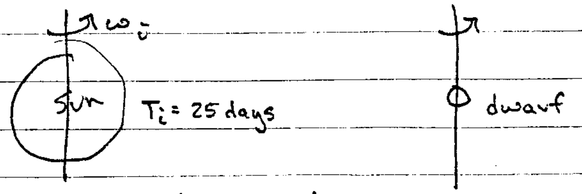
55.



solid ball $\frac{2}{5}MR^2$

$R_{sun} = 6.96 \times 10^8 m =$

$R_{Earth} = 6370$ km

$$L_{init} = L_{final}$$

$$I_{init}\,\omega_{init} = I_{final}\,\omega_{final}$$

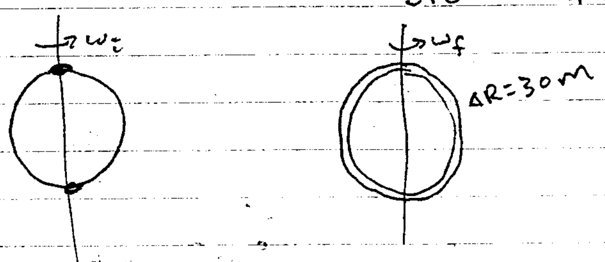
$$\left(\frac{2}{5} M R_{init}^2\right)\left(\frac{2\pi}{T_i}\right) = \left(\frac{2}{5} M R_{fin}^2\right)\left(\frac{2\pi}{T_f}\right)$$

$$\frac{R_{init}^2}{T_i} = \frac{R_{final}^2}{T_f}$$

$$\frac{(6.96 \times 10^8 m)^2}{25 days} = \frac{(6370 \times 10^3 m)^2}{T_f}$$

$$T_f = 2.1 \times 10^{-3} \text{ days}$$
$$= 5.0 \times 10^{-2} \text{ hrs}$$
$$= 3.0 \text{ min}$$

63.



$I_{solid\ sphere} = \frac{2}{5} MR^2$

$$L_{init} = L_{final}$$

$$I_{init}\,\omega_{init} = I_{final}\,\omega_f$$

There are a couple of approaches that one can take to get the moments of inertia.

① Assume that the I_{final} can be calculated by just allowing the Earth to get bigger by 30m

$$\left(\cancel{\tfrac{2}{5}} \cancel{M} R_0^2\right)\omega_{init} = \left(\cancel{\tfrac{2}{5}} \cancel{M} R_{final}^2\right)\omega_{final}$$

$$R_0^2 \frac{2\pi}{T_{init}} = R_f^2 \frac{2\pi}{T_{final}}$$

$$\frac{T_{final}}{T_{init}} = \left(\frac{R_{final}}{R_{init}}\right)^2 = \left(\frac{R_0 + \Delta R}{R_0}\right)^2 = \left(1 + \frac{\Delta R}{R_0}\right)^2$$

Use binomial expansion to evaluate.

$$\frac{T_{final}}{T_{init}} \approx 1 + 2\frac{\Delta R}{R_0}$$

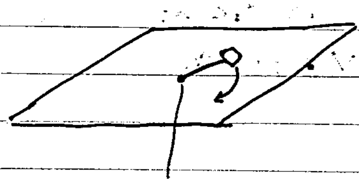
$$\frac{T_{init} + \Delta T}{T_{init}}$$

$$1 + \frac{\Delta T}{T_{init}} \approx 1 + 2\frac{\Delta R}{R}$$

$$\frac{\Delta T}{T_{init}} = 2\frac{\Delta R}{R} = 2\,\frac{30m}{6370 \times 10^3 m}$$

$$\Delta T = 9.4 \times 10^{-6} \text{ days} = 0.82 \text{ sec}$$

10.48

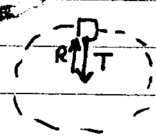


$m = 0.4\ kg$

Initially $v_i = 4\ m/s$ $R_i = 0.5\ m$

what is ~~breaking speed~~ radius when cord breaks at $T = 60\ N$

top view



$\tau_{orque} = 0$ because $\vec{r} \parallel \vec{Force}$

$\therefore$ Ang Mom conserved

$$L_{init} = L_{final}$$
$$I_i \omega_i = I_f \omega_f$$
$$m R_i^2 \omega_i = m R_f^2 \omega_f$$

