Phys 2110-5 10/29/12

Note Title 10/29/2012

Kinematics, θ, ω, α

10.18 Turbine accl's from rest at $0.52 \frac{rad}{s^2}$

a) How long it take to reach 3600 rpm?

b) How many rev's does it make during this time?

$= 3600 \text{ rpm} \left(\frac{2\pi \text{ rad}}{1 \text{ rev}}\right)$

$\therefore \left(\frac{1 \text{ min}}{60 \text{ sec}}\right)$

$= 377 \frac{rad}{s}$

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

$$t = \frac{\omega - \omega_0}{\alpha} = \frac{377 \frac{rad}{s} - 0}{0.52 \frac{rad}{s^2}} \approx 12 \text{ min}$$

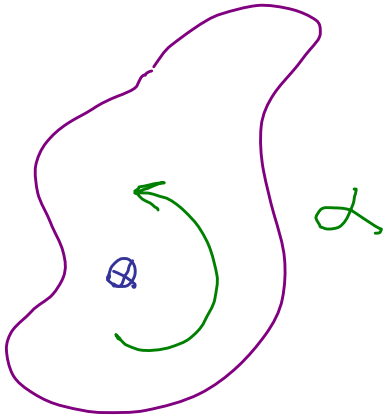
b) Find θ $(\theta_0 = 0)$

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

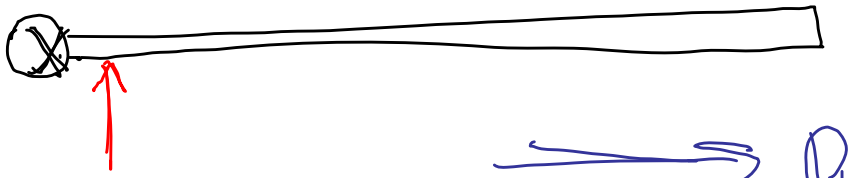
$$= 0 + \frac{1}{2}\left(0.52 \frac{rad}{s^2}\right)(720 s)^2$$

$$= 1.37 \times 10^5 \text{ rad} = 2.17 \times 10^4 \text{ rev}$$

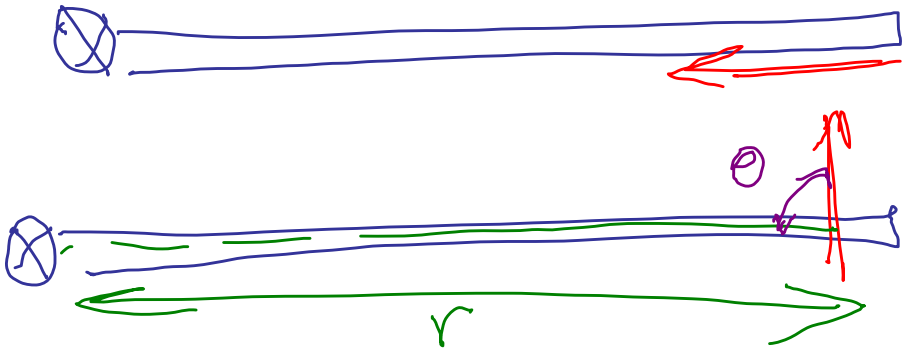
Why is there angular acceleration?



Forces Yes, but ...



→ Push far from axis



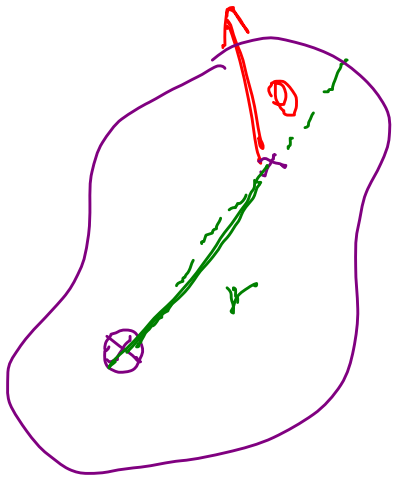
Get α,
Push far from axis r
Want sinθ to be big.

To open doors secret to success:

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

p. 158

Torque (exerted by F on rotating)



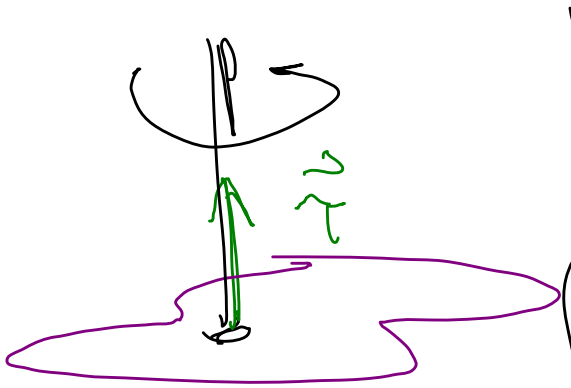
$$|\tau| = |r F \sin\theta|$$

$\Rightarrow$ Yo put in proper sign for what torque does.

