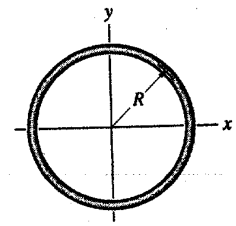
17-2

Determine the moment of inertia of the thin ring about the z axis. The ring has a mass m.



$$I_z = \int_0^{2\pi} \rho A (R\,d\theta) R^2 = 2\pi\rho A R^3$$

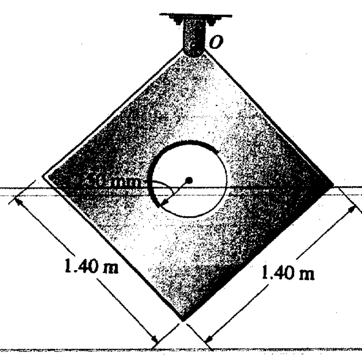
$$m = \int_0^{2\pi} \rho A R\,d\theta = 2\pi\rho A R$$

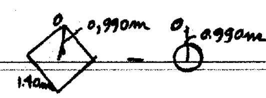
Thus,

$$I_z = m R^2 \qquad \textbf{Ans}$$

17-12

Determine the moment of inertia about an axis perpendicular to the page and passing through the pin at O. The thin plate has a hole in its center. Its thickness is 50 mm, and the material has a density $\rho = 50\ \text{kg/m}^3$.





$$m_p = 50(1.40)^2(0.050) = 4.90\ \text{kg}$$

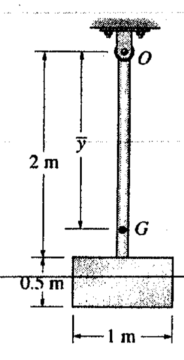
$$m_h = (50)(\pi)(0.15)^2(0.050) = 0.1767\ \text{kg}$$

$$I_O = \frac{1}{12}(4.90)[(1.40)^2 + (1.40)^2] + 4.90(0.990)^2 - [\frac{1}{2}(0.1767)(0.15)^2 + (0.1767)(0.990)^2]$$

$$I_O = 6.23\ \text{kg}\cdot\text{m}^2 \qquad \textbf{Ans}$$

17-16

The pendulum consists of the 3-kg slender rod and the 5-kg thin plate. Determine the location $\bar{y}$ of the center of mass G of the pendulum; then calculate the moment of inertia of the pendulum about an axis perpendicular to the page and passing through G.



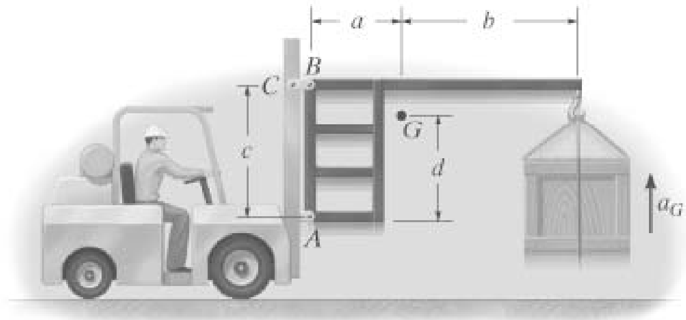
$$\bar{y} = \frac{\Sigma\tilde{y}m}{\Sigma m} = \frac{1(3)+2.25(5)}{3+5} = 1.781\ \text{m} = 1.78\ \text{m} \qquad \textbf{Ans}$$

$$I_G = \Sigma\bar{I}_{G'} + md^2$$

$$= \frac{1}{12}(3)(2)^2 + 3(1.781-1)^2 + \frac{1}{12}(5)(0.5^2+1^2) + 5(2.25-1.781)^2$$

$$= 4.45\ \text{kg}\cdot\text{m}^2 \qquad \textbf{Ans}$$

The fork lift has a boom with mass M_1 and a mass center at G. If the vertical acceleration of the boom is a_G, determine the horizontal and vertical reactions at the pin A and on the short link BC when the load M_2 is lifted.



