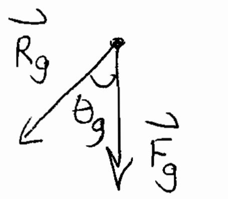
PH 201 - Chapter 09 Solutions

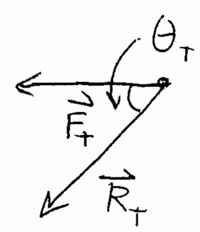
2) $L = 9.20\,m \qquad F_1 = F_2 = 185\,N \qquad R = \frac{L}{2} = 4.60\,m$

$$\Sigma\vec{\tau} = \vec{\tau}_1 + \vec{\tau}_2 = 2\vec{\tau}_1 = 2(F_1 R_1 \sin\theta_1)$$
$$\Sigma\vec{\tau} = 2(185)(4.60)(\sin 90.0^\circ) = 1700\ N\cdot m$$

6) $\vec{F}_g = (10200\ N,\ \text{down})$

$\vec{F}_T = (62300\ N,\ \text{left})$





(a) $\vec{\tau}_g = F_g R_g \sin\theta_g$

$$\tau_g = (10200)(2.50)\sin 32.0^\circ = 13500\ N\cdot m$$

(b) $\vec{\tau}_T = F_T R_T \sin\theta_T$

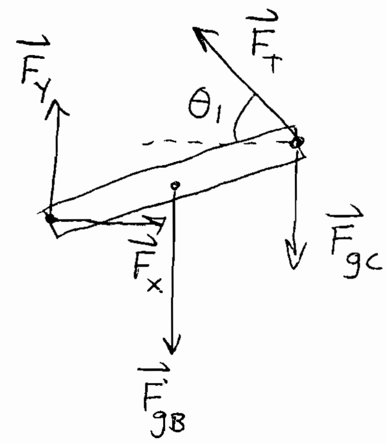
$$\tau_T = (62300)(2.50)\sin 58.0^\circ = 132000\ N\cdot m$$

8) $\Sigma\vec{\tau} = 0 \qquad F_1 = 4.00\,N \qquad \theta_1 = 90.0^\circ \qquad R_1 = 1.00\,m$

$F_2 = 6.00\,N \qquad \theta_2 = 60.0^\circ \qquad R_2 = ?$

$$\Sigma\vec{\tau} = \vec{\tau}_1 + \vec{\tau}_2 = (+\tau_1) + (-\tau_2) = 0 \qquad \tau_1 = \tau_2$$
$$F_1 R_1 \sin\theta_1 = F_2 R_2 \sin\theta_2 \qquad F_1 = F_2 R_2 \sin\theta_2$$
$$R_2 = \frac{F_1}{F_2 \sin\theta_2} = \frac{(4)}{(6)(\sqrt{3}/2)} = \frac{4}{3\sqrt{3}} = 0.770\,m = 77.0\,cm$$

20) $F_{gB} = 1220\,N \qquad F_{gc} = 1960\,N$



$$\Sigma\vec{F}_x = 0 \qquad \Sigma\vec{F}_y = 0 \qquad \Sigma\vec{\tau} = 0$$
$$\Sigma\vec{F}_x = (+F_x) + (-F_T\cos\theta_1) = 0$$
$$F_x = F_T\cos\theta_1$$

$$\Sigma \vec{F}_y = (+F_y) + (-F_{gB}) + (-F_{gc}) + (+F_T \sin\theta_1) = 0$$

$$\Sigma \vec{\tau} = \vec{\tau}_x + \vec{\tau}_y + \vec{\tau}_{gB} + \vec{\tau}_{gc} + \vec{\tau}_T = 0$$

$$0 + 0 + (-F_{gB}\tfrac{L}{2}\sin 60^\circ) + (-F_{gc} L \sin 60^\circ) + (+F_T L \sin 80^\circ) = 0$$

$$F_{gB}\frac{\sin 60^\circ}{2} + F_{gc}\sin 60^\circ = F_T \sin 80^\circ$$

$$F_T = \frac{F_{gB}(\sin 60^\circ/2) + F_{gc}\sin 60^\circ}{\sin 80^\circ} = \frac{528.275 + 1697.410}{\sin 80^\circ}$$

(a) $F_T = 2260\ \text{N}$

(b) $F_x = F_T \cos\theta_1$

$F_x = (2260)\cos 50.0^\circ = 1450\,\text{N}$

$$F_y = F_{gB} + F_{gc} - F_T \sin\theta_1 = (1220) + (1960) - (2260)\sin 50.0^\circ$$

