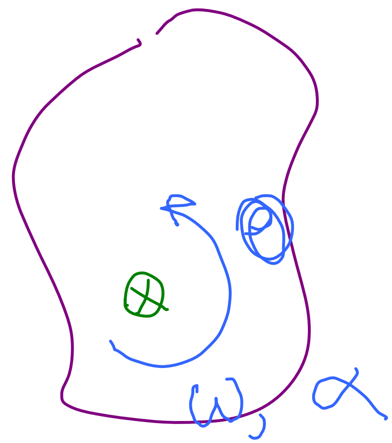
Phys 2110-4 4/1/13

Note Title 4/1/2013

Rotations



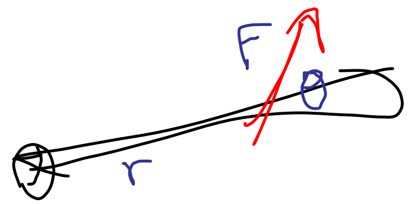
constant α

$$\omega = \omega_0 + \alpha t$$

$$\theta = \theta_0 + \omega_0 t + \tfrac{1}{2}\alpha t^2$$

$$\tau = r F \sin\theta$$

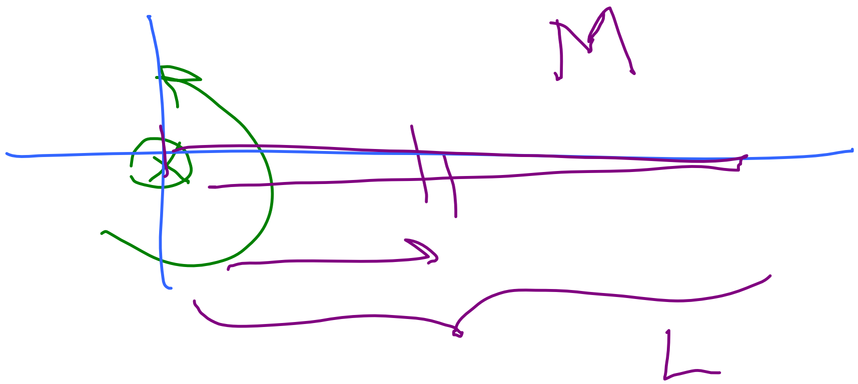
sign



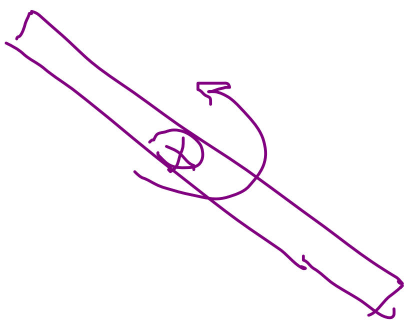
$$\tau_{net} = \left[\sum_\alpha m_\alpha r_\alpha^2\right]\alpha = I\alpha$$