Units Used:

$\mathrm{Mg} = 10^3\ \mathrm{kg}$ $\qquad$ $\mathrm{kN} = 10^3\ \mathrm{N}$

Given:

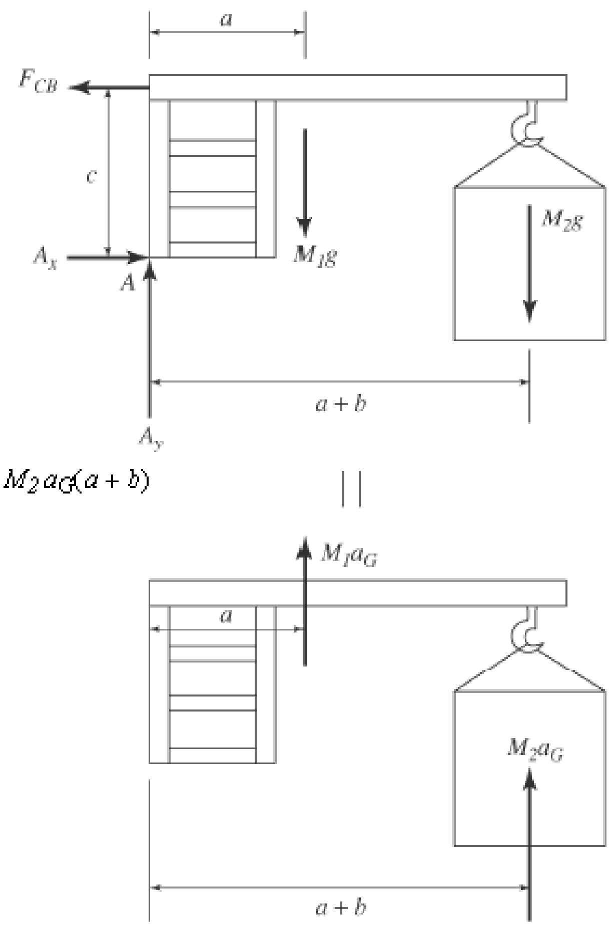
$M_1 = 800\ \mathrm{kg}$ $\qquad$ $a = 1\ \mathrm{m}$

$M_2 = 1.25\ \mathrm{Mg}$ $\qquad$ $b = 2\ \mathrm{m}$

$c = 1.5\ \mathrm{m}$

$a_G = 4\ \dfrac{\mathrm{m}}{\mathrm{s}^2}$ $\qquad$ $d = 1.25\ \mathrm{m}$

Solution:



Guesses

$A_x = 1\ \mathrm{N}$ $\qquad$ $F_{CB} = 1\ \mathrm{N}$

$A_y = 1\ \mathrm{N}$

Given

$$-F_{CB} + A_x = 0$$

$$A_y - (M_1 + M_2)g = (M_1 + M_2)a_G$$

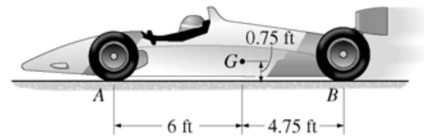
$$F_{CB}c - M_1 g a - M_2 g(a + b) = M_1 a_G a + M_2 a_G(a + b)$$

$$\begin{pmatrix} A_x \\ A_y \\ F_{CB} \end{pmatrix} = \mathrm{Find}(A_x, A_y, F_{CB})$$

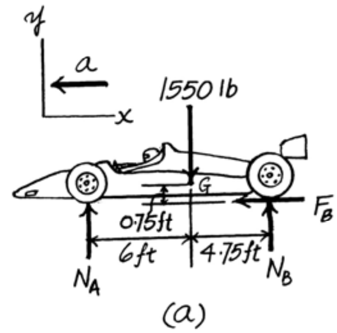
$$\begin{pmatrix} A_x \\ A_y \\ F_{CB} \end{pmatrix} = \begin{pmatrix} 41.9 \\ 28.3 \\ 41.9 \end{pmatrix} \mathrm{kN}$$

17-32

Determine the maximum acceleration that can be achieved by the car without having the front wheels A leave the track or the rear drive wheels B slip on the track. The coefficient of static friction is $\mu_s = 0.9$. The car's mass center is at G, and the front wheels are free to roll. Neglect the mass of all the wheels.



