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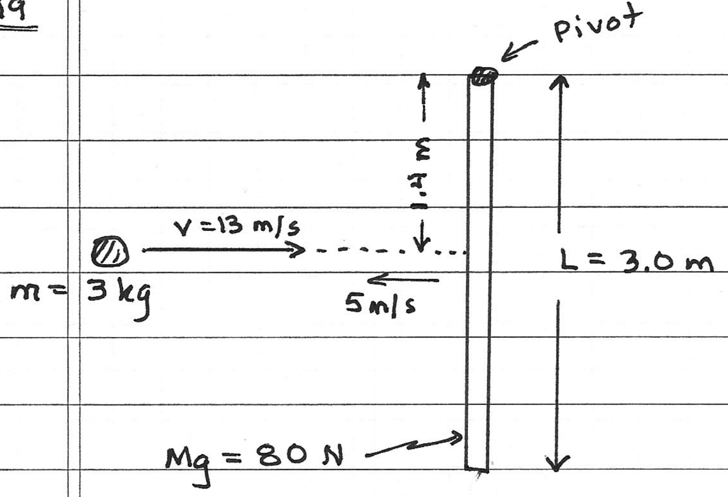
Chapter 10 Homework PS215

10.49



$\vec{L}_i = \vec{r} \times \vec{p}_i = +\,1.4\,\text{m}\,(3\,\text{kg})(13\,\text{m/s})\,\hat{k}$

$\vec{L}_f = I\omega + \vec{r} \times \vec{p}_f$

$\vec{L}_f = \left[I\omega_f - 1.4\,\text{m}\,(3\,\text{kg})(5\,\text{m/s}) \right] \hat{k}$

$L_f = \left[\frac{1}{3} M L^2 \omega_f - 1.4\,\text{m}\,(3\,\text{kg})(5\,\text{m/s}) \right]$

a.) Angular momentum is conserved $\Rightarrow \vec{L}_i = \vec{L}_f$

$|L_i| = 54.6\ \text{kg}\cdot\text{m/s}$

$|L_f| = \left[\frac{1}{3} \frac{80\,\text{N}}{9.8\,\text{m/s}^2} (3\,\text{m})^2 \omega_f - 1.4\,\text{m}(3\,\text{kg})(5\,\text{m/s}) \right]$

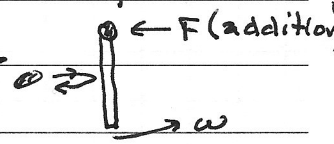
$|L_f| = 24.49\,\omega_f - 21\ \text{kg}\cdot\text{m/s}$

$|L_i| = |L_f| \quad \Rightarrow \quad 54.6 = 24.49\,\omega_f - 21$

$\omega_f = \dfrac{54.6 + 21}{24.49} = 3.087\ \text{rad/s}$

$$\boxed{\omega_f = 3.087\ \text{rad/s}}$$

b.) The collision and rebound requires a force to keep the pivot motionless — a force to the left.



However, this force does not provide a torque, thus no additional angular momentum due to that external force.

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$m_{Rotor} = 0.150\ kg$

$I = 1.20 \times 10^{-4}\ kg \cdot m^2$

$M_{frame} = 2.70 \times 10^{-2}\ kg$

$$\Omega = \frac{1\ rev}{2.20 s} = \frac{2\pi\ rad}{2.20\ s} \qquad \Omega = \frac{\tau}{L} = \frac{1}{I\omega} r(M_f + M_R)g$$

a). $\Sigma F_y = 0 \qquad -(m_f + m_R)g + F_{up} = 0$

$$F_{up} = (m_f + m_R)g = (0.027 + 0.150)kg\,(9.8\,m/s^2)$$

$$\boxed{F_{up} = 1.735\ N}$$

b.) $$\omega = \frac{1}{I\Omega} r(m_f + m_R)g$$

$$\omega = \frac{1}{1.20 \times 10^{-4}\ kg \cdot m^2}\left(\frac{2.20s}{2\pi\ rad}\right)(.04\,m)(1.735\,N) = 202.45\ \frac{rad}{sec}$$

$$\omega = 202.45\ \frac{rad}{sec}\left(\frac{1\ rev}{2\pi\ rad}\right)\left(\frac{60\,s}{min}\right) = 1933\ \frac{rev}{min}$$

$$\boxed{\omega = 1933\ rpm}$$

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$$\Omega = \frac{\Delta\phi}{\Delta t} = \frac{1.20\times10^{-6}\ \text{degrees}}{6\ \text{hours}}\left(\frac{\pi\ \text{rad}}{180\ \text{degrees}}\right)\left(\frac{1\ \text{hr}}{3600\text{s}}\right) = 9.696\times10^{-13}\ \frac{\text{rad}}{\text{sec}}$$

$$\Omega = \frac{1}{L}\tau \qquad \tau = L\Omega = I\omega\Omega$$

$$\tau = MR^2\omega\Omega = (2.00\ \text{kg})(0.025\text{m})^2\ 1.92\times10^4\left(\frac{\text{rev}}{\text{min}}\right)\left(\frac{2\pi\ \text{rad}}{1\ \text{rev}}\right)\left(\frac{1\ \text{min}}{60\text{s}}\right)\Omega$$

$$\boxed{\tau = 2.437\times10^{-12}\ \text{N}\cdot\text{m}}$$