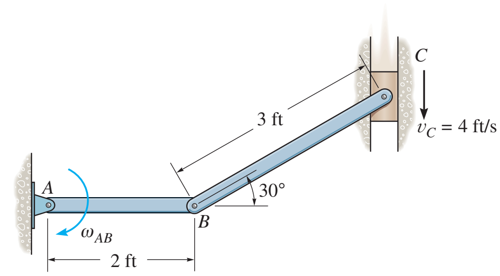
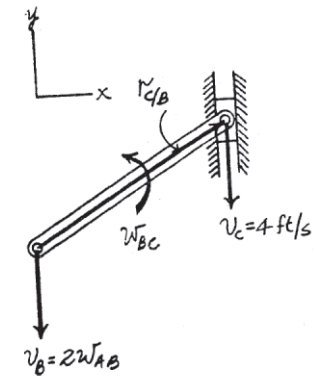
16–58.

If the block at C is moving downward at 4 ft/s, determine the angular velocity of bar AB at the instant shown.



SOLUTION

***Kinematic Diagram*:** Since link AB is rotating about fixed point A, then v_B is always directed perpendicular to link AB and its magnitude is $v_B = \omega_{AB} r_{AB} = 2\omega_{AB}$. At the instant shown, v_B is directed towards the *negative y* axis. Also, block C is moving downward vertically due to the constraint of the guide. Then v_c is directed toward *negative* y axis.



***Velocity Equation*:** Here, $\mathbf{r}_{C/A} = \{3\cos 30°\mathbf{i} + 3\sin 30°\mathbf{j}\}$ ft $= \{2.598\mathbf{i} + 1.50\mathbf{j}\}$ ft. Applying Eq. 16–16, we have

$$\mathbf{v}_C = \mathbf{v}_B + \omega_{BC} \times \mathbf{r}_{C/B}$$

$$-4\mathbf{j} = -2\omega_{AB}\mathbf{j} + (\omega_{BC}\mathbf{k}) \times (2.598\mathbf{i} + 1.50\mathbf{j})$$

$$-4\mathbf{j} = -1.50\omega_{BC}\mathbf{i} + (2.598\omega_{BC} - 2\omega_{AB})\mathbf{j}$$

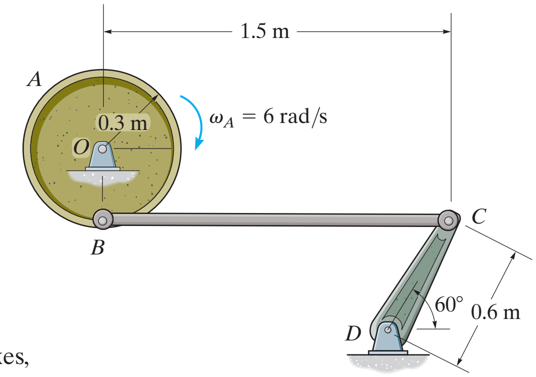
Equating **i** and **j** components gives

$$0 = -1.50\omega_{BC} \qquad \omega_{BC} = 0$$

$$-4 = 2.598(0) - 2\omega_{AB} \qquad \omega_{AB} = 2.00 \text{ rad/s} \qquad \textbf{Ans.}$$

16–62.

If the flywheel is rotating with an angular velocity of $\omega_A = 6$ rad/s, determine the angular velocity of rod BC at the instant shown.



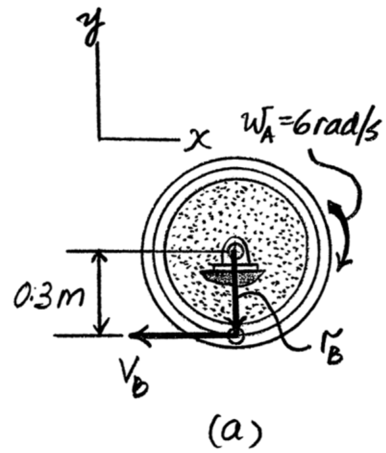
SOLUTION

Rotation About a Fixed Axis: Flywheel A and rod CD rotate about fixed axes, Figs. a and b. Thus, the velocity of points B and C can be determined from

$$v_B = \omega_A \times \mathbf{r}_B = (-6\mathbf{k}) \times (-0.3\mathbf{j}) = [-1.8\mathbf{i}] \text{ m/s}$$

$$v_C = \omega_{CD} \times \mathbf{r}_C = (\omega_{CD}\mathbf{k}) \times (0.6\cos 60°\,\mathbf{i} + 0.6\sin 60°\,\mathbf{j})$$

