Chapter Nine: Linear Momentum and Collisions

SOLUTIONS TO PROBLEMS

P9.4 (a) For the system of two blocks $\Delta p = 0$,

or $p_i = p_f$

Therefore, $0 = Mv_m + (3M)(2.00\ \text{m/s})$

Solving gives $v_m = \boxed{-6.00\ \text{m/s}}$ (motion toward the left).

(b) $\frac{1}{2}kx^2 = \frac{1}{2}Mv_M^2 + \frac{1}{2}(3M)v_{3M}^2 = \boxed{8.40\ \text{J}}$

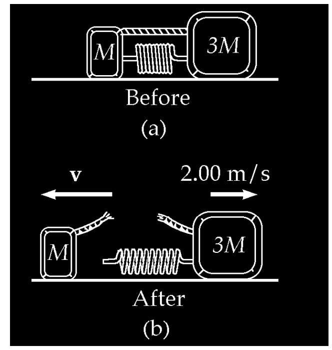

FIG. P9.4

P9.10 Assume the initial direction of the ball in the $-x$ direction.

(a) Impulse, $\mathbf{I} = \Delta\mathbf{p} = \mathbf{p}_f - \mathbf{p}_i = (0.060\,0)(40.0)\hat{\mathbf{i}} - (0.060\,0)(50.0)(-\hat{\mathbf{i}}) = \boxed{5.40\hat{\mathbf{i}}\ \text{N}\cdot\text{s}}$

(b) Work $= K_f - K_i = \frac{1}{2}(0.060\,0)\left[(40.0)^2 - (50.0)^2\right] = \boxed{-27.0\ \text{J}}$

P9.18 (a) $mv_{1i} + 3mv_{2i} = 4mv_f$ where $m = 2.50 \times 10^4$ kg

$$v_f = \frac{4.00 + 3(2.00)}{4} = \boxed{2.50\ \text{m/s}}$$

(b) $K_f - K_i = \frac{1}{2}(4m)v_f^2 - \left[\frac{1}{2}mv_{1i}^2 + \frac{1}{2}(3m)v_{2i}^2\right] = (2.50 \times 10^4)(12.5 - 8.00 - 6.00) = \boxed{-3.75 \times 10^4\ \text{J}}$

P9.20 v_1, speed of m_1 at B before collision.

$\frac{1}{2}m_1v_1^2 = m_1gh$

$v_1 = \sqrt{2(9.80)(5.00)} = 9.90\ \text{m/s}$

v_{1f}, speed of m_1 at B just after collision.

$v_{1f} = \frac{m_1 - m_2}{m_1 + m_2}v_1 = -\frac{1}{3}(9.90)\ \text{m/s} = -3.30\ \text{m/s}$

At the highest point (after collision)

$m_1gh_{\max} = \frac{1}{2}m_1(-3.30)^2$ $\qquad h_{\max} = \frac{(-3.30\ \text{m/s})^2}{2(9.80\ \text{m/s}^2)} = \boxed{0.556\ \text{m}}$

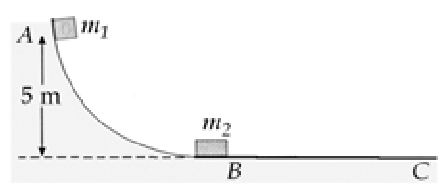

FIG. P9.20

P9.60 (a) The initial momentum of the system is zero, which remains constant throughout the motion. Therefore, when m_1 leaves the wedge, we must have

$$m_2 v_{\text{wedge}} + m_1 v_{\text{block}} = 0$$

or $(3.00\text{ kg})v_{\text{wedge}} + (0.500\text{ kg})(+4.00\text{ m/s}) = 0$

so $v_{\text{wedge}} = \boxed{-0.667\text{ m/s}}$

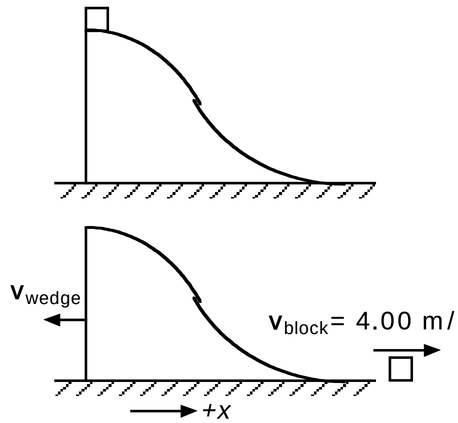

FIG. P9.60

(b) Using conservation of energy for the block-wedge-Earth system as the block slides down the smooth (frictionless) wedge, we have

$$\left[K_{\text{block}} + U_{\text{system}}\right]_i + \left[K_{\text{wedge}}\right]_i = \left[K_{\text{block}} + U_{\text{system}}\right]_f + \left[K_{\text{wedge}}\right]_f$$

or $\left[0 + m_1 g h\right] + 0 = \left[\frac{1}{2}m_1(4.00)^2 + 0\right] + \frac{1}{2}m_2(-0.667)^2$ which gives $\boxed{h = 0.952\text{ m}}$.

