Chapter 10 Solutions

P10.1 (a) $\theta\big|_{t=0} = \boxed{5.00\text{ rad}}$

$$\omega\big|_{t=0} = \left.\frac{d\theta}{dt}\right|_{t=0} = 10.0 + 4.00t\big|_{t=0} = \boxed{10.0\text{ rad/s}}$$

$$\alpha_{t=0} = \left.\frac{d\omega}{dt}\right|_{t=0} = \boxed{4.00\text{ rad/s}^2}$$

(b) $\theta\big|_{t=3.00\text{ s}} = 5.00 + 30.0 + 18.0 = \boxed{53.0\text{ rad}}$

$$\omega\big|_{t=3.00\text{ s}} = \left.\frac{d\theta}{dt}\right|_{t=3.00\text{ s}} = 10.0 + 4.00t\big|_{t=3.00\text{ s}} = \boxed{22.0\text{ rad/s}}$$

$$\alpha\big|_{t=3.00\text{ s}} = \left.\frac{d\omega}{dt}\right|_{t=3.00\text{ s}} = \boxed{4.00\text{ rad/s}^2}$$

*P10.2 $\alpha = \dfrac{d\omega}{dt} = 10 + 6t$ $\qquad \displaystyle\int_0^{\omega} d\omega = \int_0^t (10 + 6t)dt$ $\qquad \omega - 0 = 10t + 6t^2/\ 2$

$\omega = \dfrac{d\theta}{dt} = 10t + 3t^2$ $\qquad \displaystyle\int_0^{\theta} d\theta = \int_0^t (10t + 3t^2)dt$ $\qquad \theta - 0 = 10t^2/\ 2 + 3t^3/\ 3$

$\theta = 5t^2 + t^3$. At $t = 4$ s, $\theta = 5(4)^2 + (4)^3 = \boxed{144\text{ rad}}$

P10.3 (a) $\alpha = \dfrac{\omega - \omega_i}{t} = \dfrac{12.0\text{ rad/s}}{3.00\text{ s}} = \boxed{4.00\text{ rad/s}^2}$

(b) $\theta = \omega_i t + \dfrac{1}{2}\alpha t^2 = \dfrac{1}{2}\left(4.00\text{ rad/s}^2\right)(3.00\text{ s})^2 = \boxed{18.0\text{ rad}}$

P10.5 $\omega_i = \dfrac{100\text{ rev}}{1.00\text{ min}}\left(\dfrac{1\text{ min}}{60.0\text{ s}}\right)\left(\dfrac{2\pi\text{ rad}}{1.00\text{ rev}}\right) = \dfrac{10\pi}{3}\text{ rad/s},\ \omega_f = 0$

(a) $t = \dfrac{\omega_f - \omega_i}{\alpha} = \dfrac{0 - (10\pi/3)}{-2.00}s = \boxed{5.24\text{ s}}$

(b) $\theta_f = \bar{\omega}t = \left(\dfrac{\omega_f + \omega_i}{2}\right)t = \left(\dfrac{10\pi}{6}\text{ rad/s}\right)\left(\dfrac{10\pi}{6}\text{ s}\right) = \boxed{27.4\text{ rad}}$

P10.9 $\omega = 5.00\text{ rev/s} = 10.0\pi\text{ rad/s}$. We will break the motion into two stages: (1) a period during which the tub speeds up and (2) a period during which it slows down.

While speeding up, $\qquad \theta_1 = \bar{\omega}t = \dfrac{0 + 10.0\pi\text{ rad/s}}{2}(8.00\text{ s}) = 40.0\pi\text{ rad}$

While slowing down, $\qquad \theta_2 = \bar{\omega}t = \dfrac{10.0\pi\text{ rad/s} + 0}{2}(12.0\text{ s}) = 60.0\pi\text{ rad}$

So, $\qquad \theta_{\text{total}} = \theta_1 + \theta_2 = 100\pi\text{ rad} = \boxed{50.0\text{ rev}}$

P10.13 Given $r = 1.00\text{ m}$, $\alpha = 4.00\text{ rad/s}^2$, $\omega_i = 0$ and $\theta_i = 57.3° = 1.00\text{ rad}$

