17-6. A semicircle is formed by rotating the shaded area about the $x$ axis. Determine the moment of inertia of this solid with respect to the $x$ axis and express the result in terms of the mass $m$ of the solid. The material has a constant density $\rho$.

\[ I_x = \frac{m}{2} \]

\[ = \int_0^b \rho \pi y^2 \, dx \\
= \int_0^b \rho \pi \left( \sqrt{1 - \frac{x^2}{a^2}} \right)^2 \, dx \\
= \frac{\rho \pi}{3} a^3 + \frac{m}{3} \]

Thus,

\[ I_x = \frac{m}{3} \pi a^3 \quad \text{Ans} \]

17-7. The solid is formed by revolving the shaded area around the $y$ axis. Determine the radius of gyration $k_y$. The specific weight of the material is $\gamma = 300$ lb/ft$^3$.

The moment of inertia of the solid: The mass of the disk element

\[ dm = \rho \pi \, dx = \frac{\rho \pi a^2}{2} \, dx \]

\[ I_y = \frac{\rho \pi}{2} a^4 \int_0^b x^2 \, dx = \frac{\rho \pi}{2} a^4 \frac{b^3}{3} \]

The mass of the solid:

\[ m = \int_0^b \rho \pi a^2 \, dx = \frac{\rho \pi a^2 b}{2} = 12,117 \rho \]

\[ k_y = \sqrt{\frac{I_y}{m}} = \sqrt{\frac{\frac{\rho \pi}{2} a^4 \frac{b^3}{3}}{\frac{\rho \pi a^2 b}{2}}} = 1.56 \text{ in.} \quad \text{Ans} \]
17-18. The wheel consists of a thin ring having a mass of 10 kg and four spokes made from slender rods 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.

\[ I = \frac{1}{2} m r^2 + \sum I_{i} \]

\[ = \frac{1}{2} (10 \times 1^2) + 4 \times (2 \times 0.7^2) 

= 7.61 \text{ kg m}^2 \quad \text{Ans} \]

17-19. The pendulum consists of the 2 kg slender rod and the 5 kg thin plate. Determine the location \( x \) 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 \( G \).

\[ \sum m x_i = \sum m x \]

\[ = \frac{1}{2} (11 + 2.93) x \quad \text{Ans} \]

\[ I = \sum m r^2 + \sum I_{i} \]

\[ = \frac{1}{12} (2 + 7) x^2 + \sum I_{i} \]

\[ = 1.47 \text{ kg m}^2 \quad \text{Ans} \]

17-20. 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 \( O \).

\[ I = \frac{1}{12} m r^2 + \sum \left( \frac{1}{3} mr \right)^2 + \frac{1}{2} m r^2 \]

\[ = \text{Ans} \]
17-18. The slender rod has a weight of 3 lb/ft. Determine the moment of inertia of the assembly about an axis perpendicular to the page and passing through the pin at A.

\[ I = \frac{1}{12}(\frac{321}{122}) + \frac{1}{12}(\frac{321}{122}) + \frac{1}{12}(\frac{321}{122}) \]

\[ = 2.17 \text{ in}^4 \text{ Ans} \]

17-19. The pendulum consists of a plate having a weight of 12 lb and a slender rod having a weight of 4 lb. Determine the radius of gyration of the pendulum about an axis perpendicular to the page and passing through point B.

\[ I = \frac{4}{15} \text{ in}^4 \]

\[ K = \sqrt{\frac{I}{m}} = 0.15 \text{ in} \text{ Ans} \]

17-20. The pendulum consists of two slender rods AB and BC, each having a weight of 3 kg/m. The thin plate has a mass of 12 kg/m². Determine the location 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.

\[ I = \frac{1}{12}(3 \text{ kg/m}^2)(15 \text{ m})^2 - \frac{1}{12}(3 \text{ kg/m}^2)(5 \text{ m})^2 \]

\[ = 120 \text{ kg} \cdot \text{m}^2 \text{ Ans} \]

\[ g = g \cdot (3 \text{ kg/m}^2)(15 \text{ m}) \]

\[ = 5.41 \text{ kg} \cdot \text{m} \text{ Ans} \]

\[ g = \frac{1}{12}(2 \text{ kg/m}^2)(2 \text{ m})^2 - \frac{1}{12}(3 \text{ kg/m}^2)(1 \text{ m})^2 \]

\[ = 1.67 \text{ kg} \cdot \text{m}^2 \text{ Ans} \]

\[ g = 1 \cdot (2 \text{ kg/m}^2)(1 \text{ m}) \]

\[ = 2 \text{ kg} \cdot \text{m} \text{ Ans} \]
17-26. The Z-6 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 \( G \).