$$= -0.5196\omega_{CD}\mathbf{i} + 0.3\omega_{CD}\mathbf{j}$$



General Plane Motion: By referring to the kinematic diagram of link BC shown in Fig. c and applying the relative velocity equation, we have

$$\mathbf{v}_B = \mathbf{v}_C + \omega_{BC} \times \mathbf{r}_{B/C}$$

$$-1.8\mathbf{i} = -0.5196\omega_{CD}\mathbf{i} + 0.3\omega_{CD}\mathbf{j} + (\omega_{BC}\mathbf{k}) \times (-1.5\mathbf{i})$$

$$-1.8\mathbf{i} = -0.5196\omega_{CD}\mathbf{i} + (0.3\omega_{CD} - 1.5\omega_{BC})\mathbf{j}$$

Equating the **i** and **j** components

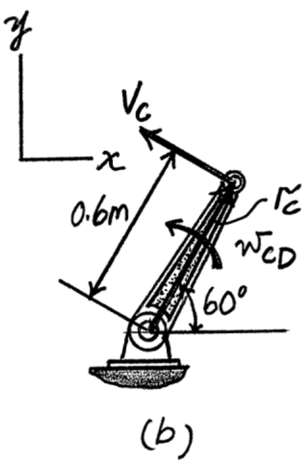
$$-1.8 = -0.5196\omega_{CD}$$

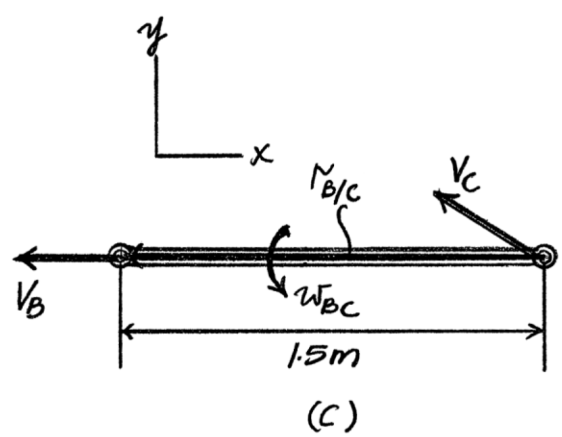
$$0 = 0.3\omega_{CD} - 1.5\omega_{BC}$$

Solving,

$$\omega_{CD} = 3.46 \text{ rad/s}$$

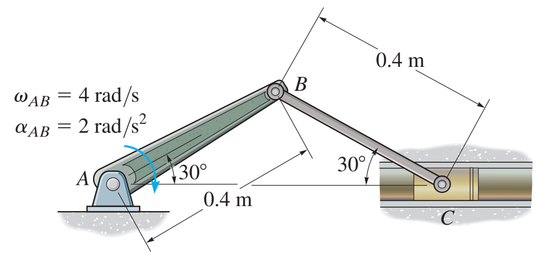
$$\omega_{BC} = 0.693 \text{ rad/s} \qquad \textbf{Ans.}$$





16–111.

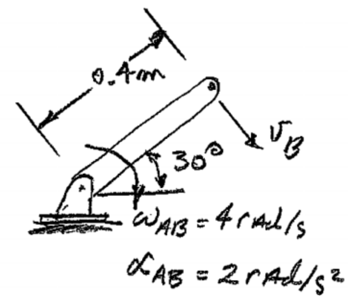
Crank AB rotates with the angular velocity and angular acceleration shown. Determine the acceleration of the slider block C at the instant shown.



SOLUTION

Angular Velocity: Since crank AB rotates about a fixed axis, Fig. a,

$$v_B = \omega_{AB} r_B = 4(0.4) = 1.6 \text{ m/s}$$



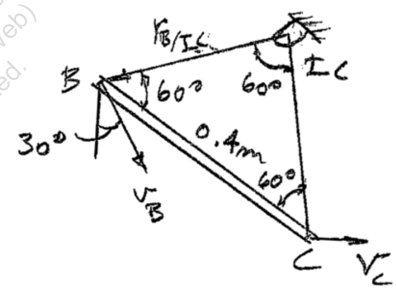
(a)

The location of the IC for link BC is indicated in Fig. b. From the geometry of this figure,

$$r_{B/IC} = 0.4 \text{ m}$$

Then

$$\omega_{BC} = \frac{v_B}{r_{B/IC}} = \frac{1.6}{0.4} = 4 \text{ rad/s}$$



(b)