(a) $\omega_f = \omega_i + \alpha t = 0 + \alpha t$

At $t = 2.00\text{ s}$, $\omega_f = 4.00\text{ rad/s}^2(2.00\text{ s}) = \boxed{8.00\text{ rad/s}}$

(b) $v = r\omega = 1.00\text{ m}(8.00\text{ rad/s}) = \boxed{8.00\text{ m/s}}$

$|a_r| = a_c = r\omega^2 = 1.00\text{ m}(8.00\text{ rad/s})^2 = 64.0\text{ m/s}^2$

$a_t = r\alpha = 1.00\text{ m}(4.00\text{ rad/s}^2) = 4.00\text{ m/s}^2$

The magnitude of the total acceleration is:

$$a = \sqrt{a_r^2 + a_t^2} = \sqrt{(64.0\text{ m/s}^2)^2 + (4.00\text{ m/s}^2)^2} = \boxed{64.1\text{ m/s}^2}$$

The direction of the total acceleration vector makes an angle ϕ with respect to the radius to point P:

$$\phi = \tan^{-1}\left(\frac{a_t}{a_c}\right) = \tan^{-1}\left(\frac{4.00}{64.0}\right) = \boxed{3.58°}$$

(c) $\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2 = (1.00\text{ rad}) + \frac{1}{2}(4.00\text{ rad/s}^2)(2.00\text{ s})^2 = \boxed{9.00\text{ rad}}$

P10.17 (a) $\omega = 2\pi f = \frac{2\pi\text{ rad}}{1\text{ rev}}\left(\frac{1\,200\text{ rev}}{60.0\text{ s}}\right) = \boxed{126\text{ rad/s}}$

(b) $v = \omega r = (126\text{ rad/s})(3.00 \times 10^{-2}\text{ m}) = \boxed{3.77\text{ m/s}}$

(c) $a_c = \omega^2 r = (126)^2(8.00 \times 10^{-2}) = 1\,260\text{ m/s}^2$ so $\mathbf{a}_r = \boxed{1.26\text{ km/s}^2\text{ toward the center}}$

(d) $s = r\theta = \omega r t = (126\text{ rad/s})(8.00 \times 10^{-2}\text{ m})(2.00\text{ s}) = \boxed{20.1\text{ m}}$

P10.32 Resolve the 100 N force into components perpendicular to and parallel to the rod, as

$$F_{par} = (100\text{ N})\cos 57.0° = 54.5\text{ N}$$

and

$$F_{perp} = (100\text{ N})\sin 57.0° = 83.9\text{ N}$$

The torque of F_{par} is zero since its line of action passes through the pivot point.

The torque of F_{perp} is $\tau = 83.9\text{ N}(2.00\text{ m}) = \boxed{168\text{ N}\cdot\text{m}}$ (clockwise)

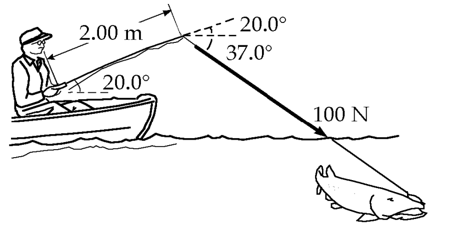

FIG. P10.32

P10.33 $\sum \tau = 0.100\text{ m}(12.0\text{ N}) - 0.250\text{ m}(9.00\text{ N}) - 0.250\text{ m}(10.0\text{ N}) = \boxed{-3.55\text{ N}\cdot\text{m}}$

The thirty-degree angle is unnecessary information.

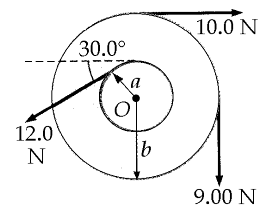

FIG. P10.33

P10.35 $m = 0.750\text{ kg}$, $F = 0.800\text{ N}$

(a) $\tau = rF = 30.0\text{ m}(0.800\text{ N}) = \boxed{24.0\text{ N}\cdot\text{m}}$

(b) $\alpha = \frac{\tau}{I} = \frac{rF}{mr^2} = \frac{24.0}{0.750(30.0)^2} = \boxed{0.035\,6\text{ rad/s}^2}$