\[
\sum F_x = m(a_x) ; \quad F_s = \frac{G}{12} \sin \theta \Rightarrow \quad a_x = \frac{G}{12} \sin \theta
\]

\[
\sum F_y = m(a_y) ; \quad F_s = 2 N \sin \theta \Rightarrow \quad a_y = \frac{2 N}{12} \sin \theta
\]

Answer: bottle is about to slip.

\( F_s = 2 \text{ lb} \)
\( N = 12 \text{ lb} \)
\( a_y = 0.44 \text{ ft/s}^2 \)

Bottle will tip before slipping.

Set: \( a_x = 1.5 \text{ in} \)

\( a_y = 0.375 \text{ in} \)

\( F_s = 0.375 \text{ lb} \) (Ans)

17-27. The assembly has a mass of 8 Mg and is hoisted using the boom and pulley system. If the winch in \( B \) draws in 2 m/s, determine the force in the hydraulic cylinder needed to support the boom. The boom has a mass of 2 Mg and mass center at \( G \).

\[
\sum F_x = m(a_x) ; \quad F_2 = \frac{G}{12} \sin \theta \Rightarrow \quad a_x = \frac{G}{12} \sin \theta
\]

\[
\sum F_y = m(a_y) ; \quad F_2 = 10 \text{ N} \sin \theta \Rightarrow \quad a_y = \frac{10 \text{ N}}{12} \sin \theta
\]

Answer:

\( a_x = 2 \text{ m/s}^2 \)

\( a_y = 1 \text{ m/s}^2 \)

Assembly:

\[
\sum F_y = m(a_y) ; \quad 27 - (10 \text{ N})(800) = (10 \text{ N})(\theta)
\]

\( T = 41.24 \text{ kN} \) (Ans)

Boom:

\[
\sum M_B = 0 ; \quad F_2(12 \text{ m})(800) = (10 \text{ N})(10 \text{ m})(\theta)
\]

\( F_2 = 159 \text{ kN} \) (Ans)
15.38. The sports car has a mass of 1.5 Mg and a center of mass at G. Determine the shortest time it takes for it to reach a speed of 80 km/h starting from rest. The engine only drives the rear wheels, whereas the front wheels are free rolling. The coefficients of static friction between the wheels and the road is \( \mu_s = 0.2 \). Neglect the mass of the wheels for the calculation. If driving power could be supplied to all four wheels, what would be the shortest time for the car to reach a speed of 80 km/h?

\[ \begin{align*}
    \text{mass} & = 1.5 \text{ Mg} \\
    \text{engine power} & = 420 \text{ kW} \\
    \text{gear ratio} & = 5.76
\end{align*} \]

For engine:
\[ \begin{align*}
    \text{force} &= \text{torque} \times \text{radius} \\
    F &= 420 \times 0.5 \\
    F &= 210 \text{ N}
\end{align*} \]

\[ \begin{align*}
    \text{acceleration} &= \frac{F - \text{friction}}{m} \\
    a &= \frac{210}{1500} \\
    a &= 0.14 \text{ m/s}^2
\end{align*} \]

\[ \begin{align*}
    \text{time} &= \sqrt{\frac{2d}{a}} \\
    t &= \sqrt{\frac{2 \times 80}{0.14}} \\
    t &= 17.6 \text{ s}
\end{align*} \]

15.39. The sports car has a weight of 4500 lb and a center of gravity at G. If it starts from rest, it counts the rear wheels to dip as it accelerates. Determine how long \( t \) takes for it to reach a speed of 10 ft/s. Also, what are the normal reactions at each of the four wheels on the road? The coefficients of static and kinetic friction at the road are \( \mu_s = 0.5 \) and \( \mu_k = 0.3 \), respectively. Neglect the mass of the wheels.