$F_y = 1450\,\text{N}$

28) $m_D = 1.20\,\text{kg}$ $R = 0.160\,\text{m}$ $m_R = 0.150\,\text{kg}$

$$I(\text{total}) = I(\text{disk}) + 3I(\text{rod}) = \tfrac{1}{2}m_D R^2 + 3(m_R R^2)$$

$$I(\text{total}) = R^2\left(\frac{m_D}{2} + 3m_R\right) = (0.16)^2(0.6 + 0.450)$$

$$I(\text{total}) = 0.0269\ \text{kg}\cdot\text{m}^2$$

31) $m = 24.3\,\text{kg}$ $R = 0.314\,\text{m}$ $F_1 = 90.0\,\text{N}$ $F_2 = 125\,\text{N}$

(a) $\Sigma\vec{\tau} = ?$ $\Sigma\vec{\tau} = \vec{\tau}_1 + \vec{\tau}_2 = (+\tau_1) + (-\tau_2)$

$$\Sigma\vec{\tau} = (+F_1 R\sin 90^\circ) + (-F_2 R \sin 90^\circ) = R(F_1 - F_2)$$

$$\Sigma\vec{\tau} = (0.314)(90 - 125) = -11.0\ \text{N}\cdot\text{m} \quad (- = cw)$$

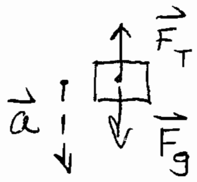
(b) $\Sigma\vec{\tau} = I\vec{\alpha}$ $I(\text{disk}) = \tfrac{1}{2}mR^2$ $\vec{\alpha} = \dfrac{\Sigma\vec{\tau}}{I} = \dfrac{\Sigma\vec{\tau}}{(mR^2/2)}$

$$\vec{\alpha} = \frac{2(\Sigma\vec{\tau})}{mR^2} = \frac{(2)(-11.0)}{(24.3)(0.314)^2} = -9.18\ \text{rad/s}^2 \quad (- = cw)$$

40) $m = 2.00\,kg$ $\quad I = 1.10\times10^{-3}\,kg\cdot m^2$ $\quad R = 0.0400\,m$

$$\Sigma\vec{\tau} = I\vec{\alpha} \qquad \Sigma\vec{\tau} = \vec{\tau}_T = +F_T R\sin 90^\circ = F_T R$$

$$F_T R = I\vec{\alpha} \qquad \boxed{F_T R = I\alpha}$$



$$\Sigma\vec{F} = F_T - F_g = -ma$$

$$F_T - mg = -ma \qquad \boxed{F_T = mg - ma = m(g-a)}$$

$\boxed{a = \alpha R}$ substitute

$F_T = m(g - \alpha R)$ substitute again

$$(m(g-\alpha R))R = I\alpha \qquad mgR - m\alpha R^2 = I\alpha$$

$$I\alpha + mR^2\alpha = mgR \qquad \alpha(I + mR^2) = mgR$$

$$\alpha = \frac{mgR}{I + mR^2} = \frac{(2)(9.8)(0.04)}{(1.1\times10^{-3}) + (2)(0.04)^2} = \frac{0.784}{0.0043}$$

$$\alpha = 182\ rad/s^2$$

$$F_T R = I\alpha \qquad F_T = \frac{I\alpha}{R} = \frac{(1.1\times10^{-3})(182.326)}{(0.04)} = 5.01\,N$$

44) (a) $KE(rot) = \frac{1}{2}I\omega^2$ $\qquad I(\text{sphere about center}) = \frac{2}{5}MR^2$

$$KE(rot) = \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{2\pi}{T}\right)^2 = \frac{4\pi^2MR^2}{5T^2}$$

$$KE(rot) = \frac{4\pi^2(5.98\times10^{24})(6.38\times10^6)^2}{5(86400)^2} = 2.57\times10^{29}\,J$$

(b) $KE(rot) = \frac{1}{2}I\omega^2$ $\qquad I = MR^2$

$$KE(rot) = \frac{1}{2}(MR^2)\left(\frac{2\pi}{T}\right)^2 = \frac{2\pi^2MR^2}{T^2}$$

$$KE(rot) = \frac{2\pi^2(5.98\times10^{24})(1.50\times10^{11})^2}{((86400)(365.25))^2} = 2.67\times10^{33}\,J$$

47) $\frac{KE(rot)}{KE(total)} = ?$ $\quad KE(rot) = \frac{1}{2} I\omega^2 = \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{V}{R}\right)^2$