Acceleration and Angular Acceleration: Since crank AB rotates about a fixed axis, Fig. a

$$\mathbf{a}_B = \alpha_{AB} \times \mathbf{r}_B - \omega_{AB}^2 \mathbf{r}_B$$

$$= (-2\mathbf{k}) \times (0.4 \cos 30°\mathbf{i} + 0.4 \sin 30°\mathbf{j}) - 4^2(0.4 \cos 30°\mathbf{i} + 0.4 \sin 30°\mathbf{j})$$

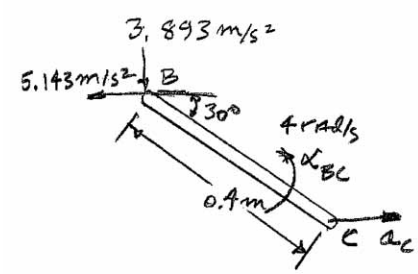
$$= [-5.143\mathbf{i} - 3.893\mathbf{j}] \text{ m/s}^2$$

Using this result and applying the relative acceleration equation by referring to Fig. c,

$$\mathbf{a}_C = \mathbf{a}_B + \alpha_{BC} \times \mathbf{r}_{C/B} - \omega_{BC}^2 \mathbf{r}_{C/B}$$

$$a_C\mathbf{i} = (-5.143\mathbf{i} - 3.893\mathbf{j}) + (\alpha_{BC}\mathbf{k}) \times (0.4 \cos 30°\mathbf{i} - 0.4 \sin 30°\mathbf{j}) - 4^2(0.4 \cos 30°\mathbf{i} - 0.4 \sin 30°\mathbf{j})$$

$$a_C\mathbf{i} = (0.2\alpha_{BC} - 10.69)\mathbf{i} + (0.3464\alpha_{BC} - 0.6928)\mathbf{j}$$



(c)

Equating the **i** and **j** components, yields

$$a_C = 0.2\alpha_{BC} - 10.69 \qquad \textbf{(1)}$$

$$0 = 0.3464\alpha_{BC} - 0.6928 \qquad \textbf{(2)}$$

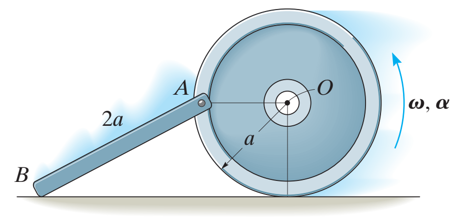
Solving Eqs. (1) and (2),

$$\alpha_{BC} = 2 \text{ rad/s}^2$$

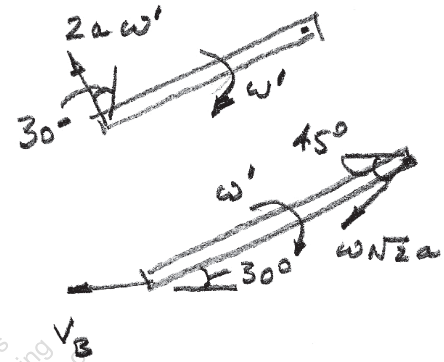
$$a_C = -10.29 \text{ m/s}^2 = 10.3 \text{ m/s}^2 \leftarrow \qquad \textbf{Ans.}$$

16–119.

The wheel rolls without slipping such that at the instant shown it has an angular velocity $\boldsymbol{\omega}$ and angular acceleration $\boldsymbol{\alpha}$. Determine the velocity and acceleration of point B on the rod at this instant.



SOLUTION



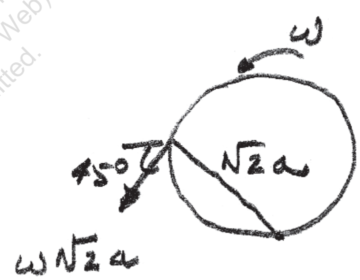
$$\overline{v}_B = \overline{v}_A + \overline{v}_{B/A\,(Pin)}$$

$$\overset{+}{\leftarrow}\; v_B = \frac{1}{\sqrt{2}}\left(\omega\sqrt{2}a\right) + 2a\omega'\left(\frac{1}{2}\right)$$

$$+\uparrow\; O = -\frac{1}{\sqrt{2}}\left(\omega\sqrt{2}a\right) + 2a\omega'\left(\frac{\sqrt{3}}{2}\right)$$

