GIANCOLI HOMEWORK SOLUTIONS
Section 8-8, #51-64

51. GIVEN

$m = 0.210kg$

$r = 1.10m$

$\omega = 10.4\,rad/s$

KNOWN

$L = I\omega$

$I = mr^2$

SOLUTION

$L = I\omega = (mr^2)\omega = (0.210)(1.10)^2(10.4) = 2.64kg \cdot m^2/s$

52. GIVEN

$m = 2.8kg$

$r = 18cm = 0.18m$

$\omega = \frac{1500rev}{min}\,x\,\frac{1min}{60s}\,x\,\frac{2\pi rad}{rev} = 157\,rad/s$

uniform cylinder

KNOWN

$L = I\omega$

$I = \frac{1}{2}mr^2$

$\tau = \frac{\Delta L}{\Delta t}$

SOLUTION

a. $L = I\omega = \left(\frac{1}{2}mr^2\right)\omega = \frac{1}{2}(2.8)(0.18)^2(157) = 7.12kg \cdot m^2/s$

b. $\tau = \frac{\Delta L}{\Delta t} = \frac{0-7.12}{6.0} = 1.19m \cdot N$

53. GIVEN

$\omega_i = 1.3\,rev/s$

$\omega_f = 0.8\,rev/s$

SOLUTION

a. By raising his arms he has increased his moment of inertia because part of his mass is now at a larger radius. Since angular momentum ($L = I\omega$) is conserved, an increase in I must mean a decrease in ω.

b. $L_f = L_i$

$I_f \omega_f = I_i \omega_i$

$$I_f = I_i \frac{\omega_i}{\omega_f} = I_i \frac{1.3}{0.8} = 1.63 I_i$$

54. GIVEN

$3.5 I_t = I_s$

$$\omega_t = \frac{2.0rev}{1.5s} = 1.33\, rev/s$$

KNOWN

$L_t = L_s$

$I_t \omega_t = I_s \omega_s$

SOLUTION

$I_t \omega_t = I_s \omega_s$

$$\frac{I_t \omega_t}{I_s} = \omega_s$$

$3.5 I_t = I_s$

$$\omega_s = \frac{I_t \omega_t}{3.5 I_t} = \frac{\omega_t}{3.5} = \frac{1.33}{3.5} = 0.381\, rev/s$$

55. GIVEN

$$\omega_i = \frac{1.0rev}{2.0s} = 0.5\, rev/s$$

$\omega_f = 3.0\, rev/s$

$I_i = 4.6 kg \cdot m^2$

KNOWN

$L_f = L_i$

$I_f \omega_f = I_i \omega_i$

SOLUTION

$$I_f = \frac{I_i \omega_i}{\omega_f} = \frac{(4.6)(0.5)}{(3.0)} = 0.7676 kg \cdot m^2$$

She does this by pulling her arms in close to her body to reduce her moment of inertia.

56. GIVEN

$$\omega = \frac{1.5 rev}{sec} x \frac{2\pi rad}{rev} = 9.42\, rad/s$$

$m_w = 5.0kg$

$d_w = 0.40m, r_w = 0.20m$

wheel is a uniform disk

$m_c = 3.1kg$

$r_c = 8.0cm = 0.08m$

wheel is a uniform disk

KNOWN

$L_w = L_{w+c}$

$I_w \omega_w = (I_w + I_c)\omega_{w+c}$

$$I_{disk} = \frac{1}{2}mr^2$$

$\omega = 2\pi f$

SOLUTION

$$\frac{I_w \omega_w}{(I_w + I_c)} = \omega_{w+c} = \frac{\left(\frac{1}{2}m_w {r_w}^2\right)\omega_w}{\left(\frac{1}{2}m_w {r_w}^2 + \frac{1}{2}m_c {r_c}^2\right)} = \frac{\left(\frac{1}{2}(5)(0.2)^2\right)(9.42)}{\left(\frac{1}{2}(5)(0.2)^2 + \frac{1}{2}(3.1)(0.08)^2\right)} = 8.57\, rad/s$$

