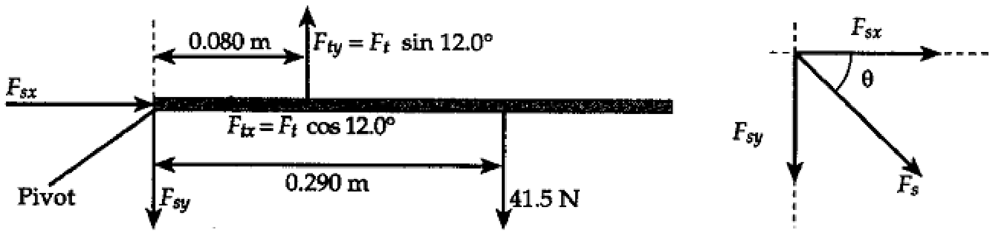
Homework 9 - Solutions

Note Title 1/4/2006

8.7



Requiring that $\Sigma\tau = 0$, using the shoulder joint at point O as a pivot, gives

$$\Sigma\tau = (F_t \sin 12.0°)(0.080 \text{ m}) - (41.5 \text{ N})(0.290 \text{ m}) = 0, \text{ or } F_t = \boxed{724 \text{ N}}$$

Then $\Sigma F_y = 0 \Rightarrow \quad -F_{sy} + (724 \text{ N})\sin 12.0° - 41.5 \text{ N} = 0,$

yielding $\quad F_{sy} = 109 \text{ N}$

$\Sigma F_x = 0$ gives $\quad F_{sx} - (724 \text{ N})\cos 12.0° = 0$, or $F_{sx} = 708 \text{ N}$

Therefore, $\quad F_s = \sqrt{F_{sx}^2 + F_{sy}^2} = \sqrt{(708 \text{ N})^2 + (109 \text{ N})^2} = \boxed{716 \text{ N}}$.

8.8 If the mass of a hydrogen atom is 1.00 u (i.e., 1 unit), then the mass of the oxygen atom is 16.0 u.

$$x_{cg} = \frac{\Sigma m_i x_i}{\Sigma m_i} = \frac{(16.0 \text{ u})(0) + 2(1.00 \text{ u})\left[(0.100 \text{ nm})\cos 53.0°\right]}{(16.0 + 1.00 + 1.00) \text{ u}} = \boxed{6.69 \times 10^{-3} \text{ nm}}$$

$$y_{cg} = \frac{\Sigma m_i y_i}{\Sigma m_i}$$

$$= \frac{(16.0)(0) + (1.00)\left[(0.100)\sin 53.0°\right] + (1.00)\left[-(0.100)\sin 53.0°\right] \text{ u} \cdot \text{nm}}{(16.0 + 1.00 + 1.00) \text{ u}} = \boxed{0}$$

8.9 Require that $\Sigma\tau = 0$ about an axis through the elbow and perpendicular to the page. This gives

$$\Sigma\tau = +\left[(2.00\text{ kg})(9.80\text{ m/s}^2)\right](25.0\text{ cm}+8.00\text{ cm}) - (F_B\cos 75.0°)(8.00\text{ cm}) = 0$$

or $$F_B = \frac{(19.6\text{ N})(33.0\text{ cm})}{(8.00\text{ cm})\cos 75.0°} = \boxed{312\text{ N}}$$

$\boxed{19}$ Refer to diagram P8.19 on page 256 of your book.

When a person is biting down on the food, the system is in equilibrium. Thus, the sum of the forces is zero and the sum of the torques is zero.

Consider our torques about the point on the jawbone where $\vec{T}$ is applied. About this point, there is a torque due to $\vec{F}_c$ and a torque due to $\vec{R}$.

$\tau_R = R\,(3.5\text{ cm})$, $\tau_F = |F_c|\,(7.5\text{ cm})$

Equilibrium tells us $\tau_F - \tau_R = 0 \Rightarrow |F_c|(7.5) - R(3.5) = 0$

$\Rightarrow R = |F_c|\left(\frac{7.5}{3.5}\right) = (50\text{ N})\left(\frac{7.5}{3.5}\right) = \boxed{107\text{ N} = R}$

Equilibrium also tells us that the sum of the forces is zero. Then:

$-F_c + T - R = 0 \Rightarrow \boxed{T = F_c + R = 157\text{ N}}$

8.29 The moment of inertia for rotations about an axis is $I = \Sigma m_i r_i^2$, where r_i is the distance mass m_i is from that axis.

(a) For rotation about the x-axis,

$$I_x = (3.00\text{ kg})(3.00\text{ m})^2 + (2.00\text{ kg})(3.00\text{ m})^2 +$$
$$(2.00\text{ kg})(3.00\text{ m})^2 + (4.00\text{ kg})(3.00\text{ m})^2 = \boxed{99.0\text{ kg}\cdot\text{m}^2}.$$

(b) When rotating about the y-axis,

$$I_y = (3.00\text{ kg})(2.00\text{ m})^2 + (2.00\text{ kg})(2.00\text{ m})^2 +$$
$$(2.00\text{ kg})(2.00\text{ m})^2 + (4.00\text{ kg})(2.00\text{ m})^2 = \boxed{44.0\text{ kg}\cdot\text{m}^2}.$$

(c) For rotations about an axis perpendicular to the page through point O, the distance r_i for each mass is $r_i = \sqrt{(2.00\text{ m})^2 + (3.00\text{ m})^2} = \sqrt{13.0}$ m.