\[ \begin{align*}
    \text{force} &= \text{mass} \times \text{acceleration} \\
    F &= 4500 \times 0.14 \\
    F &= 630 \text{ N}
\end{align*} \]

\[ \begin{align*}
    \text{time} &= \sqrt{\frac{2d}{a}} \\
    t &= \sqrt{\frac{2 \times 10}{0.14}} \\
    t &= 11.3 \text{ s}
\end{align*} \]
17-45. The van has a weight of 4500 lb and center of gravity at G. It carries a fixed 800-lb load which has a center of gravity at G'. If the van is traveling at 40 ft/s, determine the distance it skids before stopping. The brakes cause all the wheels to lock or skid. The coefficient of kinetic friction between the wheels and the pavement is \( \mu_k = 0.3 \). Compare this distance with that of the van being empty. Neglect the mass of the wheels.

\[
\begin{align*}
-2W_1 &= m_1 \cdot a' \\
-2W_0 &= m_2 \cdot a' \\
-1 &\lesssim m_3 \cdot a' \\
W_1 - W_2 - 400 &= 0
\end{align*}
\]

(1)

(2)

\[ W_2 = 280 \text{ lb} \text{ in Eq. (1)} \text{ and (2)} \]

\[ m_1 = 3500 \text{ lb} \text{ in Eq. (1)} \text{ and (2)} \]

\[ \alpha = 5.06 \text{ ft/s}^2 \]

\[ \beta = 41.3 \text{ ft} \]

\[ \gamma = 45.8 \text{ ft} \]

Thus, \( r = 3.8 \text{ ft} \) Ans

For empty van, \( W_2 = 0 \) in Eq. (1) and (2)

\[ m_1 = 4500 \text{ lb} \]

\[ \alpha = 5.06 \text{ ft/s}^2 \]

Thus, \( r = 32.2 \text{ ft} \) before Ans

17-46. The crate has a mass of 50 kg and rests on the cart having an inclined surface. Determine if the crate will tip over or slide relative to the cart when the cart is subjected to the smallest acceleration necessary to cause one of these relative motions. What is the magnitude of this acceleration? The coefficient of static friction between the crate and the cart is \( \mu_s = 0.5 \).

Equation of Motion: Assume the crate slips. Then \( f_s = \mu_s N = 0.5 N \).

\[
\begin{align*}
2W_1 + 2W_0 &= 50 \times 9.81 \times 0.5 \times 15^\circ \\
&= 150 \text{ N} \text{ in Eq. (1)} \text{ and (2)} \]

(1)

(2)

\[ + 2f_s = m_1 a' \]

(3)

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

\[ W_2 = 447.8 \text{ N} \]

\[ a' = 0.293 \text{ m/s}^2 \]

Ans

Since \( a' < 0.3 \text{ m/s}^2 \), then crate will not tip. Thus, the crate slips. Ans
17-49. The spiral pipe has a mass of 80 kg and rests on the surface of the platform. As it is hoisted from one level to the next, $\alpha = 0.25 \text{ rad/s}^2$ and $\gamma = 0.5 \text{ rad/s}$ at the initial  $\theta = 30^\circ$. If $\gamma$ does not slip determine the no-slip reactions of the pipe on the platform at this instant.

17-50. The spiral pipe has a mass of 80 kg and rests on the surface of the platform for which the coefficient of static friction is $\mu_s = 0.3$. Determine the greatest angular acceleration $\alpha$ of the platform, starting from rest, when $\theta = 45^\circ$, without causing the pipe to slip on the platform.

17-51. The crate Chas a weight of 150 lb and rests on the track elevate for which the coefficient of static friction is $\mu_s = 0.4$. Determine the largest initial angular accelerations, starting from rest, which the parallel links $AB$ and $DE$ can have without causing the crate to slip. No toppling occurs.
17.56. The drum has a weight of 80 lb and a radius of gyration \( k_0 = 0.4 \text{ ft} \). If the cable, which is wrapped around the drum, is subjected to a vertical force \( P = 50 \text{ lb} \), determine the time needed to increase the drum’s angular velocity from \( \omega_0 = 5 \text{ rad/s} \) to \( \omega_f = 25 \text{ rad/s} \). Neglect the mass of the cable.

