac{N_B}{2} = 620 \text{ N}$ **Ans**