$$\omega' = \frac{\omega}{\sqrt{3}}$$

$$v_B = 1.58\,\omega a \qquad \textbf{Ans.}$$

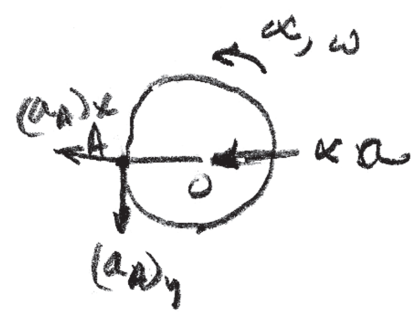


$$\overline{a}_A = \overline{a}_O + \overline{a}_{A/O\,(Pin)}$$

$$\underset{\leftarrow}{(a_A)_x} + \underset{\downarrow}{(a_A)_y} = \underset{\leftarrow}{\alpha a} + \underset{\downarrow}{\alpha(a)} + \underset{\rightarrow}{\omega^2 a}$$

$$(a_A)_x = \alpha a - \omega^2 a$$

$$(a_A)_y = \alpha a$$



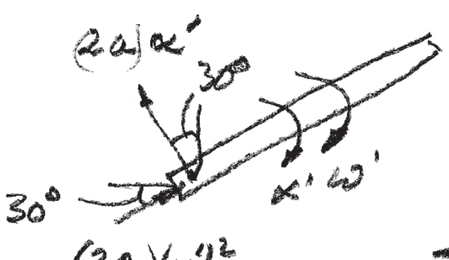
$$\overline{a}_B = \overline{a}_A + \overline{a}_{B/A\,(Pin)}$$

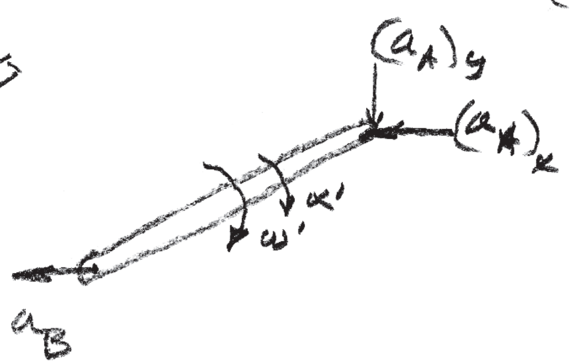
$$a_B = \alpha a - \omega^2 a + 2a(\alpha')\left(\frac{1}{2}\right) - 2a\left(\frac{\omega}{\sqrt{3}}\right)^2\frac{\sqrt{3}}{2}$$

$$O = -\alpha a + 2a\alpha'\left(\frac{2}{\sqrt{3}}\right) + 2a\left(\frac{\omega}{\sqrt{3}}\right)^2\left(\frac{1}{2}\right)$$

$$\alpha' = 0.577\alpha - 0.1925\omega^2$$

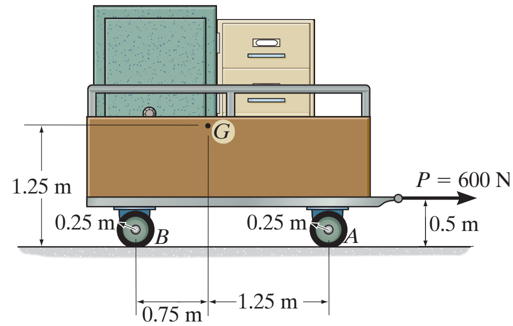
$$a_B = 1.58\alpha a - 1.77\omega^2 a \qquad \textbf{Ans.}$$





17–34.

The trailer with its load has a mass of 150 kg and a center of mass at G. If it is subjected to a horizontal force of $P = 600$ N, determine the trailer's acceleration and the normal force on the pair of wheels at A and at B. The wheels are free to roll and have negligible mass.



SOLUTION

Equations of Motion: Writing the force equation of motion along the x axis,

$$\stackrel{+}{\rightarrow} \Sigma F_x = m(a_G)_x; \qquad 600 = 150a \qquad a = 4 \text{ m/s}^2 \rightarrow \qquad \textbf{Ans.}$$