\[
\omega_f (t) = \omega_0 + \frac{P}{2I} t
\]

\[
\omega_0 = 10.87 \text{ rad/s}^2
\]

\[
\omega_f = 100 \text{ rad/s}^2
\]

\[
25 = 10 + 18.75 t
\]

\[
t = 0.56 \text{ s}
\]

17.57. The spool is supported on small rollers at A and B. Determine the constant force \( P \) that must be applied to the cable in order to unwind 8 m of cable in 4 s starting from rest. Also calculate the normal forces at A and B during this time. The spool has a mass of 60 kg and a radius of gyration \( k_0 = 0.85 \text{ m} \). For the calculation neglect the mass of the cable and the mass of the rollers at A and B.

\[
\omega_0 = 0 \Rightarrow \frac{d}{dt} (2k_m \omega) = \frac{d}{dt} (2k_m \omega)
\]

\[
\omega_0 = 0 \Rightarrow \frac{d}{dt} (2k_m \omega) = \frac{d}{dt} (2k_m \omega)
\]

\[
\omega_0 = 0 \Rightarrow \frac{d}{dt} (2k_m \omega) = \frac{d}{dt} (2k_m \omega)
\]

\[
P = 39.6 \text{ N}
\]

\[
N_A \cos 15^\circ - N_B \cos 15^\circ = 0
\]

\[
N_A \sin 15^\circ + N_B \sin 15^\circ = 39.6 - 588.6 = 0
\]

\[
N_A = N_B = 325 \text{ N}
\]
17-61. The 20-kg roll of paper has a radius of gyration \( k_a = 90 \text{ mm} \) about an axis passing through point \( A \). It is pin-supported at both ends by two brackets \( AB \). If the roll rests against a wall for which the coefficient of kinetic friction is \( \mu_k = 0.2 \) and a vertical force \( F = 30 \text{ N} \) is applied to the end of the paper, determine the angular acceleration of the roll as the paper unrolls.

\[ \ddot{\theta} = \frac{m(a_i \dot{\theta})}{I_r} \]
\[ N_x = k_a \sin 37.8^{\circ} = 0 \]
\[ \dot{v}_a = \frac{m(a_i \dot{\theta})}{I_r} \]
\[ v_a = 0 \text{ at } 30 \text{ N} \]
\[ v_a = \frac{-20(0.0322) - 30(3.121)}{20(0.0322)} \]
\[ \text{Resulting} \]
\[ N_x = 100 \text{ N} \]
\[ I_r = 260 \text{ N m} \]
\[ a = 7.28 \text{ m/s}^2 \]

17-62. Cable is unwound from a spool supported on small rollers at \( A \) and \( B \) by exerting a force of \( T = 300 \text{ N} \) on the cable in the direction shown. Compute the time needed to unwind 5 m of cable from the spool if the spool and cable have a total mass of 60 kg and a cental radius of gyration of \( k_o = 1.2 \text{ m} \). For the calculation, neglect the mass of the cable being unwound and the mass of rollers at \( A \) and \( B \). The rollers turn with no friction.

\[ \text{Equations of Motion:} \quad \text{The mass moment of inertia of the spool along \( O \) is given by} \quad I_{bc} = \frac{m_0^2}{12} = \frac{3600(1.2^2)}{12} = 644 \text{ kg m}^2 \]
\[ \text{Applying} \quad \ddot{\theta} = \frac{5}{4} = 0.5 \text{ rad} \]

\[ \begin{align*}
\text{Resulting} \quad & 6.33(60) + \frac{1}{2}(0.2778)^2 \\
\text{Ans} \quad & 6.31 \text{ s}
\end{align*} \]

17-63. The door will close automatically using torsional spring mounted on the hinges. Each spring has a stiffness \( k = 50 \text{ N m/rad} \) so that the torque on each hinge is \( M = 50\theta \text{ N m} \), where \( \theta \) is measured in radians. If the door is released from rest when it is open at \( \theta = 90^\circ \), determine its angular velocity at the instant \( \theta = 0^\circ \). For the calculation, treat the door as a thin plate having a mass of 70 kg.

