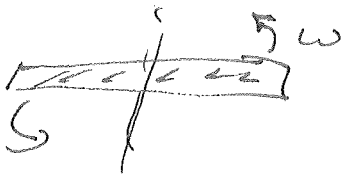
Physics 160

Extra Credit #26

# Twirling A Baton

Uniform rod with
$M = 0.12\,kg$
$L = 80cm = 0.8m$




a) Rotated about its center with $\omega = 3 rad/s$

$L = I\omega$. Rotated about center $\Rightarrow I = \frac{1}{12}mL^2 = \frac{1}{12}(0.12kg)(0.8m)^2$

$\Rightarrow I = 0.0064\,kg \cdot m^2$

$\Rightarrow L = 0.0064 kg \cdot m^2 (3 rad/s) = 0.0192\,kg \cdot m^2/s$

b) Now Rotated about one end with $\omega = 3 rad/s$

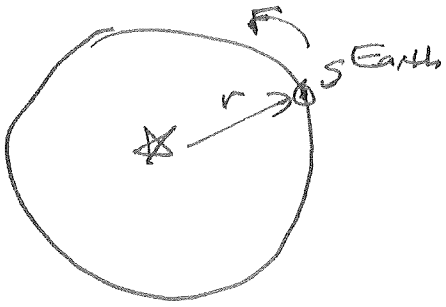
Rotated about one end $\Rightarrow I = \frac{1}{3}mL^2 = \frac{1}{3}(0.12kg)(0.8m)^2 = 0.0256 kg \cdot m^2$

$\Rightarrow L = (0.0256\,kg \cdot m^2)(3 rad/s) = 0.0768\,kg \cdot m^2$

10.38 Find Ang. Mom of Earth due to its yearly motion

Have to use Astronomical Data from textbook

Earth's mass: $5.97\times10^{24}$ kg. Since yearly motion, we use Distance to Sun $\Rightarrow r = 1.5\times10^{11}$ m




at this scale, Earth can be treated as a particle since its radius is negligible compared to r

$\Rightarrow L = mvr$

to find v: we know it takes 1 year to go around. $\Rightarrow$ one circumference

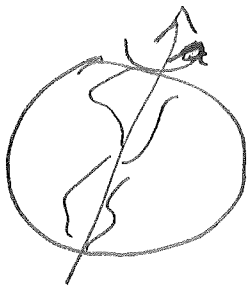
$$t = 1\,\text{year}\times\frac{365\,\text{day}}{\text{year}}\times\frac{24\,\text{h}}{\text{day}}\times\frac{3600\,\text{s}}{\text{h}} = 3.15\times10^{7}\,\text{s}$$

$$v = \frac{2\pi r}{t} = \frac{2\pi(1.5\times10^{11}\,\text{m})}{3.15\times10^{7}\,\text{s}} = 29886\,\text{m/s}$$

$\therefore$ $L = (5.97\times10^{24}\,\text{kg})(29886\,\text{m/s})(1.5\times10^{11}\,\text{m}) = 2.68\times10^{40}\,\text{kg}\cdot\text{m}^2/\text{s}$

b) Find L due to Daily motion $\rightarrow$ Here we use $L = I\omega$

Since at this scale Earth is a gigantic sphere $\Rightarrow$ many different values of v.



Solid sphere : $I = \frac{2}{5} m R^2$

but R is Earth's RADIUS.

$R = 6.38 \times 10^6 m$

$\Rightarrow I = \frac{2}{5}(5.97 \times 10^{24} kg)(6.38 \times 10^6 m)^2 = 9.72 \times 10^{37} kg \cdot m^2$

Earth Rotates 1 rev in 24 hour $\Rightarrow \omega = \frac{1 rev}{24 h} \times \frac{2\pi rad}{rev} \times \frac{h}{3600 s}$

$\Rightarrow \omega = 7.27 \times 10^{-5} rad/s$

$\therefore L = (9.72 \times 10^{37} kg \cdot m^2)(7.27 \times 10^{-5} rad/s) = 7.07 \times 10^{33} kg \cdot m^2/s$