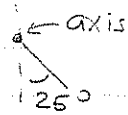
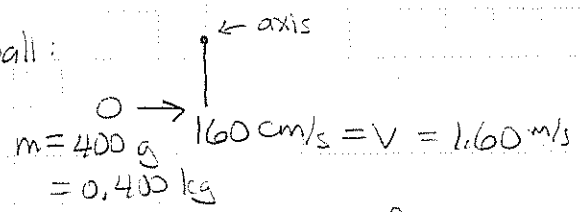
Physics 200B Assignment 11

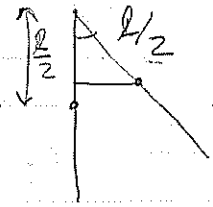
1. sign: front view, $M = 2.40\ kg$  $\ell = 50.0\ cm$ side view: 

collision with snowball:



a) Just before impact, sign has swung down from 25.0° angle to vertical

use conservation of mechanical energy to find angular speed (ω) at bottom:

initial height of c.m. of sign 

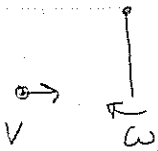
$$h = \frac{\ell}{2} - \frac{\ell}{2}\cos 25^\circ$$
$$= 0.25\ m - 0.25\ m \cos 25^\circ$$
$$= 0.0234\ m = h$$

so $U_i = K_f \Rightarrow Mgh = \frac{1}{2} I\omega^2$

$I = \frac{1}{3}ML^2$ (remember door problem from Ch. 10)

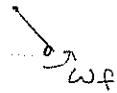
$$\Rightarrow Mgh = \frac{1}{2}\left(\frac{1}{3}M\ell^2\right)\omega^2 \Rightarrow \omega = \frac{\sqrt{6gh}}{\ell} = \frac{\sqrt{6(9.8)(0.0234)\ m^2/s^2}}{0.5\ m} = 2.35\ \frac{rad}{s}$$

b) conservation of angular momentum in collision



snow distance of closest approach = ℓ

before: $\vec{L}_{sign} = -I\omega\,\hat{k} = -\frac{1}{3}M\ell^2\omega\,\hat{k}$, $\vec{L}_{snow} = \ell m v\,\hat{k}$ } $\vec{L}_i = \ell m v - \frac{1}{3}M\ell^2\omega\,\hat{k}$

after:  $I_f = \frac{1}{3}M\ell^2 + m\ell^2$ } $\vec{L}_f = \left(\frac{1}{3}M\ell^2 + m\ell^2\right)\omega_f\,\hat{k}$

so $\vec{L}_i = \vec{L}_f \Rightarrow \ell m v - \frac{1}{3}M\ell^2\omega_i = \left(\frac{1}{3}M\ell^2 + m\ell^2\right)\omega_f$

$$\Rightarrow \omega_f = \frac{\ell m v - \frac{1}{3}M\ell^2\omega_i}{\frac{1}{3}M\ell^2 + m\ell^2}$$

$$= \frac{(0.5\ m)(0.4\ kg)(1.60\ m/s) - \frac{1}{3}(2.4\ kg)(0.5\ m)^2(0.235\ /s)}{\frac{1}{3}(2.4\ kg)(0.5\ m)^2 + (0.4\ kg)(0.5\ m)^2}$$

$$= -0.497\ rad/s$$

continued