$$\frac{\omega}{2\pi} = f = \frac{8.57}{2\pi} = 1.36\, rev/s$$

57. GIVEN

$$\omega = \frac{3.5 rev}{sec} x \frac{2\pi rad}{rev} = 22.0\, rad/s$$

$m_w = 55kg$

$r = 15cm = 0.15m$

$h = 1.5m$

skater is a uniform cylinder

KNOWN

$L = I\omega$

$$I = \frac{1}{2}mr^2$$

$$\tau = \frac{\Delta L}{\Delta t}$$

SOLUTION

a. $L = \frac{1}{2}mr^2\omega = \frac{1}{2}(55)(0.15)^2(22.0) = 13.6kg \cdot m^2/s$

b. $\tau = \frac{\Delta L}{\Delta t} = \frac{0-13.6}{5.0} = 2.72m \cdot N$

58. GIVEN

a. Earth is a uniform sphere

b. Earth is a point particle

$m_{Earth} = 6.0x10^{24}kg$

$r_{Earth} = 6.4x10^6m$

$r_{Earth-Sun} = 1.5x10^8km = 1.5x10^{11}m$

KNOWN

$L = I\omega$

$I_{sphere} = \frac{2}{5}mr^2$

SOLUTION

a. $\omega_{rotation} = \frac{1rev}{24h} x \frac{2\pi rad}{rev} x \frac{1h}{60min} x \frac{1min}{60s} = 7.27x10^{-5}\, rad/s$

$L = I\omega = \frac{2}{5}mr^2\omega = \frac{2}{5}(6.0x10^{24})(6.4x10^6)^2(7.27x10^{-5}) = 7.15x10^{33}kg \cdot m^2/s$

b. $\omega_{revolving} = \frac{1rev}{365days} x \frac{2\pi rad}{rev} x \frac{1day}{24h} x \frac{1h}{60min} x \frac{1min}{60s} = 1.99x10^{-7}\, rad/s$

$L = I\omega = mr^2\omega = (6.0x10^{24})(1.5x10^{11})^2(1.99x10^{-7}) = 2.69x10^{40}kg \cdot m^2/s$

59. GIVEN

I, ω

KNOWN

$L = I\omega$

$L_f = L_i$

SOLUTION

$(I + I)\omega_f = I\omega_i$

$(2I)\omega_f = I\omega_i$

$\omega_f = \frac{I\omega_i}{(2I)}$

$\omega_f = \frac{1}{2}\omega_i$

60. GIVEN

uniform disk

$\omega_{disk} = 2.4\, rev/s$

uniform rod

$m_{disk} = m_{rod}$

$r_{disk} = r_{rod}$

KNOWN

$L_f = L_i$

$L = I\omega$

$I_{disk} = \frac{1}{2}mr^2$

$I_{rod} = \frac{1}{12}ml^2$

$l = 2r$

SOLUTION

$(I_{disk} + I_{rod})\omega_f = I_{disk}\omega_i$

$\left(\frac{1}{2}mr^2 + \frac{1}{12}ml^2\right)\omega_f = \frac{1}{2}mr^2\omega_i$

$\left(\frac{1}{2}mr^2 + \frac{1}{12}m(2r)^2\right)\omega_f = \frac{1}{2}mr^2\omega_i$

$\left(\frac{1}{2}mr^2 + \frac{4}{12}m(r)^2\right)\omega_f = \frac{1}{2}mr^2\omega_i$

$\left(\frac{10}{12}mr^2\right)\omega_f = \frac{1}{2}mr^2\omega_i$

$\frac{6}{5mr^2}\left(\frac{5mr^2}{6}\right)\omega_f = \frac{6}{5mr^2}\left(\frac{1}{2}mr^2\omega_i\right)$

$\omega_f = \frac{3}{5}(\omega_i) = \frac{3}{5}(2.4) = 1.44\, rev/s$

61. GIVEN

$m_{person} = 75kg$

$r_{plat} = 3.0m$

$I_{plat} = 920kg \cdot m^2$

$\omega_{plat} = 2.0\, rad/s$

KNOWN

$L_f = L_i$

$L = I\omega$

$I_{person} = mr^2$ *, when the person is in the center, r = 0, so* $I_{person} = 0$ *and* $L_{person} = 0$