What is torque

Scalar, for scalar

(+/−).



"Moment of the force"

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

Units?

Units?

$$[\tau] = m \cdot N \cdot 1$$

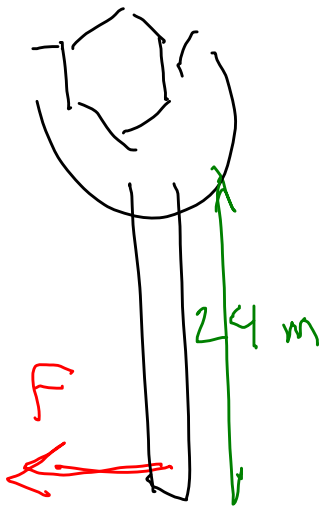
$$= N \cdot m = J$$

Torque is not energy. Say $N \cdot m$

English Unit ft·lb Torque lb·ft

Torque depends on where force applied & direction.

10.22 Tighten spark-plugs to torque of 35 Nm.
Pull on end of 24-cm long wrench at
a) Rt angle to shaft
b) At 110° to shaft.



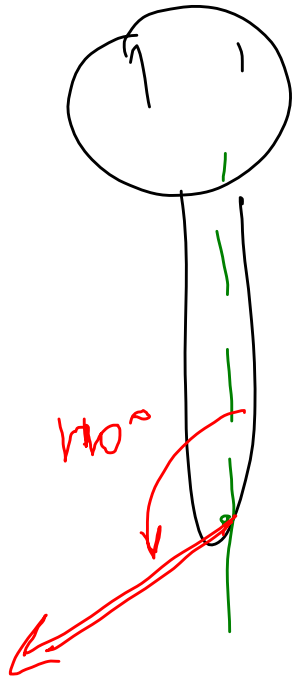
a) $\tau = 35\ N\cdot m = Fr\sin\theta$

$= F(0.24\ m) = 146\ N$

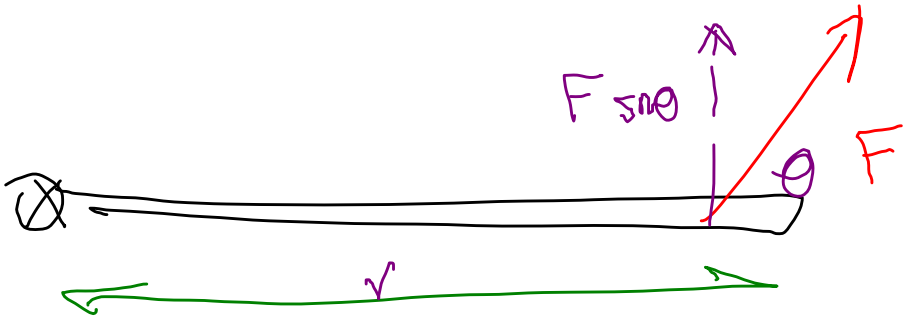
$$\tau = rF\sin 110^\circ = 35\ N\cdot m$$

