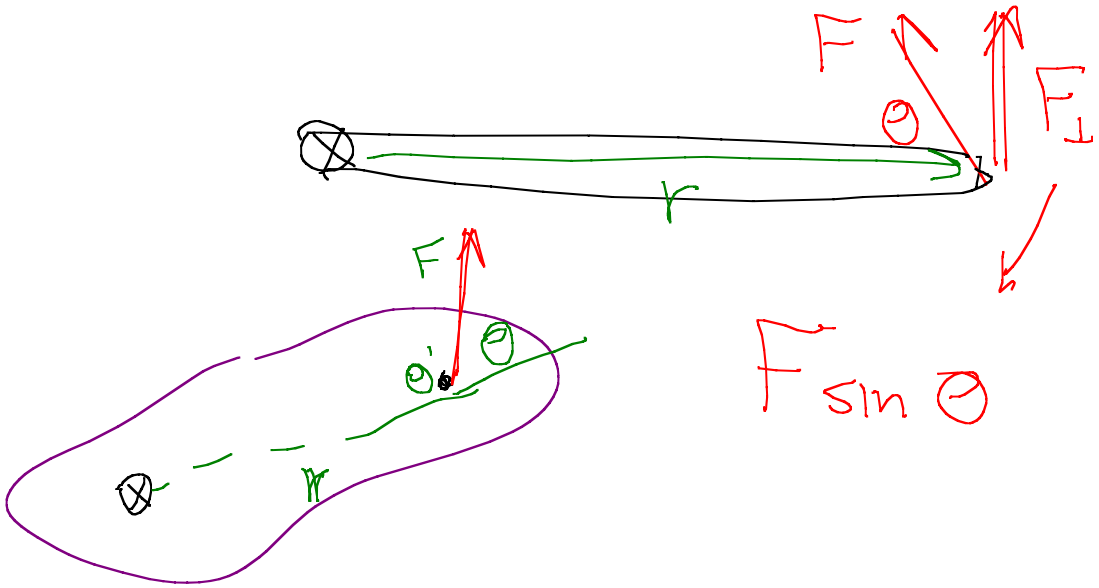
Phys 2110-3 11/1/10

Note Title 11/1/2010

$\tau = r F_\perp$

$\equiv r F \sin\theta$



Torque

Engr: Moment of force

What is it?

Scalar (for now)

Really a vector.

$\vec{\tau} = \vec{r} \times \vec{F}$

ω

Units ?

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

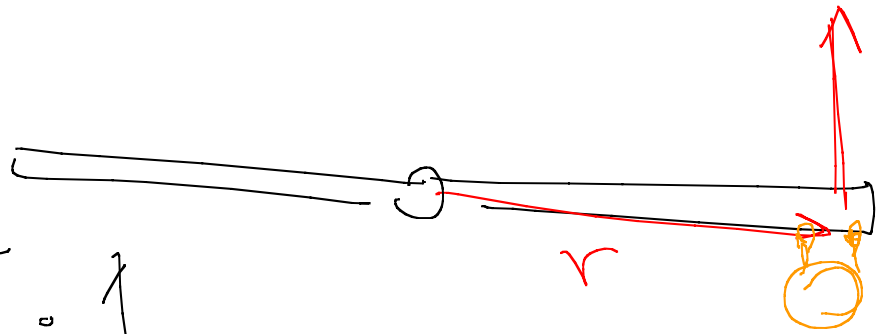
$m \cdot N$ ↑

$N \cdot m = J$ This is OK

Torque never combines energy

Please use $N \cdot m$

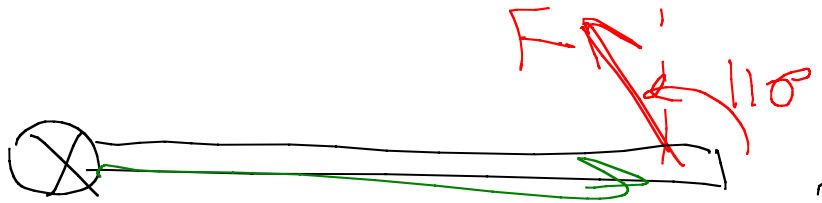
10.22 A torque of 110 N·m is req'd to start revolving door. If a child can push w/ max force 90 N, how far from door's axis must she apply force



$$\tau = rF \cdot 1$$

$$r = \frac{\tau}{F} = \frac{110\ \text{N}\cdot\text{m}}{90\ \text{N}} = 1.22\ \text{m}$$

10.23 Car tune-up manual calls for tightening spark plugs to 35.0 N·m. To achieve this torque with what force you pull on end of 24-cm-long wrench if b) pull at 110° to wrench shaft?