\[ \theta = \frac{1}{12} m \omega^2 + \Delta \theta (10(1.2^2) + 70(0.8^2)) = 33.6 \text{ rad}^2 \]

\[ \Delta \theta = \frac{m_0 \omega^2}{12} = 21(2000) = 33.6 \text{ rad}^2 \]

\[ \omega = 3.14 \text{ rad/s} \]

Ans
17.73. The disk has a mass of 20 kg and is originally spinning at the end of the strut with an angular velocity of \( \omega = 60 \text{ rad/s} \). If it is then placed against the wall, for which the coefficient of kinetic friction is \( \mu_k = 0.3 \), determine the time required for the motion to stop. What is the force in strut \( BC \) during this time?

\[ F = m(a) = m(0) = 0 \]

\[ T \]

\[ F = ma \]

\[ 2.4N - 0.3 \times 9.8 \times 0.15 = \frac{1}{2} (20)(0.15)^2 \]

\[ N_x = 96.6 \text{ N} \]

\[ F_T = 193 \text{ N} \quad \text{Ans} \]

\[ \alpha = 19.3 \text{ rad/s} \]

\[ \theta = 90^\circ \]

\[ v = 30 \pm 19.3 \text{ rad/s} \]

17.74. The disk has a mass \( M \) and a radius \( R \). If a block of mass \( m \) is attached to the cord, determine the angular acceleration of the disk when the block is released from rest. Also, what is the velocity of the block after it falls a distance \( 2R \) starting from rest?

\[ \alpha = \frac{\Delta \theta}{\Delta t} \]

\[ v^2 = 2a\Delta t \]

\[ v = \frac{2mgR}{(R+2m)} \quad \text{Ans} \]

17.75. The two blocks \( A \) and \( B \) have a mass \( m_a \) and \( m_p \). Immersively where \( m_p = m_a \). If the pulley can be treated as a disk of mass \( M \), determine the acceleration of block \( A \).

\[ g = \frac{\Delta x}{\Delta t} \]

\[ \alpha = \frac{\Delta v}{\Delta t} \]

\[ \alpha = \frac{\Delta x}{\Delta t} = \frac{2gR}{M} \]

\[ \text{Ans} \]
27-09. The semicircular disk having a mass of 10 kg is rotating at \( \omega = 4 \text{ rad/s} \) at the instant \( \theta = 60^\circ \). If the coefficient of static friction at \( A \) is \( \mu_s = 0.5 \), determine if the disk slips at this instant.

**Equation of Motion:** The mass moment of inertia of the semicircular disk about its center of mass is given by \( I = \frac{1}{2} \left( 10 \cdot (0.1)^2 \right) = 0.5 \times 10^{-8} \text{ kg m}^2 \).

From the geometry, \( \lambda = \sqrt{(0.1)^2 + 0.4^2} = 0.4124 \text{ m} \) and \( \theta = 60^\circ \text{ rad} \) for \( \lambda = 0.3477 \text{ m} \).

Also, using law of sines on \( \Delta \), \( \omega = 60^\circ \), \( \delta = 25.0^\circ \cdot \text{Applying Eq. 17-18, we have}

\[
\begin{align*}
2M_\omega & = \sum \mathbf{f} \\
& = 10(0.81)(0.1699\cos 60^\circ) = 0.5118 \text{ N m} \\
& = 10(a_1) \cdot \sin 25^\circ \cdot (0.3477) \quad \text{[1]} \\
\sum \mathbf{F} & = m\mathbf{a} \\
\mathbf{F}_1 & = 10(a_1) \quad \text{[2]} \\
\mathbf{N} & - 10(0.81) = 10(a_1) \quad \text{[3]}
\end{align*}
\]

**Kinematics:** Assume the semicircular disk does not slip at \( A \), then \( a_1 = 0 \). Hence, \( a_2 = - \frac{0.3477\cos 25.0^\circ \cdot 0.3477\cos 25.0^\circ}{4.89} \). \( \mathbf{F}_1 = - \mathbf{F}_2 = (-0.1478 \cdot 0.3151 \cdot -0.6 \cdot (-0.1478 \cdot 0.3151) \cdot (-0.3523 \cdot -0.3151) \cdot (-0.3523 \cdot -0.3151) \cdot (-0.3523 \cdot -0.3151))