moment of inertia

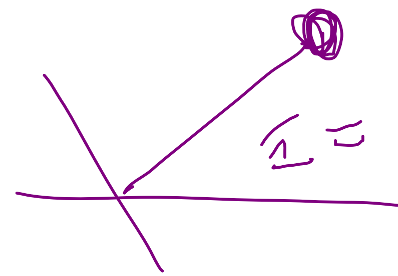
$$F = ma$$



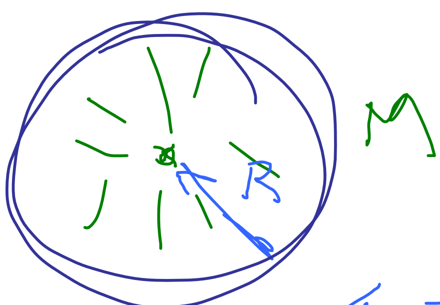
$$I = \frac{1}{3} M L^2$$



$$I = \frac{1}{12} M L^2$$



$$I = m r^2$$

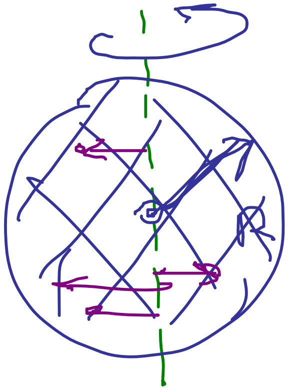


Hoop

$$I = M R^2$$

Disk, uniform

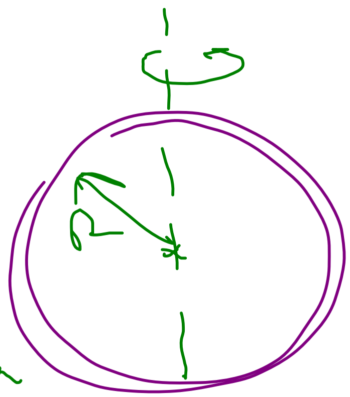
$$I = \frac{1}{2} M R^2$$



uniform sphere

M, R

$$I_{\text{solid sp.}} = \frac{2}{5}MR^2$$



m

M, R

Hollow Sphere

$$I_{\text{hollow sphere}} = \frac{2}{3}MR^2$$

Parallel Axis Theorem

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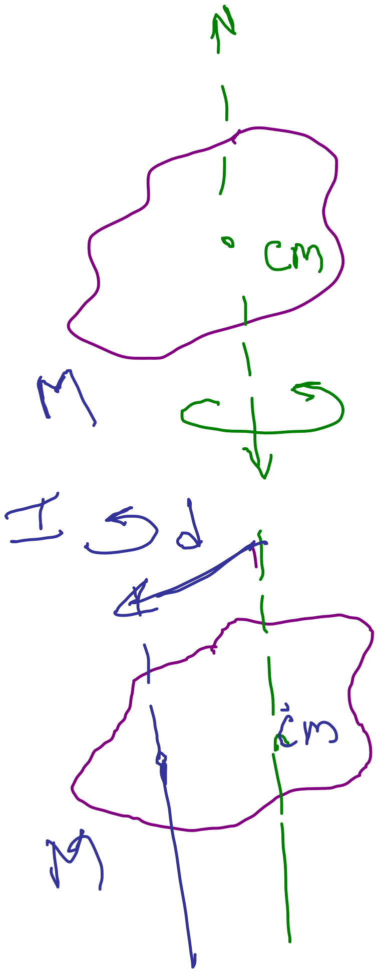


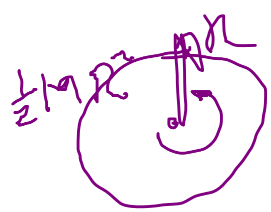
I, any axis thru CM

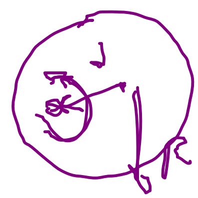
I_{cm}

New axis is parallel, disp'd by dist d

Moment of inertia around new axis

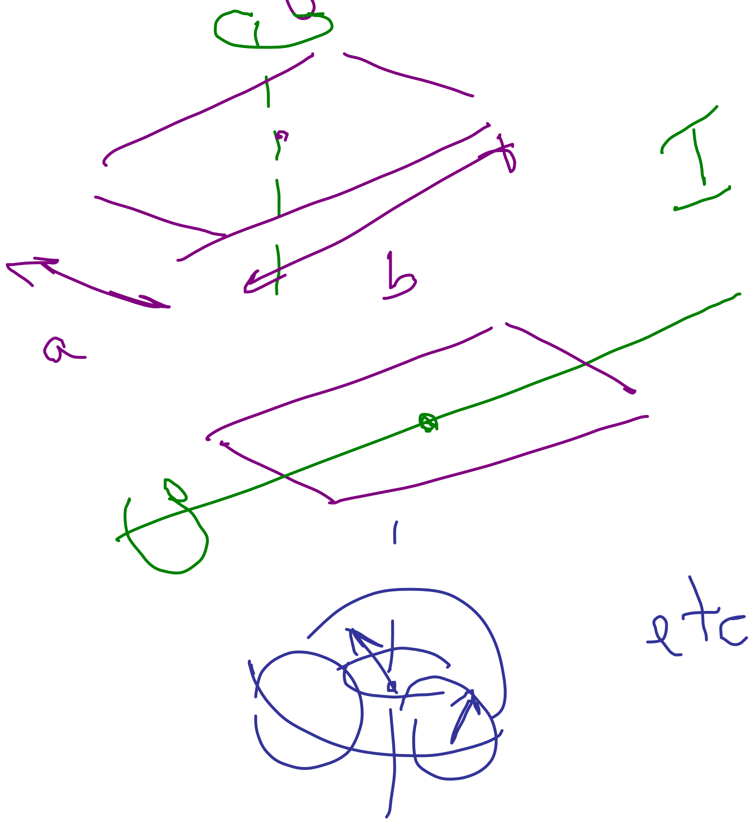
$$I = I_{cm} + Md^2$$





$$I = \frac{1}{2}MR^2 + Md^2$$

Table of mom'ts of inertia.



etc.

$$I = \frac{1}{12} M(a^2 + b^2)$$

$$I = \underline{\qquad\qquad}$$

$$F = ma$$

$$\tau_{net} = I\alpha$$

10.27 Rock-tumbling machine

hollow cyl. mass 65 g radius 7.1 cm.

