2. (a) The second hand of the smoothly running watch turns through 2π radians during 60 s. Thus,

$$\omega = \frac{2\pi}{60} = 0.105 \text{ rad/s} .$$

(b) The minute hand of the smoothly running watch turns through 2π radians during 3600 s. Thus,

$$\omega = \frac{2\pi}{3600} = 1.75 \times 10^{-3} \text{ rad/s} .$$

(c) The hour hand of the smoothly running 12-hour watch turns through 2π radians during 43200 s. Thus,

$$\omega = \frac{2\pi}{43200} = 1.45 \times 10^{-4} \text{ rad/s} .$$

17. The wheel has angular velocity $\omega_0 = +1.5$ rad/s $= +0.239$ rev/s^2 at $t = 0$, and has constant value of angular acceleration $\alpha < 0$, which indicates our choice for positive sense of rotation. At t_1 its angular displacement (relative to its orientation at $t = 0$) is $\theta_1 = +20$ rev, and at t_2 its angular displacement is $\theta_2 = +40$ rev and its angular velocity is $\omega_2 = 0$.

   (a) We obtain t_2 using Eq. 11-15:

$$\theta_2 = \frac{1}{2}(\omega_0 + \omega_2)\,t_2 \quad \Longrightarrow \quad t_2 = \frac{2(40)}{0.239}$$

   which yields $t_2 = 335$ s which we round off to $t_2 \approx 340$ s.

   (b) Any equation in Table 11-1 involving α can be used to find the angular acceleration; we select Eq. 11-16.

$$\theta_2 = \omega_2 t_2 - \frac{1}{2}\alpha t_2^2 \quad \Longrightarrow \quad \alpha = -\frac{2(40)}{335^2}$$

   which yields $\alpha = -7.12 \times 10^{-4}$ rev/s^2 which we convert to $\alpha = -4.5 \times 10^{-3}$ rad/s^2.

   (c) Using $\theta_1 = \omega_0 t_1 + \frac{1}{2}\alpha t_1^2$ (Eq. 11-13) and the quadratic formula, we have

$$t_1 = \frac{-\omega_0 \pm \sqrt{\omega_0^2 + 2\theta_1\alpha}}{\alpha} = \frac{-0.239 \pm \sqrt{0.239^2 + 2(20)\,(-7.12 \times 10^{-4})}}{-7.12 \times 10^{-4}}$$

   which yields two positive roots: 98 s and 572 s. Since the question makes sense only if $t_1 < t_2$ we conclude the correct result is $t_1 = 98$ s.

21. With $v = 50(1000/3600) = 13.9$ m/s, Eq. 11-18 leads to

$$\omega = \frac{v}{r} = \frac{13.9}{110} = 0.13 \text{ rad/s} .$$

33. The kinetic energy (in J) is given by $K = \frac{1}{2}I\omega^2$, where I is the rotational inertia (in kg·m^2) and ω is the angular velocity (in rad/s). We have

$$\omega = \frac{(602\,\text{rev/min})(2\pi\,\text{rad/rev})}{60\,\text{s/min}} = 63.0\,\text{rad/s} .$$

Consequently, the rotational inertia is

$$I = \frac{2K}{\omega^2} = \frac{2(24400\,\text{J})}{(63.0\,\text{rad/s})^2} = 12.3\ \text{kg}\cdot\text{m}^2 .$$

54. With rightward positive for the block and clockwise negative for the wheel (as is conventional), then we note that the tangential acceleration of the wheel is of opposite sign from the block's acceleration (which we simply denote as a); that is, $a_t = -a$. Applying Newton's second law to the block leads to

$$P - T = ma \qquad \text{where } m = 2.0 \text{ kg} .$$

Applying Newton's second law (for rotation) to the wheel leads to

$$-TR = I\alpha \qquad \text{where } I = 0.050 \text{ kg} \cdot \text{m}^2 .$$

Noting that $R\alpha = a_t = -a$, we multiply this equation by R and obtain

$$-TR^2 = -Ia \implies T = a\,\frac{I}{R^2} .$$

Adding this to the above equation (for the block) leads to

$$P = \left(m + \frac{I}{R^2}\right) a .$$

Thus, $a = 0.92$ m/s^2 and therefore $\alpha = -4.6$ rad/s^2, where the negative sign should not be mistaken for a deceleration (it simply indicates the clockwise sense to the motion).

55. (a) We use constant acceleration kinematics. If down is taken to be positive and a is the acceleration of the heavier block, then its coordinate is given by $y = \frac{1}{2}at^2$, so

$$a = \frac{2y}{t^2} = \frac{2(0.750\,\text{m})}{(5.00\,\text{s})^2} = 6.00 \times 10^{-2}\ \text{m/s}^2\ .$$

The lighter block has an acceleration of $6.00 \times 10^{-2}\,\text{m/s}^2$ upward.

(b) Newton's second law for the heavier block is $m_h g - T_h = m_h a$, where m_h is its mass and T_h is the tension force on the block. Thus,

$$T_h = m_h(g - a) = (0.500\,\text{kg})\left(9.8\,\text{m/s}^2 - 6.00 \times 10^{-2}\,\text{m/s}^2\right) = 4.87\ \text{N}\ .$$

(c) Newton's second law for the lighter block is $m_l g - T_l = -m_l a$, where T_l is the tension force on the block. Thus,

$$T_l = m_l(g + a) = (0.460\,\text{kg})\left(9.8\,\text{m/s}^2 + 6.00 \times 10^{-2}\,\text{m/s}^2\right) = 4.54\,\text{N}\ .$$

(d) Since the cord does not slip on the pulley, the tangential acceleration of a point on the rim of the pulley must be the same as the acceleration of the blocks, so

$$\alpha = \frac{a}{R} = \frac{6.00 \times 10^{-2}\,\text{m/s}^2}{5.00 \times 10^{-2}\,\text{m}} = 1.20\ \text{rad/s}^2\ .$$

(e) The net torque acting on the pulley is $\tau = (T_h - T_l)R$. Equating this to $I\alpha$ we solve for the rotational inertia:

$$\begin{aligned} I &= \frac{(T_h - T_l)R}{\alpha} \\ &= \frac{(4.87\,\text{N} - 4.54\,\text{N})(5.00 \times 10^{-2}\,\text{m})}{1.20\,\text{rad/s}^2} \\ &= 1.38 \times 10^{-2}\ \text{kg}\cdot\text{m}^2\ . \end{aligned}$$

60. The initial angular speed is $\omega = (280)(2\pi/60) = 29.3$ rad/s. We use Eq. 11-44 for the work and Eq. 7-42 for the average power.

(a) Since the rotational inertia is (Table 11-2(a)) $I = (32)(1.2)^2 = 46.1$ kg·m^2, the work done is

$$W = \Delta K = 0 - \frac{1}{2}I\omega^2 = -\frac{1}{2}(46.1)(29.3)^2$$

which yields $|W| = 19.8 \times 10^3$ J.

(b) The average power (in absolute value) is therefore

$$|P| = \frac{|W|}{\Delta t} = \frac{19.8 \times 10^3}{15} = 1.32 \times 10^3 \text{ W} .$$