Using this result to write the moment equation about point A,

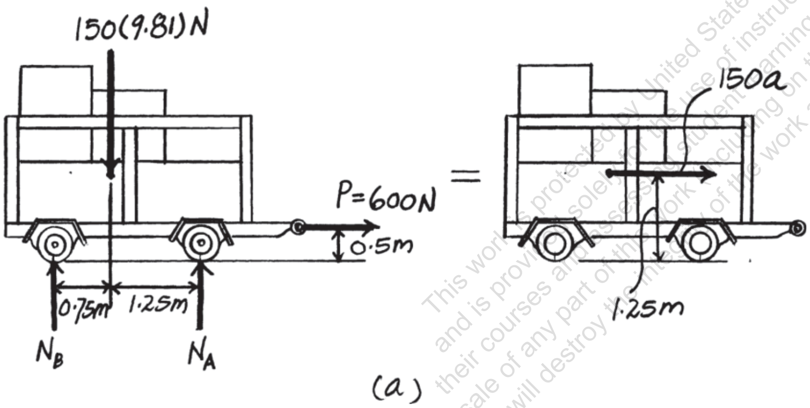
$$\circlearrowleft + \Sigma M_A = (M_k)_A; \qquad 150(9.81)(1.25) - 600(0.5) - N_B(2) = -150(4)(1.25)$$

$$N_B = 1144.69 \text{ N} = 1.14 \text{ kN} \qquad \textbf{Ans.}$$

Using this result to write the force equation of motion along the y axis,

$$+\uparrow \Sigma F_y = m(a_G)_y; \quad N_A + 1144.69 - 150(9.81) = 150(0)$$

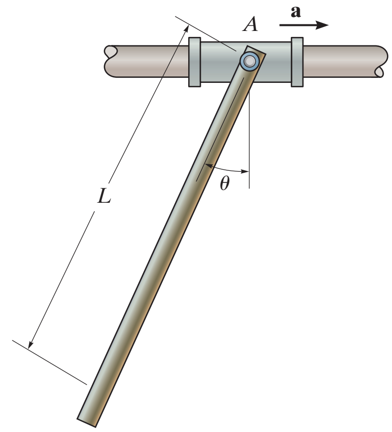
$$N_A = 326.81 \text{ N} = 327 \text{ N} \qquad \textbf{Ans.}$$



(a)

17–39.

The uniform bar of mass m is pin connected to the collar, which slides along the smooth horizontal rod. If the collar is given a constant acceleration of **a**, determine the bar's inclination angle θ. Neglect the collar's mass.

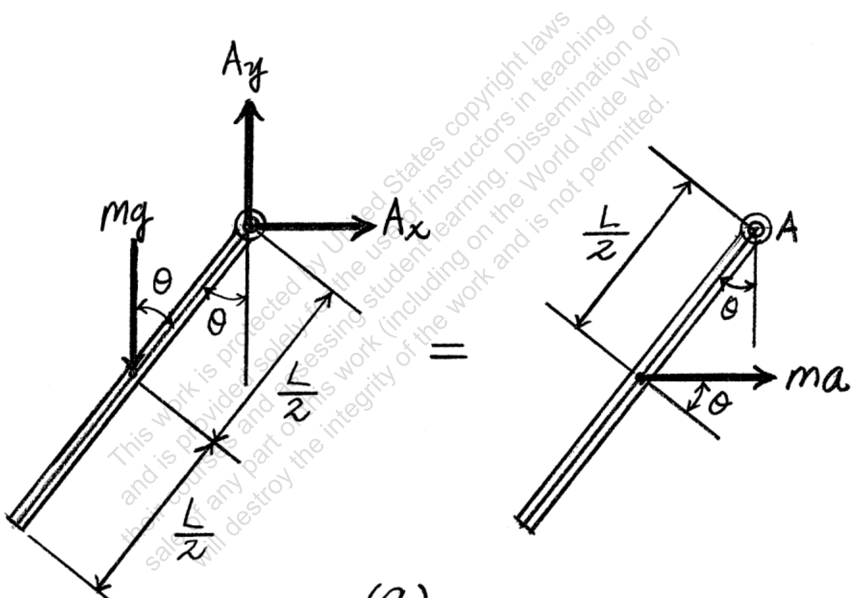


SOLUTION

Equations of Motion: Writing the moment equation of motion about point A,

$$+\Sigma M_A = (M_k)_A; \qquad mg\sin\theta\left(\frac{L}{2}\right) = ma\cos\theta\left(\frac{L}{2}\right)$$

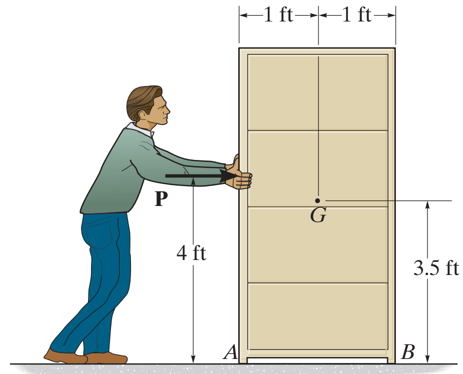
$$\theta = \tan^{-1}\left(\frac{a}{g}\right)$$ **Ans.**



(a)

17–43.