Equations of Motion:



(a)

$$\overset{+}{\leftarrow}\Sigma F_x = m(a_G)_x; \qquad F_B = \frac{1550}{32.2}a \qquad \textbf{(1)}$$

$$+\uparrow\Sigma F_y = m(a_G)_y; \quad N_A + N_B - 1550 = 0 \qquad \textbf{(2)}$$

$$\circlearrowleft + \Sigma M_G = 0; \qquad N_B(4.75) - F_B(0.75) - N_A(6) = 0 \qquad \textbf{(3)}$$

If we assume that the front wheels are about to leave the track, $N_A = 0$. Substituting this value into Eqs. (2) and (3) and solving Eqs. (1), (2), (3),

$$N_B = 1550 \text{ lb} \qquad F_B = 9816.67 \text{ lb} \qquad a = 203.93 \text{ ft/s}^2$$

Since $F_B > (F_B)_{\text{max}} = \mu_s N_B = 0.9(1550) \text{ lb} = 1395 \text{ lb}$, the rear wheels will slip. Thus, the solution must be reworked so that the rear wheels are about to slip.

$$F_B = \mu_s N_B = 0.9 N_B \qquad \textbf{(4)}$$

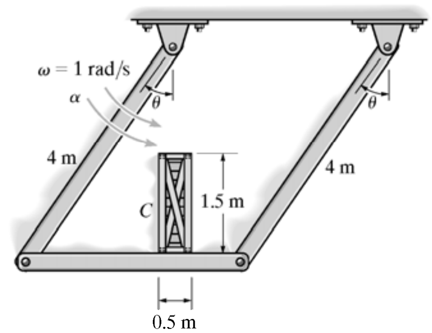
Solving Eqs. (1), (2), (3), and (4) yields

$$N_A = 626.92 \text{ lb} \qquad N_B = 923.08 \text{ lb}$$

$$a = 17.26 \text{ ft/s}^2 = 17.3 \text{ ft/s}^2 \qquad \textbf{Ans.}$$

17-50

The 50-kg uniform crate rests on the platform for which the coefficient of static friction is $\mu_s = 0.5$. If at the instant $\theta = 30°$ the supporting links have an angular velocity $\omega = 1$ rad/s and angular acceleration $\alpha = 0.5$ rad/s^2, determine the frictional force on the crate.



Curvilinear Translation:

$(a_G)_n = (1)^2(4) = 4 \text{ m/s}^2$

$(a_G)_t = 0.5(4) \text{ m/s}^2 = 2 \text{ m/s}^2$

$\overset{+}{\rightarrow} \Sigma F_x = m(a_G)_x;\quad F_C = 50(4)\sin 30° + 50(2)\cos 30°$

$+\uparrow \Sigma F_y = m(a_G)_y;\quad N_C - 50(9.81) = 50(4)\cos 30° - 50(2)\sin 30°$

Solving,

$F_C = 186.6 \text{ N}$

$N_C = 613.7 \text{ N}$

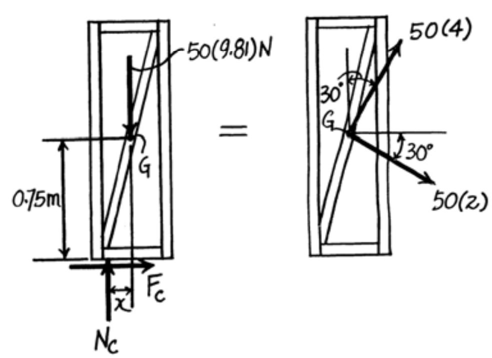
$(F_C)_{\max} = 0.5(613.7) = 306.9 \text{ N} > 186.6 \text{ N}$ **OK**