$\tau = 35$ N·m

$r = 0.24$ m

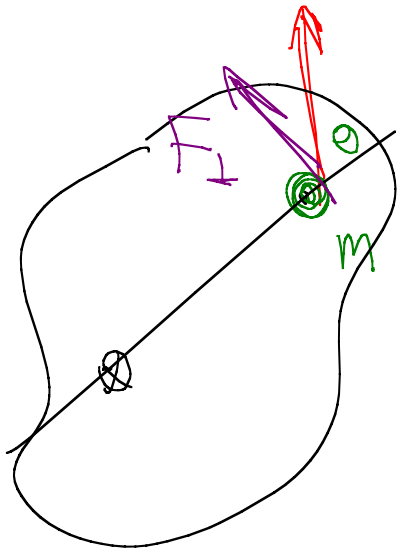
$\tau = r F \sin(110°)$

$$F = \frac{\tau}{r \sin(110°)} = 155 \text{ N}$$

τ gives α

Heuristic derivation.

m (mass point) can only move tangentially



Use N's 2nd law for tangential

$$F_{\perp} = m a_t$$

tangential

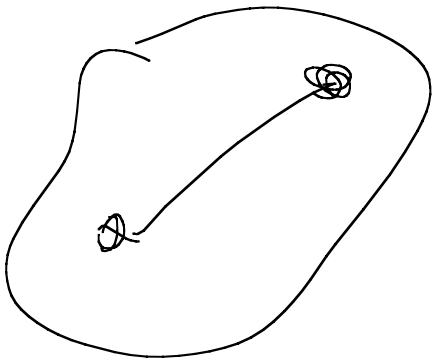
$$a_t = r\alpha$$

$$F_{\sin\theta} = m(r\alpha)$$

Mult both sides by r

$$r F_{\sin\theta} = (m r^2)\alpha$$

$$\tau = (m r^2)\,\alpha$$



For single particle. what about the whole object

Add up left & right sides

$$\tau_{total} = \sum_i (m_i r_i^2)\,\alpha$$

$$= \left[\sum_i m_i r_i^2\right]\alpha$$

$$\tau_{total\ (ext)} = \left[\sum_i m_i r_i^2\right]\alpha$$

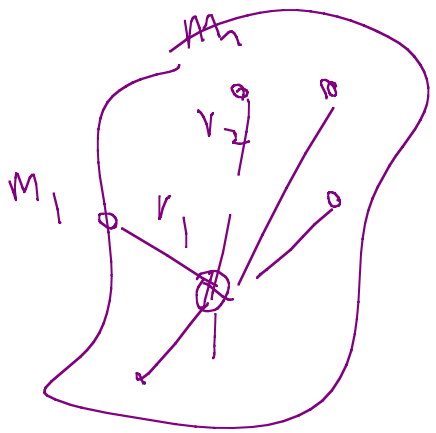
moment of inertia

I

τ — mass — α

$F = ma$

$$I = \sum_i m_i r_i^2$$



$$I = m_1 r_1^2 + m_2 r_2^2 + \ldots$$

Moment of inertia

Scalar (Positive)

(Actually it's a matrix!)

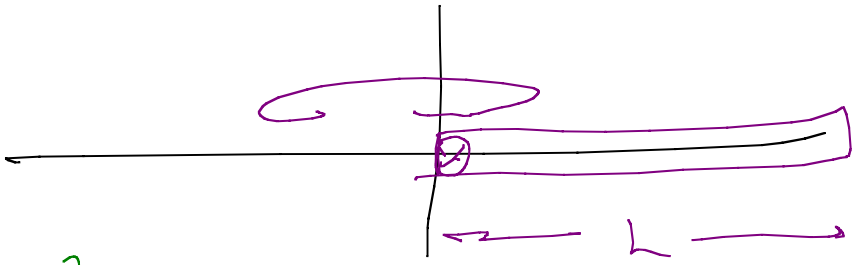
Units: $kg\,m^2$

Examples of I

Example:

Uniform stick

rotates about end

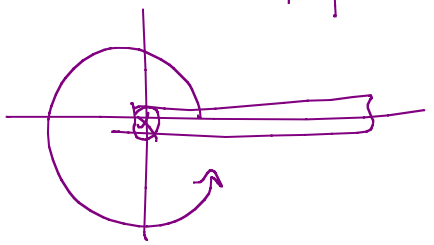


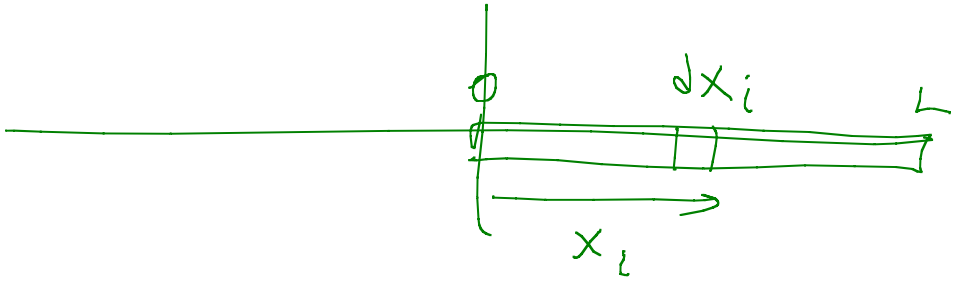
$$I = \sum_i dm_i \cdot x_i^2$$

$$= \frac{M}{L} \sum_i x_i^2 \, dx_i$$

$$= \frac{M}{L} \int_0^L x^2 \, dx$$

$$= \frac{M}{L}\left(\frac{1}{3}L^3\right) = \frac{1}{3}ML^2$$

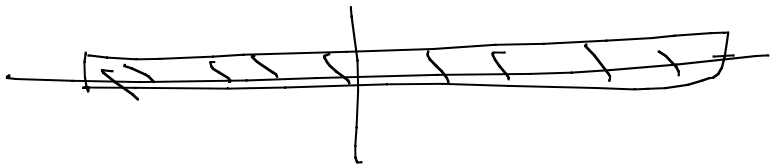




Density $= M/L$

$dm_i = \frac{M}{L} \cdot dx_i$

Also:



Do this as
two small sticks!

Next time