$$r = 0.24\ m$$

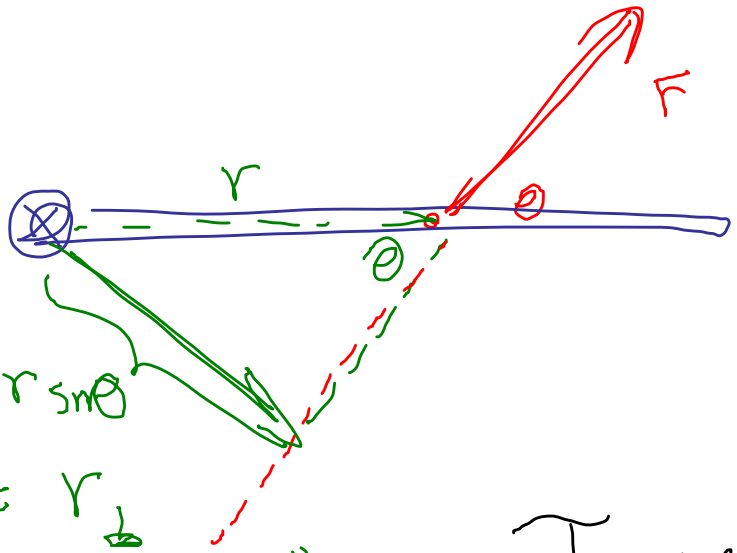
$$\Longrightarrow \boxed{155\ N}$$



For torque only perp part of force matters



$$\tau = r\underbrace{F\sin\theta}_{F_\perp} \qquad \tau = rF_\perp$$

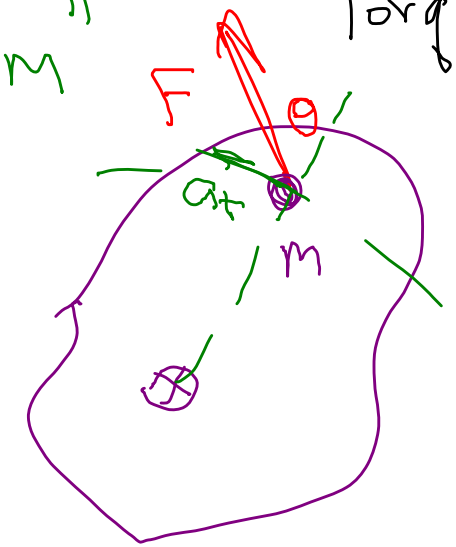


"lever arm"

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

$\tau = F\, r_\perp$

Torque - huh! What's it good for?



Force F will give m a linear accel. (also angular accel)

$F_t = m a_t$

$$F_\perp = m a_t$$

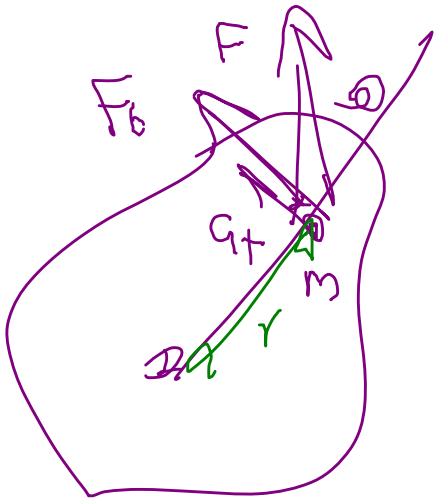
$$F \sin\theta = m r \alpha$$

Mult both sides by r

$$r F \sin\theta = m r^2 \alpha$$

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

τ = F, $m r^2$ = m, α = a



$$a_t = r \alpha$$

$$F = m a$$

Correct relation comes summing over all mass points

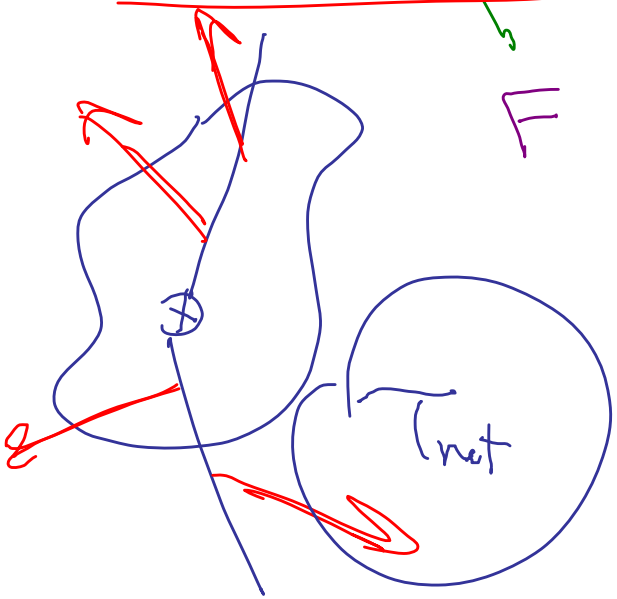
$$\tau_{net\ (ext)} = \left(\sum m_i r_i^2\right) \alpha$$

$$F = m a$$

same for all mass points

call this I, moment of inertia, rotational inertia

What I? Discuss



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

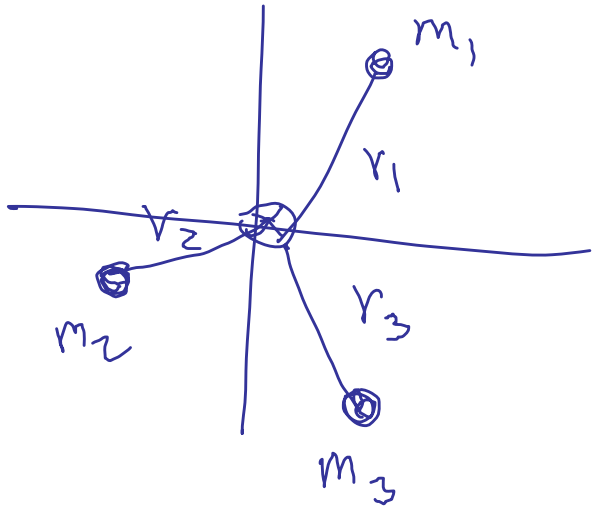
Scalar

Matrix

Units ?

mr^2

kg m^2



$m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2$

Next time examples !