Determine the acceleration of the 150-lb cabinet and the normal reaction under the legs A and B if $P = 35$ lb. The coefficients of static and kinetic friction between the cabinet and the plane are $\mu_s = 0.2$ and $\mu_k = 0.15$, respectively. The cabinet's center of gravity is located at G.



SOLUTION

Equations of Equilibrium: The free-body diagram of the cabinet under the static condition is shown in Fig. *a*, where **P** is the unknown minimum force needed to move the cabinet. We will assume that the cabinet slides before it tips. Then, $F_A = \mu_s N_A = 0.2N_A$ and $F_B = \mu_s N_B = 0.2N_B$.

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad P - 0.2N_A - 0.2N_B = 0 \qquad \textbf{(1)}$$

$$+\uparrow \Sigma F_y = 0; \qquad N_A + N_B - 150 = 0 \qquad \textbf{(2)}$$

$$+\Sigma M_A = 0; \qquad N_B(2) - 150(1) - P(4) = 0 \qquad \textbf{(3)}$$

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

$$P = 30\text{ lb} \qquad N_A = 15\text{ lb} \qquad N_B = 135\text{ lb}$$

Since $P < 35$ lb and $\mathbf{N}_A$ is positive, the cabinet will slide.

Equations of Motion: Since the cabinet is in motion, $F_A = \mu_k N_A = 0.15N_A$ and $F_B = \mu_k N_B = 0.15N_B$. Referring to the free-body diagram of the cabinet shown in Fig. *b*,

$$\overset{+}{\rightarrow} \Sigma F_x = m(a_G)_x; \qquad 35 - 0.15N_A - 0.15N_B = \left(\frac{150}{32.2}\right)a \qquad \textbf{(4)}$$

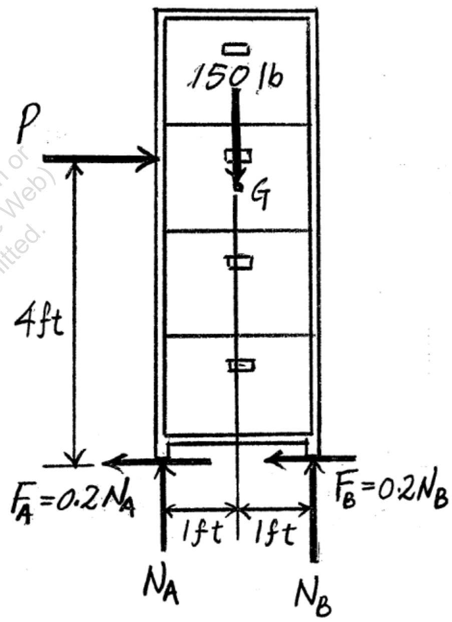
$$\overset{+}{\rightarrow} \Sigma F_x = m(a_G)_x; \qquad N_A + N_B - 150 = 0 \qquad \textbf{(5)}$$

$$+\Sigma M_G = 0; \quad N_B(1) - 0.15N_B(3.5) - 0.15N_A(3.5) - N_A(1) - 35(0.5) = 0 \quad \textbf{(6)}$$

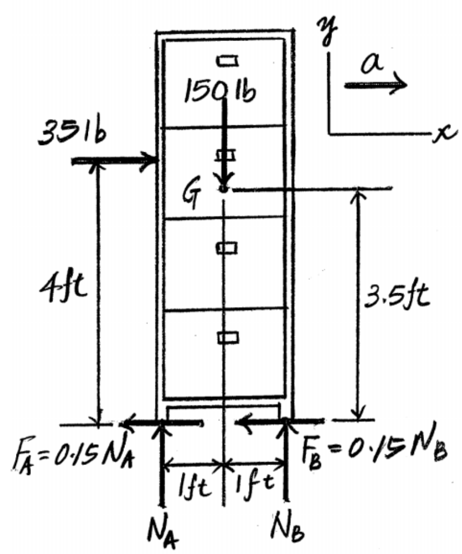
Solving Eqs. (4), (5), and (6) yields

$$a = 2.68\text{ ft/s}^2 \qquad \textbf{Ans.}$$

$$N_A = 26.9\text{ lb} \qquad N_B = 123\text{ lb} \qquad \textbf{Ans.}$$



(a)



(b)