Closed ends, disks, mass 22g.

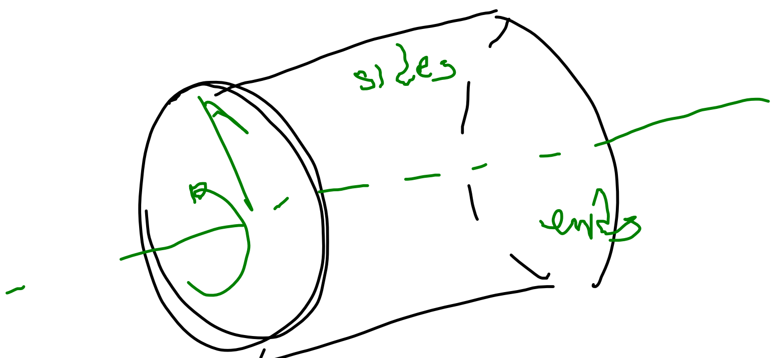
a) Rot'l inertia around central axis

b) Torque necessary to give it ang accel of

$3.4 \frac{rad}{s^2}$

$I_{sides} = M_{side} R^2 = (0.065\,kg)(0.071\,m)^2$

$= 3.28 \times 10^{-4}\ kg\,m^2$



$I_{ends} = 2 \cdot \frac{1}{2} M_{end} R^2$

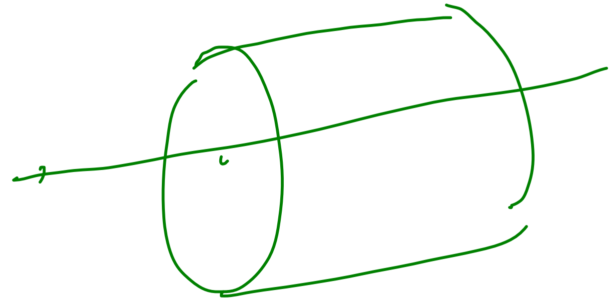
$= (0.022\,kg)(0.071\,m)^2$

$= 1.11 \times 10^{-4}\ kg\,m^2$

$I_{total} = 4.38 \times 10^{-4}\ kg\,m^2$

$I = 4.38 \times 10^{-4}\ kg\,m^2$

$\alpha = 3.4\ rad/s^2$

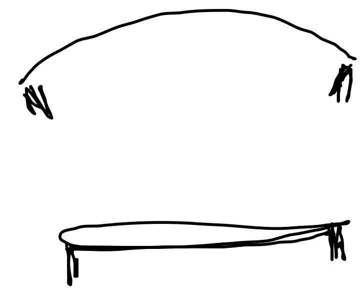


$\tau = I\alpha$

$= (4.4 \times 10^{-4}\ kg\,m^2)(3.4\ rad/s^2)$

$= 1.5 \times 10^{-3}\ N \cdot m$

10.32 25-cm diameter Frisbee (100 g) has half mass spread over uniform disk & other half on edge.



a) What is moment of inertia

$R = 0.125 \text{ m}$

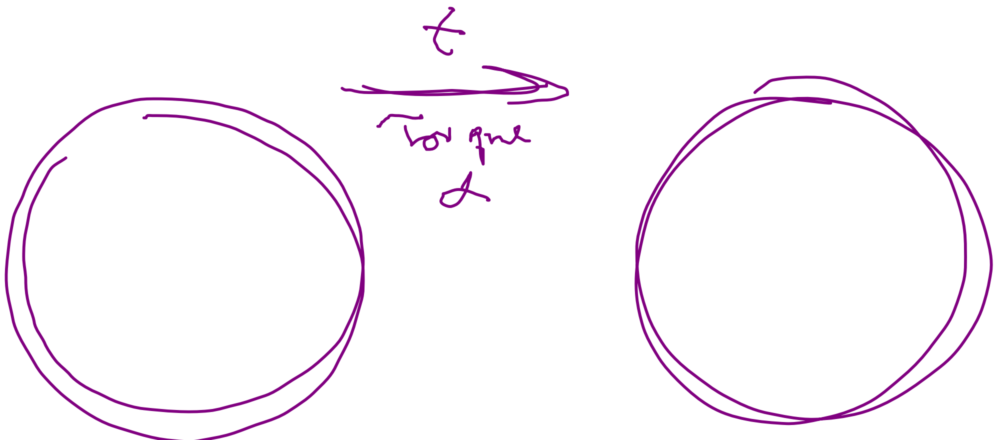
$$I = \frac{1}{2} M_{disk} R^2 + M_{edge} R^2$$