(c) $a_t = \alpha r = 0.035\,6(30.0) = \boxed{1.07\text{ m/s}^2}$

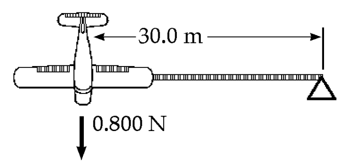

FIG. P10.35

P10.37 For m_1,

$$\sum F_y = ma_y: \quad +n - m_1 g = 0$$

$$n_1 = m_1 g = 19.6\text{ N}$$

$$f_{k1} = \text{m}_k n_1 = 7.06\text{ N}$$

$$\sum F_x = ma_x: \quad -7.06\text{ N} + T_1 = (2.00\text{ kg})a \qquad (1)$$

For the pulley,

$$\sum \text{t} = I\text{a}: \quad -T_1 R + T_2 R = \frac{1}{2}MR^2\left(\frac{a}{R}\right)$$

$$-T_1 + T_2 = \frac{1}{2}(10.0\text{ kg})a$$

$$-T_1 + T_2 = (5.00\text{ kg})a \qquad (2)$$

For m_2, $+n_2 - m_2 g\cos\text{q} = 0$

$$n_2 = 6.00\text{ kg}\left(9.80\text{ m/s}^2\right)\left(\cos 30.0°\right)$$

$$= 50.9\text{ N}$$

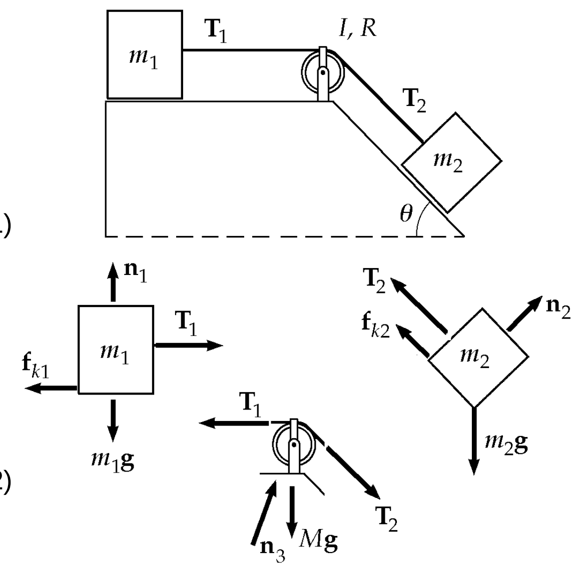

FIG. P10.37

$$f_{k2} = \text{m}_k n_2$$

$$= 18.3\text{ N}: \; -18.3\text{ N} - T_2 + m_2\sin\text{q} = m_2 a$$

$$-18.3\text{ N} - T_2 + 29.4\text{ N} = (6.00\text{ kg})a \qquad (3)$$

(a) Add equations (1), (2), and (3):

$$-7.06\text{ N} - 18.3\text{ N} + 29.4\text{ N} = (13.0\text{ kg})a$$

$$a = \frac{4.01\text{ N}}{13.0\text{ kg}} = \boxed{0.309\text{ m/s}^2}$$

(b) $T_1 = 2.00\text{ kg}\left(0.309\text{ m/s}^2\right) + 7.06\text{ N} = \boxed{7.67\text{ N}}$

$T_2 = 7.67\text{ N} + 5.00\text{ kg}\left(0.309\text{ m/s}^2\right) = \boxed{9.22\text{ N}}$

P10.39 $\sum \text{t} = I\text{a} = \frac{1}{2}MR^2\text{a}$

$$-135\text{ N}(0.230\text{ m}) + T(0.230\text{ m}) = \frac{1}{2}(80\text{ kg})\left(\frac{1.25}{2}\text{ m}\right)^2\left(-1.67\text{ rad/s}^2\right)$$

$T = \boxed{21.5\text{ N}}$

*P10.40 The chosen tangential force produces constant torque and so constant angular acceleration.

q = 0 + 0 + (1/2)at^2 2(2p rad) = (1/2) a$(10\text{ s})^2$ a = 0.251 rad/s^2

$\sum$t = I a TR = 100 kg·m^2(0.251 /s^2) = 25.1 N·m

$\boxed{\text{Infinitely many pairs of values that satisfy this requirement exist, such as T = 25.1 N and R = 1.00 m}}$