Halliday ♦ Resnick ♦Walker

FUNDAMENTALS OF PHYSICS
SIXTH EDITION

Selected Solutions

Chapter 11

11.13
11.29
11.55
11.65

13. We take $t = 0$ at the start of the interval and take the sense of rotation as positive. Then at the end of the $t = 4.0\,\mathrm{s}$ interval, the angular displacement is $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$. We solve for the angular velocity at the start of the interval:

$$\omega_0 = \frac{\theta - \frac{1}{2}\alpha t^2}{t} = \frac{120\,\mathrm{rad} - \frac{1}{2}\left(3.0\,\mathrm{rad/s^2}\right)(4.0\,\mathrm{s})^2}{4.0\,\mathrm{s}} = 24\ \mathrm{rad/s}\ .$$

We now use $\omega = \omega_0 + \alpha t$ (Eq. 11-12) to find the time when the wheel is at rest:

$$t = -\frac{\omega_0}{\alpha} = -\frac{24\,\mathrm{rad/s}}{3.0\,\mathrm{rad/s^2}} = -8.0\ \mathrm{s}\ .$$

That is, the wheel started from rest 8.0 s before the start of the described 4.0 s interval.

29. Since the belt does not slip, a point on the rim of wheel C has the same tangential acceleration as a point on the rim of wheel A. This means that $\alpha_A r_A = \alpha_C r_C$, where α_A is the angular acceleration of wheel A and α_C is the angular acceleration of wheel C. Thus,

$$\alpha_C = \left(\frac{r_A}{r_C}\right) \alpha_A = \left(\frac{10\,\text{cm}}{25\,\text{cm}}\right) (1.6\,\text{rad/s}^2) = 0.64 \text{ rad/s}^2 \ .$$

Since the angular speed of wheel C is given by $\omega_C = \alpha_C t$, the time for it to reach an angular speed of $\omega = 100\,\text{rev/min} = 10.5\,\text{rad/s}$ starting from rest is

$$t = \frac{\omega_C}{\alpha_C} = \frac{10.5\,\text{rad/s}}{0.64\,\text{rad/s}^2} = 16 \text{ s} \ .$$

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:

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

65. We use conservation of mechanical energy. The center of mass is at the midpoint of the cross bar of the **H** and it drops by $L/2$, where L is the length of any one of the rods. The gravitational potential energy decreases by $MgL/2$, where M is the mass of the body. The initial kinetic energy is zero and the final kinetic energy may be written $\frac{1}{2}I\omega^2$, where I is the rotational inertia of the body and ω is its angular velocity when it is vertical. Thus

$$0 = -MgL/2 + \frac{1}{2}I\omega^2 \implies \omega = \sqrt{MgL/I} \ .$$

Since the rods are thin the one along the axis of rotation does not contribute to the rotational inertia. All points on the other leg are the same distance from the axis of rotation, so that leg contributes $(M/3)L^2$, where $M/3$ is its mass. The cross bar is a rod that rotates around one end, so its contribution is $(M/3)L^2/3 = ML^2/9$. The total rotational inertia is $I = (ML^2/3) + (ML^2/9) = 4ML^2/9$. Consequently, the angular velocity is

$$\omega = \sqrt{\frac{MgL}{I}} = \sqrt{\frac{MgL}{4ML^2/9}} = \sqrt{\frac{9g}{4L}} \ .$$