Chapter Ten: Rotation of a Rigid Object
About a Fixed Axis

SOLUTIONS TO PROBLEMS

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

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

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

P10.15 (a) $\omega = \frac{v}{r} = \frac{25.0\text{ m/s}}{1.00\text{ m}} = \boxed{25.0\text{ rad/s}}$

(b) $\omega_f^2 = \omega_i^2 + 2\alpha(\Delta\theta)$

$$\alpha = \frac{\omega_f^2 - \omega_i^2}{2(\Delta\theta)} = \frac{(25.0\text{ rad/s})^2 - 0}{2\left[(1.25\text{ rev})(2\pi\text{ rad/rev})\right]} = \boxed{39.8\text{ rad/s}^2}$$

(c) $\Delta t = \frac{\Delta\omega}{\alpha} = \frac{25.0\text{ rad/s}}{39.8\text{ rad/s}^2} = \boxed{0.628\text{ s}}$

P10.20 $m_1 = 4.00\text{ kg}$, $r_1 = |y_1| = 3.00\text{ m}$;

$m_2 = 2.00\text{ kg}$, $r_2 = |y_2| = 2.00\text{ m}$;

$m_3 = 3.00\text{ kg}$, $r_3 = |y_3| = 4.00\text{ m}$;

$\omega = 2.00\text{ rad/s}$ about the x-axis

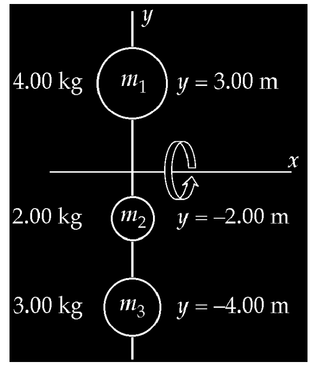

FIG. P10.20

(a) $$I_x = m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2$$

$$I_x = 4.00(3.00)^2 + 2.00(2.00)^2 + 3.00(4.00)^2 = \boxed{92.0\text{ kg}\cdot\text{m}^2}$$

$$K_R = \frac{1}{2} I_x \omega^2 = \frac{1}{2}(92.0)(2.00)^2 = \boxed{184\text{ J}}$$

(b) $$v_1 = r_1\omega = 3.00(2.00) = \boxed{6.00\text{ m/s}} \qquad K_1 = \frac{1}{2} m_1 v_1^2 = \frac{1}{2}(4.00)(6.00)^2 = 72.0\text{ J}$$

$$v_2 = r_2\omega = 2.00(2.00) = \boxed{4.00\text{ m/s}} \qquad K_2 = \frac{1}{2} m_2 v_2^2 = \frac{1}{2}(2.00)(4.00)^2 = 16.0\text{ J}$$

$$v_3 = r_3\omega = 4.00(2.00) = \boxed{8.00\text{ m/s}} \qquad K_3 = \frac{1}{2} m_3 v_3^2 = \frac{1}{2}(3.00)(8.00)^2 = 96.0\text{ J}$$

$$K = K_1 + K_2 + K_3 = 72.0 + 16.0 + 96.0 = \boxed{184\text{ J}} = \frac{1}{2} I_x \omega^2$$

P10.32 The normal force exerted by the ground on each wheel is

$$n = \frac{mg}{4} = \frac{(1\,500\text{ kg})(9.80\text{ m/s}^2)}{4} = 3\,680\text{ N}$$

The torque of friction can be as large as

$$\tau_{\max} = f_{\max} r = (\mu_s n) r = (0.800)(3\,680\text{ N})(0.300\text{ m}) = \boxed{882\text{ N}\cdot\text{m}}$$

The torque of the axle on the wheel can be equally as large as the light wheel starts to turn without slipping.

P10.33 In the previous problem we calculated the maximum torque that can be applied without skidding to be 882 N · m. This same torque is to be applied by the frictional force, f, between the brake pad and the rotor for this wheel. Since the wheel is slipping against the brake pad, we use the coefficient of kinetic friction to calculate the normal force.

$$\tau = fr = (\mu_k n) r, \text{ so } n = \frac{\tau}{\mu_k r} = \frac{882\text{ N}\cdot\text{m}}{(0.500)(0.220\text{ m})} = 8.02\times 10^3\text{ N} = \boxed{8.02\text{ kN}}$$