$KE(rot) = \frac{1}{5}Mv^2 \quad KE(total) = KE(rot) + KE(lin)$

$KE(lin) = \frac{1}{2}Mv^2$

$$\frac{KE(rot)}{KE(total)} = \frac{\frac{1}{5}Mv^2}{\frac{1}{5}Mv^2 + \frac{1}{2}Mv^2} = \frac{1/5}{1/5+1/2} = \frac{1/5}{2/10+5/10}$$

$$= \frac{1/5}{7/10} = \frac{1}{5}\,\frac{10}{7} = \frac{2}{7}$$

50) Cube: Translational Motion, but no Rotational Motion

$(KE+PE_g)_i = (KE+PE_g)_f \quad 0 + mgh = \frac{1}{2}mv^2 + 0$

$V_c = \sqrt{2gh}$ (cube)

Marble: Both kinds of Motion

From previous problem, $KE(total) = \frac{1}{2}mv^2 + \frac{1}{5}mv^2$

$(KE+PE_g)_i = (KE+PE_g)_f \quad 0 + mgh = \frac{1}{2}mv^2 + \frac{1}{5}mv^2 + 0$

$mgh = \frac{5}{10}mv^2 + \frac{2}{10}mv^2 = \frac{7}{10}mv^2 \quad V_m = \sqrt{\frac{10gh}{7}}$ (marble)

$$\frac{V_c}{V_m} = \frac{\sqrt{2gh}}{\sqrt{10gh/7}} = \frac{\sqrt{2}}{\sqrt{10/7}} = \sqrt{\frac{14}{10}} = \sqrt{\frac{7}{5}}$$

54) $R_D = 2.00m \quad m_D = 100kg \quad V_0 = \omega_0 = 0 \quad m_p = 40.0kg$

$R_p = 1.25m \quad V_p = 2.00\,m/s \quad \omega_D = ?$

Conservation of Angular Momentum

$(\vec{L}_D + \vec{L}_p)_i = (\vec{L}_D + \vec{L}_p)_f \quad 0 + 0 = \vec{L}_D + \vec{L}_p \quad \vec{L}_D = -\vec{L}_p$

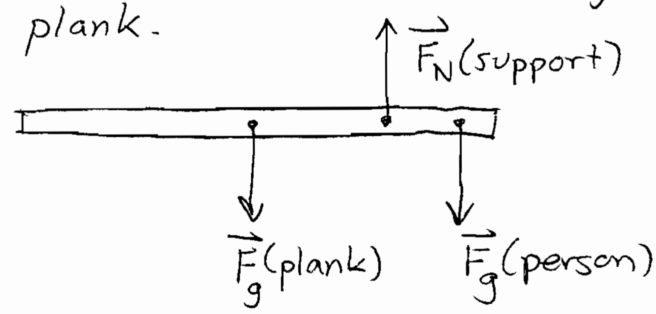
$L_D = I_D\omega_D = \frac{1}{2}m_D R_D^2 \omega_D \quad L_p = I_p\omega_p = m_p R_p^2 \frac{V_p}{R_p} = m_p V_p R_p$

$L_p = L_p \qquad \frac{1}{2} m_D R_D^2 \omega_D = m_p v_p R_p \qquad \omega_D = \frac{2 m_p v_p R_p}{m_D R_D^2}$

$$\omega_D = \frac{(2)(40)(2)(1.25)}{(100)(2)^2} = \frac{200}{400} = 0.500 \text{ rad/s}^2$$

The disk will rotate in the opposite direction.

64) Just as the plank begins to tip, it loses contact with the left support. So, there is only one normal force acting on the plank, caused by the right support. Put the axis of rotation where the right support touches the plank.



$$\Sigma \vec{\tau} = 0$$

$$\Sigma \vec{\tau} = \vec{\tau}(\text{plank}) + \vec{\tau}(\text{person}) + \vec{\tau}(\text{support}) = 0$$

$\vec{\tau}(\text{support}) = 0$ because $R(\text{support}) = 0$

$\vec{\tau}(\text{plank}) = -\vec{\tau}(\text{person}) \qquad \tau(\text{plank}) = \tau(\text{person})$

$$\tau(\text{plank}) = F_g(\text{plank})\, R(\text{plank})$$

$$\tau(\text{person}) = F_g(\text{person})\, R(\text{person})$$

$$R(\text{person}) = \frac{F_g(\text{plank})\, R(\text{plank})}{F_g(\text{person})} = \frac{(225)\left(\frac{5}{2} - 1.1\right)}{(450)}$$

$$R(\text{person}) = 0.700 \text{ m}$$