# *Chapter 08* *(Bueche & Jerde)* ***Rotational Work, Energy, and Momentum***

Note that 1 rev = $2\pi$ rad = 360°

**P05** $I = 0.0015$ kg·m$^2$ & $\omega_0 = 45$ rev/min = 4.71 rad/s. (**a**) $W = (½)I\omega_0^2 = 1.67\times10^{-2}$ J; (**b**) $\alpha = \omega_0/t = 0.1885$ rad/s$^2$, $\tau = I\alpha = 2.83\times10^{-4}$ N·m .

**P13** $(½)I\omega^2 = Pt$, $t = I\omega^2/2P = (0.800)[24.0(2)/60]^2/2(0.200) = 12.6$ (s) .

**P15** $\tau\,\theta = Fr\theta = (½)I\omega^2$. $\theta = I\omega^2/(2Fr) = 142$ rad = 22.6 rev .

**P21** $I = I_M + 2I_m = Ma^2 + 2m(a + b)^2$ .

**P23** $I_o = I_{cm} + MR^2$. (**a**) For the loop, $I_o = MR^2 + MR^2 = 2MR^2$; (**b**) For the disc, $I_o = (½)MR^2 + MR^2 = (3/2)MR^2$ .

**P24** $I_o = I_{cm} + M(L+R)^2 = 2MR^2/5 + M(L+R)^2 = M(7R^2/5 + L^2 + 2RL)$ .

**P31** $\tau\,\theta = \tau\,\underline{\omega}\,t = (½)I\omega_0^2$ and $\underline{\omega} = \omega_0/2$ $\Rightarrow$ $\tau = I\omega_0/t = 0.0302$ N·m .

**P35** $a = 2y/t^2 = 2(3.00)/(5.00^2) = 0.24$ (m/s$^2$). $F_{net} = 0.06\,g - T = 0.06\,a$ & $\tau = TR$ or $T(0.08) = Ia = Ia/r = I\,\alpha/(0.08)$ $\Rightarrow$ $I = 3.84\times10^{-4}[(g/a) - 1]$ or $I = 0.0153$ kg·m$^2$ & $T = 0.577$ N .

**P39** $(m_r - m_\ell)gh = (½)(m_r + m_\ell)(\omega r)^2 + (½)I\omega^2$. (**a**) Using $r = 0.080$ cm, $m_r = 0.520$ kg, $m_\ell = 0.500$ kg, and $I = 0.008$ kg·m$^2$, we get $\omega = 8.05$ rad/s; (**b**) $\underline{v} = \omega\,r/2 = 0.322$ m/s; so $t = y/\underline{v} = 7.46$ s .

**P40** (**a**) $m_dgh = (½)(m_d + m_h)v_f^2 + (½)I(v_f/r)^2$. $v_f = 2.09$m/s; (**b**) $t = h/\underline{v} = 2h/v_f = 0.960$ s; (c) $K_p = (½)I(v/r)^2 = 2.73$ J .

**P41** $r = 6$ cm & $h = 50$ cm. (**a**) $mgh = (½)mv^2 + (½)(mr^2)(v/r)^2 = mv^2$, $v = (gh)^{1/2} = 2.21$ m/s; (**b**) $\omega = v/r = 36.9$ (rad/s) = 5.87 (rev/s).

**P42** (**a**) $r = 6$ cm, $k = 5$ cm & $I = mk^2$ $\Rightarrow$ $v = 2.41$ m/s & $\omega = 6.38$ rev/s; (**b**) $r = 6$ cm & $I = (½)mr^2$ $\Rightarrow$ $v = 2(gh/3)^{1/2} = 2.56$ m/s & $\omega = 6.78$ rev/s .

**P44** $W = \Delta K = (½)mv^2 + (½)I\omega^2 = ½(7mr^2/5)\omega^2 = 0.700\,mr^2\omega^2 = 8064$ J .

**P46** $v = 12$ m/s. Const of energy: $mgh = (½)mv^2 + (½)(½mr^2)(v/r)^2 = 3mv^2/4$ $\Rightarrow$ $h = 3v^2/(4g) = 11.0$ m.

**P48** $v_{cm} = [2gh/(1+I_{cm}/mr^2)]^{1/2}$. For the same moment $I_{cm}$, the sphere has the largest $mr^2$ or least $I_{cm}/mr^2$. So the sphere wins the race to the bottom of the incline .

**P51** (**a**) $I = 2mr^2 = 0.600$ kg·m$^2$; (**b**) $I_0\omega_0 = I\omega$, where $I = 2(1.20)(0.300)^2 = 0.216$ (kg·m$^2$); thus $\omega = 27.8$ rev/s .

**P55** $mvL = mv_0L_0 \Rightarrow v = (L_0/L)v_0$. (**a**) $v = 4v_0/3$; (**b**) $v = 2v_0$; (**c**) $v = 3v_0$ .

**P62** (**a**) $F_{net} = Mg$ . $T = Ma_{cm} = Mr\alpha$ , $\tau = T\,r = I\alpha = (½)Mr^2\alpha$. We have $\alpha = 2g/(3r) = 33$ rad/s$^2$; (**b**) $T = Mg/3 = (0.60)(9.8)/3 = 2.0$ (N); (**c**) $h = r\theta$, $\theta = h/r = 12.5$ rad. $\omega_f^2 = \omega_0^2 + 2\alpha\theta$, $\omega_f = (2\alpha\theta)^{1/2} = 29$ rad/s .

**P64** Before sticking: $I_{cm,i} = (½)MR^2$, $L_i = 2\,I_{cm,i}\omega_0$. After sticking: $I_{cm,f} = 2[(½)MR^2 + MR^2] = 3MR^2$ and $L = I_{cm,f}\omega_f$. Thus $\omega_f = \omega_0/3$ .