Equating \( \mathbf{F}_1 \) and \( \mathbf{F}_2 \) components, we have

\[
\begin{align*}
(a_1) & = 0.3151 \omega - 0.3523 & \text{[4]} \\
(a_1) & = 0.1478 \omega - 0.3523 & \text{[5]}
\end{align*}
\]

Substituting \([1], [2], [3], [4] \) and \([5] \) yields

\[
\begin{align*}
\alpha & = 0.3151 \left( \frac{0.1478}{0.3523} \right) \omega^2 = 2.012 \omega^2 \\
\beta & = 0.6799 \omega^3 \\
N & = 91.32 \text{ N}
\end{align*}
\]

Since \( \beta < (\beta)_{max} = \mu_s N = 0.5 \times 91.32 = 45.66 \text{ N} \), then the semicircular disk does not slip.

\( \text{Ans} \)
17-97. The spool has a mass of 100 kg and a radius of gyration \( k_o = 0.3 \text{ m} \). If the coefficients of static and kinetic friction at \( A \) are \( \mu_s = 0.2 \) and \( \mu_k = 0.15 \), respectively, determine the angular acceleration of the spool if \( P = 600 \text{ N} \).

\[
I_s F_t = m a (i_A): \quad 600 \times 0.1 = 100 a
\]

\[
I_s F_t = m a (i_A): \quad N_A - 100(0.41) = 0
\]

\[
I_s F_t = m a (i_A): \quad 0.000(0.25) - F_k(0.41) = \frac{[0.000(1.5)]^2}{2}
\]

Assume no slipping:

\( a_o = 0.4 \text{ m/s}^2 \)

\( a = (1.6 \text{ rad})^2 / \text{Ams} \)

\( a_t = 6.24 \text{ m/s}^2 \quad N_A = 981 \text{ N} \quad F_k = 24.0 \text{ N} \)

Since \( V_{cm}^2 = 0 \times 0.41 = 0.196 \text{ N} > 24.0 \text{ N} \quad \text{OK} \)

17-98. The upper body of the crash dummy has a mass of 75 lb; a center of gravity at \( G \), and a radius of gyration about \( G \) of \( k_o = 0.7 \text{ ft} \). By means of the seat belt this body segment is assumed to be pin-connected to the seat of the car at \( A \). If a crash causes the car to decelerate at 30 ft/s^2, determine the angular velocity of the body when it has rotated to \( \theta = 30^\circ \).

\[
(I_sM_d = 2(I_sM_A): \quad \frac{75(1.75)}{12} = \left[ \frac{\pi}{120} \right]^2 a + \left[ \frac{\pi}{120} \right] (a_1)(Gh)
\]

\( a_2 = -30 \text{ rad/s}^2 \quad a_1 = (a_2)(Gh) \)

\[
142.176 \text{ rad/s} = 1.1041 \times 332.37 \times \cos 8° = 4.4064 a
\]

\[
142.176 = 332.37 \times \cos 8°
\]

\( a = 0.00 \theta \)

\[
\int a \, dt = \int \left( \frac{14.932 \text{ rad/s}^2}{23.77 \text{ rad/s}^2} \right) \theta
\]

\[
\theta = -14.932 \text{ rad/s} - \text{cos}^2 \theta + 23.77 \text{ rad/s} \times \text{cos}^2 \theta
\]

\( a = 5.11 \text{ rad/s}^2 \quad \text{Ans} \)
The 16-lb bowling ball is cast horizontally onto a lane such that initially $v = 0$ and its mass center has a velocity $v = 8$ ft/s. If the coefficient of kinetic friction between the lane and the ball is $\mu_k = 0.12$, determine the distance the ball travels before it rolls without slipping.

For the calculation, neglect the finger holes in the ball and assume the ball has a uniform density.

Solving:

$N_a = 16.8$: $a = \frac{3.80}{3.5} = 1.1$ ft/s²

When the ball rolls without slipping: $v = \omega 0.353$.

$$\begin{align*}
\omega & = \omega_0 + \alpha t \\
\omega & = 9.46 \times 10^{-2} \text{ rad/s} \\
v & = 9.80 \text{ ft/s}
\end{align*}$$