$V = R\omega$

$$\cancel{m} R_i v_i = \cancel{m} R_f v_f$$

Forces are governed by $F = ma$

So
$$m a_{rad} = T$$
$$m\, v^2/R = T$$

At the breaking point $T \to 60$ Newtons

$V \to V_f$

$R \to R_f$

$\left[\ V_f = \frac{R_i v_i}{R_f}\right.$ from above

$$m \frac{\left(\frac{R_i v_i}{R_f}\right)^2}{R_f} = T$$

$$m \frac{R_i^2}{R_f^2} v_i^2 = T R_f$$

$$m R_i^2 v_i^2 = T R_f^3$$

$$(0.4)(0.5)^2 4^2 = 60 R_f^3$$

$$R_f = 0.30\ m$$

12-46

$$L_{perihelion} = L_{aphelion}$$

$$r_p p_p = r_a p_a$$

$$r_p m v_p = r_a m v_a$$

$$(1.471 \times 10^{11})(3.027 \times 10^{4}) = (1.521 \times 10^{11}) v_a$$

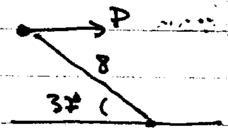
$$v_a = 2.927 \times 10^{4} \ m/s$$

10.23

$\vec{L} = \vec{r} \times \vec{p}$

$|\vec{L}| = L = r_\perp p$

$r_\perp$ ← impact parameter

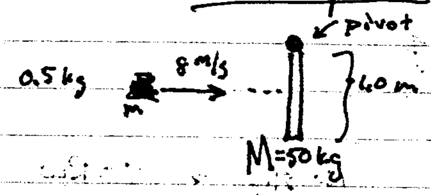


impact parameter $= r_\perp = (8\,m)\sin 37° = 4.8\,m$

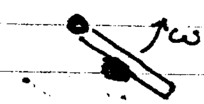
$L = 4.8\,(0.6\,kg \cdot 12\,m/s)$
$= 34.6\ kg\,m^2/s$

10.27

Before top view



After top view



Conservation of Ang Momentum

$L_{before} = L_{after}$

$r_\perp m v = I_{door}\,\omega + I_{mud}\,\omega$

$0.5(0.5)8 =$

$I_{door} = \frac{1}{3} M a^2 = \frac{1}{3}\, 50\,(1)^2$
$= 16.7\ kg\,m^2$

$I_{mud} = MR^2 = (0.5)(0.5)^2$
(point obj) $= 0.125\ kg\,m^2$

$2 = (I_{door} + I_{mud})\,\omega$

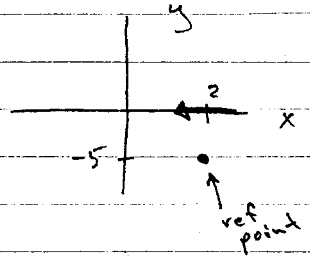
$2 = (16.7 + 0.125)\,\omega$

$\omega = 0.119\ rad/sec$

The moment of Inertia of mud is only 8% effect.

Ch12

c)



$$\vec{r}_{\substack{\text{wrt}\\\text{ref}\\\text{point}}} = (x_0 - 2 - \tfrac{1}{2}t^4)\,\hat{\imath} + 5\,\hat{\jmath} + 0\,\hat{k}$$

$$\vec{p} = -6t^3\,\hat{\imath} + 0\,\hat{\jmath} + 0\,\hat{k}$$

$$\vec{F} = -18\,\hat{\imath} + 0\,\hat{\jmath} + 0\,\hat{k}$$

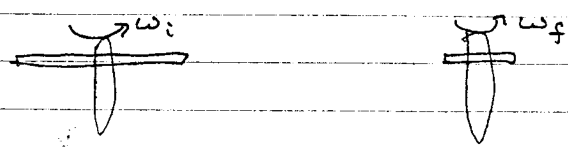
$$\vec{L} = \vec{r} \times \vec{p} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ x_0 - 2 - \tfrac{1}{2}t^4 & 5 & 0 \\ -6t^3 & 0 & 0 \end{vmatrix} = \hat{\imath}\,(0) - \hat{\jmath}\,(0) + \hat{k}\left[-(5)(-6t^3)\right]$$

$$= 30t^3\,\hat{k}$$

$$\vec{\tau} = \vec{r} \times \vec{F} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ x_0 - 2 - \tfrac{1}{2}t^4 & 5 & 0 \\ -18 & 0 & 0 \end{vmatrix} = \hat{\imath}\,(0) - \hat{\jmath}\,(0) + \hat{k}\left[-(-18)5\right]$$

$$= 90\,\hat{k}$$

51.



