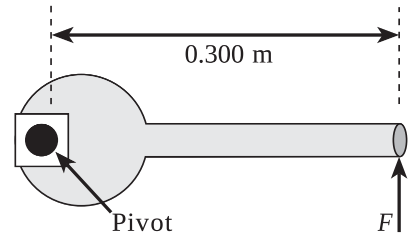
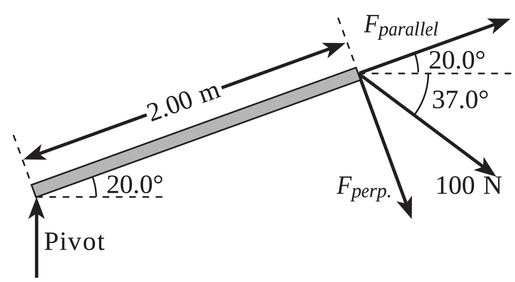
PHY 2130 Homework solutions
Assignment 8

8.1 To exert a given torque using minimum force, the lever arm should be as large as possible. In this case, the maximum lever arm is used when the force is applied at the end of the wrench and perpendicular to the handle.



Then, $F_{min} = \dfrac{\tau}{d_{max}} = \dfrac{40.0\ \text{N}\cdot\text{m}}{0.300\ \text{m}} = \boxed{133\ \text{N}}$

8.6 Resolve the 100-N force into components parallel to and perpendicular to the rod, as



$$F_{parallel} = (100\ \text{N})\cos(20.0° + 37.0°) = 54.5\ \text{N}$$

and

$$F_{perp.} = (100\ \text{N})\sin(20.0° + 37.0°) = 83.9\ \text{N}$$

The torque due to the 100-N force is equal to the sum of the torques of its components.

Thus,

$$\tau = (54.5\ \text{N})(0) - (83.9\ \text{N})(2.00\ \text{m}) = \boxed{-168\ \text{N}\cdot\text{m}}$$

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

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

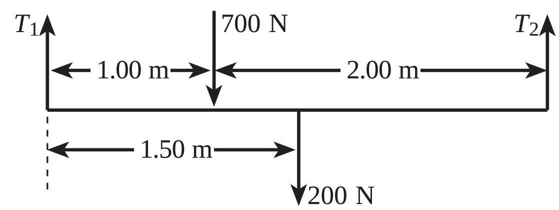
or $$F_B = \frac{(19.6\ \text{N})(33.0\ \text{cm})}{(8.00\ \text{cm})\cos 75.0°} = \boxed{312\ \text{N}}$$

8.18 Consider the torques about an axis perpendicular to the page through the left end of the scaffold.

$$\Sigma\tau = 0 \Rightarrow T_1(0) - (700\text{ N})(1.00\text{ m}) - (200\text{ N})(1.50\text{ m}) + T_2(3.00\text{ m}) = 0.$$

From which, $T_2 = \boxed{333\text{ N}}$.

Then, from $\Sigma F_y = 0$, we have



$$T_1 + T_2 - 700\text{ N-}200\text{ N=}0,$$

or

$$T_1 = 900\text{ N-}T_2 = 900\text{ N-}333\text{ N=}\boxed{567\text{ N}}$$

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 $r_i = \sqrt{(2.00\text{ m})^2 + (3.00\text{ m})^2} = \sqrt{13.0}\text{ m}$.

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

8.30 The required torque in each case is $\tau = I\alpha$.

Thus, $\tau_x = I_x\alpha = \left(99.0\ \text{kg}\cdot\text{m}^2\right)\left(1.50\ \text{rad/s}^2\right) = \boxed{149\ \text{N}\cdot\text{m}}$,

$\tau_y = I_y\alpha = \left(44.0\ \text{kg}\cdot\text{m}^2\right)\left(1.50\ \text{rad/s}^2\right) = \boxed{66.0\ \text{N}\cdot\text{m}}$,

and $\tau_O = I_O\alpha = \left(143\ \text{kg}\cdot\text{m}^2\right)\left(1.50\ \text{rad/s}^2\right) = \boxed{215\ \text{N}\cdot\text{m}}$.