$\zeta + \Sigma M_G = \Sigma(M_k)_G;\quad N_C(x) - F_C(0.75) = 0$

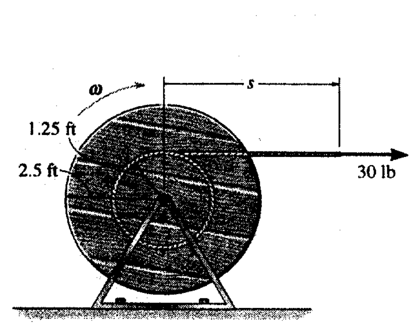
$613.7(x) - 186.6(0.75) = 0$

$x = 0.228 \text{ m} < 0.25 \text{ m}$ **OK**

Thus, $F_C = 187 \text{ N}$ **Ans.**



A cord is wrapped around the inner core of a spool. If the cord is pulled with a constant tension of 30 lb and the spool is originally at rest, determine the spool's angular velocity when $s = 8$ ft of cord has unwound. Neglect the weight of the 8-ft portion of cord. The spool and the entire cord have a total weight of 400 lb, and the radius of gyration about the axle A is $k_A = 1.30$ ft.



$I_A = mk_A^2 = \left(\frac{400}{32.2}\right)(1.30)^2 = 20.99$ slug · ft²

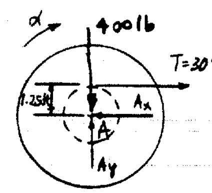
$\circlearrowleft + \Sigma M_A = I_A\,\alpha$: $30(1.25) = 20.99(\alpha)$ $\alpha = 1.786$ rad/s²

The angular displacement is $\theta = \frac{s}{r} = \frac{8}{1.25} = 6.4$ rad.

$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$

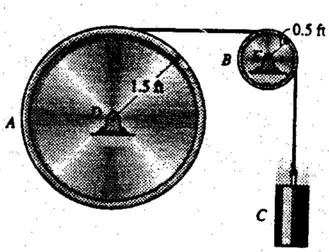
$\omega^2 = 0 + 2(1.786)(6.4 - 0)$

$\omega = 4.78$ rad/s **Ans**



17-81

A cord having negligible mass is wrapped over the 15-lb disk at A and passes over the 5-lb disk at B. If a 3-lb block C is attached to its end and released from rest, determine the speed of the block after it descends 3 ft. Also, what is the tension in the horizontal and vertical segments of the cord? Assume no slipping of the cord over the disk at B. Neglect friction at the pins D and E.



Disk A :

$$\circlearrowleft + \Sigma M_D = I_D \alpha_A; \quad T_A(1.5) = \left[\frac{1}{2}\left(\frac{15}{32.2}\right)(1.5)^2\right]\alpha_A \qquad (1)$$

Disk B :

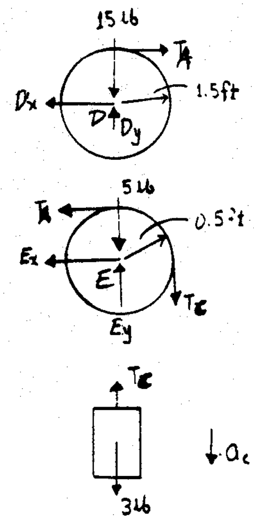
$$\circlearrowleft + \Sigma M_E = I_E \alpha_B; \quad T_C(0.5) - T_A(0.5) = \left[\frac{1}{2}\left(\frac{5}{32.2}\right)(0.5)^2\right]\alpha_B$$

Block C :

$$+\downarrow \Sigma F_y = m(a_G)_y; \quad 3 - T_C = \left(\frac{3}{32.2}\right)a_C \qquad (3)$$

$$\alpha_B = \frac{a_C}{0.5} \qquad (4)$$

$$\alpha_A = \frac{a_C}{1.5} \qquad (5)$$



Substituting Eqs. 1, 3, 4 and 5 into Eq. 2,

$$\left(3 - \frac{3}{32.2}a_C\right)(0.5) - \frac{1}{2}\left(\frac{15}{32.2}\right)(1.5)\left(\frac{a_C}{1.5}\right)(0.5) = \left[\frac{1}{2}\left(\frac{5}{32.2}\right)(0.5)^2\right]\left(\frac{a_C}{0.5}\right)$$

$a_C = 7.43$ ft/s^2

Thus

$T_A = 1.73$ lb **Ans**

$T_C = 2.31$ lb **Ans**

$$(+\downarrow) \quad v^2 = v_0^2 + 2a_c(s - s_0)$$

$$v_C^2 = 0 + 2(7.43)(3 - 0)$$

$v_C = 6.68$ ft/s **Ans**