Thus, $I_O = \left[(3.00+2.00+2.00+4.00)\text{ kg}\right](13.0\text{ m}^2) = \boxed{143\text{ kg}\cdot\text{m}^2}.$

8.33 (a) $\tau_{net} = I\alpha = (6.8\times10^{-4}\ \text{kg}\cdot\text{m}^2)(66\ \text{rad/s}^2) = 4.5\times10^{-2}\ \text{N}\cdot\text{m}$

The torque exerted by the fish is $\tau_{fish} = F\cdot r$, and this also equals

$$\tau_{fish} = \tau_{net} + \tau_{friction} = (4.5\times10^{-2} + 1.3)\ \text{N}\cdot\text{m}$$

Thus, $$F = \frac{\tau_{fish}}{r} = \frac{(4.5\times10^{-2}+1.3)\ \text{N}\cdot\text{m}}{4.0\times10^{-2}\ \text{m}} = \boxed{34\ \text{N}}$$

8.34 $I = MR^2 = (1.80\ \text{kg})(0.320\ \text{m})^2 = 0.184\ \text{kg}\cdot\text{m}^2$

$$\tau_{net} = \tau_{applied} - \tau_{resistive} = I\alpha\text{, or } F\cdot r - f\cdot R = I\alpha$$

yielding $$F = \frac{I\alpha + f\cdot R}{r}$$

(a) $$F = \frac{(0.184\ \text{kg}\cdot\text{m}^2)(4.50\ \text{rad/s}^2) + (120\ \text{N})(0.320\ \text{m})}{4.50\times10^{-2}\ \text{m}} = \boxed{872\ \text{N}}$$

(b) $$F = \frac{(0.184\ \text{kg}\cdot\text{m}^2)(4.50\ \text{rad/s}^2) + (120\ \text{N})(0.320\ \text{m})}{2.80\times10^{-2}\ \text{m}} = \boxed{1.40\ \text{kN}}$$

8.47 The initial moment of inertia of the system is

$$I_i = \Sigma m_i r_i^2 = 4\left[M(1.0\ \text{m})^2\right] = M(4.0\ \text{m}^2).$$

The moment of inertia of the system after the spokes are shortened is

$$I_f = \Sigma m_f r_f^2 = 4\left[M(0.50\ \text{m})^2\right] = M(1.0\ \text{m}^2).$$

From conservation of angular momentum, $I_f\omega_f = I_i\omega_i$,

or $$\omega_f = \left(\frac{I_i}{I_f}\right)\omega_i = (4)(2.0\ \text{rev/s}) = \boxed{8.0\ \text{rev/s}}.$$

8.51 The initial angular velocity of the puck is $\omega_i = \frac{v_i}{r_i} = \frac{0.800\ \text{m/s}}{0.400\ \text{m}} = 2.00\ \frac{\text{rad}}{\text{s}}$.

Since the tension in the string does not exert a torque about the axis of revolution, the angular momentum of the puck is conserved, or $I_f\omega_f = I_i\omega_i$.

Thus, $\omega_f = \left(\frac{I_i}{I_f}\right)\omega_i = \left(\frac{mr_i^2}{mr_f^2}\right)\omega_i = \left(\frac{0.400\ \text{m}}{0.250\ \text{m}}\right)^2 (2.00\ \text{rad/s}) = 5.12\ \text{rad/s}$

The net work done on the puck is

$$W_{net} = KE_f - KE_i = \frac{1}{2}I_f\omega_f^2 - \frac{1}{2}I_i\omega_i^2 = \frac{1}{2}\left[\left(mr_f^2\right)\omega_f^2 - \left(mr_i^2\right)\omega_i^2\right] = \frac{m}{2}\left[r_f^2\omega_f^2 - r_i^2\omega_i^2\right],$$

or $$W_{net} = \frac{(0.120\ \text{kg})}{2}\left[(0.250\ \text{m})^2(5.12\ \text{rad/s})^2 - (0.400\ \text{m})^2(2.00\ \text{rad/s})^2\right]$$

This yields $W_{net} = \boxed{5.99\times10^{-2}\ \text{J}}$

8.54 For one of the crew, $\Sigma F_c = ma_c$ becomes $n = m\left(\frac{v_t^2}{r}\right) = mr\omega_i^2$.

We require $n = mg$, so the initial angular velocity must be $\omega_i = \sqrt{\frac{g}{r}}$.

From conservation of angular momentum, $I_f\omega_f = I_i\omega_i$, or $\omega_f = \left(\frac{I_i}{I_f}\right)\omega_i$.

Thus, the angular velocity of the station during the union meeting is

$$\omega_f = \left(\frac{I_i}{I_f}\right)\sqrt{\frac{g}{r}} = \left[\frac{5.00\times10^8\ \text{kg}\cdot\text{m}^2 + 150(65.0\ \text{kg})(100\ \text{m})^2}{5.00\times10^8\ \text{kg}\cdot\text{m}^2 + 50(65.0\ \text{kg})(100\ \text{m})^2}\right]\sqrt{\frac{g}{r}} = 1.12\sqrt{\frac{g}{r}}.$$

The centripetal acceleration experienced by the managers still on the rim is

$$a_c = r\omega_f^2 = r(1.12)^2\frac{g}{r} = (1.12)^2(9.80\ \text{m/s}^2) = \boxed{12.3\ \text{m/s}^2}.$$