$I_i = 6$ kg m^2 $\qquad I_f = 2$ kg m^2

$\omega_i = 1.2$ rev/s $\qquad \omega_f = ?$

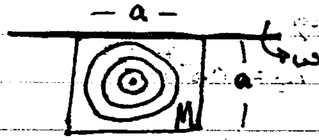
a)
$$L_{init} = L_{final}$$
$$I_{init}\,\omega_i = I_f\,\omega_f$$
$$6\,(1.2) = 2\,\omega_f$$
$$\omega_f = 3.6 \text{ rev/s}$$

b)
$$\omega_i = 1.2 \text{ rev/sec} = (1.2)2\pi \text{ rad/se} = 7.54 \text{ rad/s}$$
$$\omega_f = 3.6 \text{ rev/sec} = 3.6(2\pi) \text{ rad/sec} = 22.61 \text{ rad/s}$$

c)
$$KE_i = \tfrac{1}{2} I_i \omega_i^2 = \tfrac{1}{2}(6)(7.54)^2 = 171 \text{ J}$$
$$KE_f = \tfrac{1}{2} I_f \omega_f^2 = \tfrac{1}{2}(2)(22.61)^2 = 511 \text{ J}$$

Work done by his arms

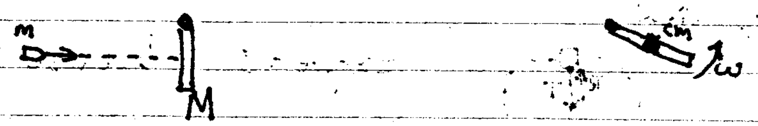
12.49



$M = 2.2$ kg $\qquad a = 0.2$ m

bullet: $m = 5\times10^{-3}$ kg $\qquad V = 300$ m/s

a) side view $\qquad$ before $\qquad$ after



Collision → conserv. momentum

$$L_{before} = L_{after}$$

Assume bullet stops in target

$$r_1\, mV = I_{board}\,\omega + I_{bullet}\,\omega$$
$$= (I_{board} + I_{bullet})\,\omega$$

$$I_{board} = \tfrac{1}{3} M a^2$$
$$= \tfrac{1}{3}\, 2.2\, (0.2)^2$$
$$= 0.0293\ \text{kg m}^2$$

$$I_{bullet} = m R^2 =$$
$$= 5\times10^{-3}\,(0.1)^2$$
$$= 5\times10^{-5} = \text{very small}$$

$$0.1\,(5\times10^{-3})\,300 = (0.0293)\,\omega$$
$$\omega = 5.12\ \text{rad/s}$$

b) Max height → board is rotating initially.

$$\tfrac{1}{2} I\omega^2 = mgh$$
$$\tfrac{1}{2}(0.0293)(5.12)^2 = 2.2\,(9.8)\,h$$
$$h = 0.0178\ \text{m}$$

– hgt cm raises up.

c) Collecting previous equations

$$r_1 mV = I_{board}\,\omega \qquad \text{and} \qquad \tfrac{1}{2} I\omega^2 = mgh$$
$$\omega = \frac{r_1 mV}{I}$$
$$\tfrac{1}{2} I \left(\frac{r_1 mV}{I}\right)^2 = mgh$$

$$\frac{1}{2}\,\frac{r_1^2 m^2 V^2}{I} = Mgh$$
$$\frac{1}{2}\,\frac{(0.1)^2 (5\times10^{-3})^2 V^2}{0.0293} = 2.2\,(9.8)\,0.2$$
$$(4.27^{-6})\,V^2 = \quad \rightarrow \quad V = 1005\ \text{m/s}$$