$KE = \frac{1}{2}I\omega^2$

SOLUTION

a. $(I_{person} + I_{plat})\omega_f = I_{plat}\omega_i$

$$\omega_f = \frac{I_{plat}\omega_i}{(I_{person} + I_{plat})}$$

$$\omega_f = \frac{I_{plat}\omega_i}{(m_{person}r_{plat}^2 + I_{plat})}$$

$$\omega_f = \frac{(920)(2.0)}{((75)(3)^2 + 920)} = 1.15\, rad/s$$

b. $KE_{before} = \frac{1}{2}I\omega_i^2 = \frac{1}{2}(920)(2)^2 = 1840J$

$$KE_{after} = \frac{1}{2}(m_{person}r_{plat}^2 + I_{plat})\omega_i^2 = \frac{1}{2}((75)(3)^2 + 920)(1.15)^2 = 1061J$$

62. GIVEN

$d_{mgr} = 4.2m$, $r_{mgr} = 2.1m$

$\omega_{mgr} = 0.80\, rad/s$

$I_{mgr} = 1760kg \cdot m^2$

$m_{person} = 65kg$

KNOWN

$L_f = L_i$

$L = I\omega$

$I_{person} = m_{person}r^2$

SOLUTION

$(4I_{person} + I_{mgr})\omega_f = I_{mgr}\omega_i$

$$\omega_f = \frac{I_{mgr}\omega_i}{(4I_{person} + I_{mgr})}$$

$$\omega_f = \frac{I_{mgr}\omega_i}{(4m_{person}r^2 + I_{mgr})} = \frac{(1760)(0.8)}{(4(65)(2.1)^2 + (1760))} = 0.484\, rad/s$$

The second half of the question is ambiguous because you don't know whether they mean the people were initially on board with $\omega = 0.80$ or $\omega = 0.48$. If they were on when angular velocity was 0.80, then the angular velocity would increase above that. If they were on when the angular velocity was 0.48 (which is what the answer key was written for), then the angular velocity would increase back up to 0.80.

63. GIVEN

$T = 30days$

KNOWN

$L_f = L_i$

$L = I\omega$

$\omega = \frac{2\pi}{T}$

$I_{sphere} = \frac{2}{5}mr^2$

SOLUTION

$\omega_i = \frac{2\pi}{30days} x \frac{1day}{24} x \frac{1h}{60min} x \frac{1min}{60s} = 2.42x10^{-6}$

$I_f\omega_f = I_i\omega_i$

$\omega_f = \frac{I_i}{I_f}\omega_i = \frac{\frac{2}{5}m_i{r_i}^2}{\frac{2}{5}(0.5m_i)(0.1r_i)^2}\omega_i = \frac{1}{(0.5)(0.01)^2}(2.42x10^{-6}) = 4.85x10^{-2}$

64. GIVEN

$v_{tan} = \frac{120km}{h} x \frac{1h}{60min} x \frac{1min}{60s} x \frac{1000m}{1km} = 33.3m/s$

uniform cylinder of air

$\rho = \frac{1.3kg}{m^3}$

$r = 100km = 100{,}000m$

$h = 4.0km = 4{,}000m$

KNOWN

$KE = \frac{1}{2}I\omega^2$

$I_{cylinder} = \frac{1}{2}mr^2$

$\rho = \frac{m}{V}$

$\rho V = m$

$V_{cylinder} = \pi r^2 h$

$v = \omega r$

$\frac{v}{r} = \omega$

$L = I\omega$

SOLUTION

a. $KE = \frac{1}{2} I\omega^2$

$$KE = \frac{1}{2}\left(\frac{1}{2}mr^2\right)\left(\frac{v}{r}\right)^2$$

$$KE = \frac{1}{2}\left(\frac{1}{2}(\rho V)r^2\right)\left(\frac{v}{r}\right)^2$$

$$KE = \frac{1}{2}\left(\frac{1}{2}(\rho\pi r^2 h)\cancel{r^2}\right)\left(\frac{v}{\cancel{r}}\right)^2$$

$$KE = \frac{1}{2}\left(\frac{1}{2}(1.3)\pi(100{,}000)^2(4{,}000)\right)(33.3)^2 = 4.53x10^{16}J$$

b. $L = I\omega$

$$L = \left(\frac{1}{2}(\rho\pi r^2 h)r^{\cancel{2}}\right)\left(\frac{v}{\cancel{r}}\right)$$

$$L = \frac{1}{2}(1.3)\pi(100{,}000)^2(4{,}000)(100{,}000)(33.3) = 2.72x10^{20}kg\cdot m^2/s$$