8.41 The moment of inertia of the cylinder is

$$I = \frac{1}{2}MR^2 = \frac{1}{2}\left(\frac{w}{g}\right)R^2 = \frac{1}{2}\left(\frac{800\ \text{N}}{9.80\ \text{m/s}^2}\right)(1.50\ \text{m})^2 = 91.8\ \text{kg}\cdot\text{m}^2.$$

The angular acceleration is given by

$$\alpha = \frac{\tau}{I} = \frac{F\cdot R}{I} = \frac{(50.0\ \text{N})(1.50\ \text{m})}{91.8\ \text{kg}\cdot\text{m}^2} = 0.817\ \text{rad/s}^2.$$

At $t = 3.00$ s, the angular velocity is

$$\omega = \omega_i + \alpha t = 0 + \left(0.817\ \text{rad/s}^2\right)(3.00\ \text{s}) = 2.45\ \text{rad/s},$$

and the kinetic energy is

$$KE_{rot} = \frac{1}{2}I\omega^2 = \frac{1}{2}\left(91.8\ \text{kg}\cdot\text{m}^2\right)(2.45\ \text{rad/s})^2 = \boxed{276\ \text{J}}$$

8.44 Using conservation of mechanical energy,

$$\left(KE_{trans} + KE_{rot} + PE_g\right)_f = \left(KE_{trans} + KE_{rot} + PE_g\right)_i,$$

or $$\frac{1}{2}Mv_t^2 + \frac{1}{2}I\omega^2 + 0 = 0 + 0 + Mg(L\sin\theta).$$

Since $I = \frac{2}{5}MR^2$ for a solid sphere and $v_t = R\omega$ when rolling without slipping, this becomes $\frac{1}{2}MR^2\omega^2 + \frac{1}{5}MR^2\omega^2 = Mg(L\sin\theta)$ and reduces to

$$\omega = \sqrt{\frac{10gL\sin\theta}{7R^2}} = \sqrt{\frac{10\left(9.8\ \text{m/s}^2\right)(6.0\ \text{m})\sin 37^\circ}{7(0.20\ \text{m})^2}} = \boxed{36\ \text{rad/s}}$$

8.50 The total angular momentum of the system is

$$I_{total} = I_{masses} + I_{student} = 2\left(mr^2\right) + 3.0 \text{ kg}\cdot\text{m}^2$$

Initially, $r = 1.0 \text{ m}$, and $I_i = 2\left[(3.0 \text{ kg})(1.0 \text{ m})^2\right] + 3.0 \text{ kg}\cdot\text{m}^2 = 9.0 \text{ kg}\cdot\text{m}^2$

Afterward, $r = 0.30 \text{ m}$, so

$$I_f = 2\left[(3.0 \text{ kg})(0.30 \text{ m})^2\right] + 3.0 \text{ kg}\cdot\text{m}^2 = 3.5 \text{ kg}\cdot\text{m}^2$$

(a) From conservation of angular momentum, $I_f\omega_f = I_i\omega_i$, or

$$\omega_f = \left(\frac{I_i}{I_f}\right)\omega_i = \left(\frac{9.0 \text{ kg}\cdot\text{m}^2}{3.5 \text{ kg}\cdot\text{m}^2}\right)(0.75 \text{ rad/s}) = \boxed{1.9 \text{ rad/s}}$$

(b) $KE_i = \frac{1}{2}I_i\omega_i^2 = \frac{1}{2}\left(9.0 \text{ kg}\cdot\text{m}^2\right)(0.75 \text{ rad/s})^2 = \boxed{2.5 \text{ J}}$

$KE_f = \frac{1}{2}I_f\omega_f^2 = \frac{1}{2}\left(3.5 \text{ kg}\cdot\text{m}^2\right)(1.9 \text{ rad/s})^2 = \boxed{6.4 \text{ J}}$