$$= \frac{1}{2}(0.054 \text{ g})(0.125)^2 + (0.054 \text{ kg})(0.125 \text{ m})^2$$

$$\approx 1.17 \times 10^{-3} \text{ kg m}^2$$

b) With a quarter-turn flick of wrist a student can set Frisbee at 550 rpm

Find mag of torque exerted on Frisbee?



$\omega_0 = 0$

$\theta = \frac{1}{4}\text{ rev} = \frac{\pi}{2}\text{ rad}$

$$\omega = 550\,\frac{\text{rev}}{\text{min}} \cdot \frac{2\pi\text{ rad}}{1\text{ rev}} \cdot \frac{1\text{ m}}{60\text{ sec}} = 57.6\,\frac{\text{rad}}{\text{s}}$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

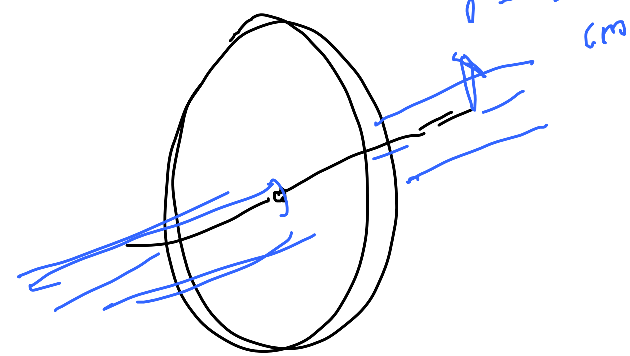
$$\alpha = \frac{\omega^2}{2\theta} = \frac{\left(57.6\,\frac{\text{rad}}{\text{s}}\right)^2}{2\left(\pi/2\right)} = 1056\,\frac{\text{rad}}{\text{s}^2}$$

$$\tau = I\alpha$$
$$= 1.24 \text{ N}\cdot\text{m} \qquad \text{(check)}$$

10.33 Energy stored in flywheel

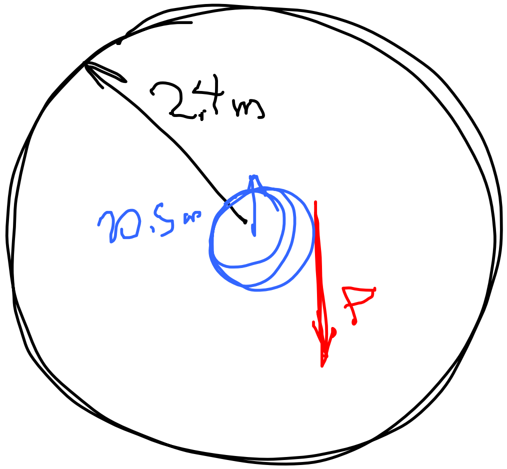
$M = 7.7 \times 10^8$ kg

Radius 2.4 m



Flywheel is on shaft 41 cm in diameter

If fric force of 34 kN acts tangentially on shaft, how long take flywheel to stop from 360-rpm rot'n rate?



$$I = \frac{1}{2} M R^2$$
$$= \frac{1}{2}(7.7 \times 10^4 \text{ kg})(2.4 \text{ m})^2$$
$$= 2.2 \times 10^5 \text{ kg m}^2$$

Force is app'd to shaft

$$\tau = rF \cdot 1$$
$$= (0.205 \text{ m})(34 \times 10^3 \text{ N})$$
$$= 6.97 \times 10^3 \text{ N} \cdot \text{m}$$

$$\tau = I\alpha$$

$$\alpha = \tau / I$$

You do it

rad/s² ______

360 rpm $\longrightarrow$ rad/s

$$\omega = \omega_0 + \alpha t$$

$$t = \frac{\omega - \omega_0}{\alpha} = \frac{0 - (\omega)}{\alpha} = 20 \text{ min.}$$

neg number