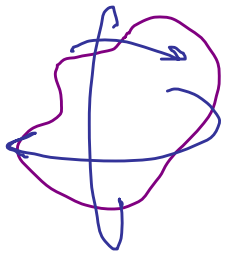
Phys 2110-4 10/28/11

Note Title 10/28/2011

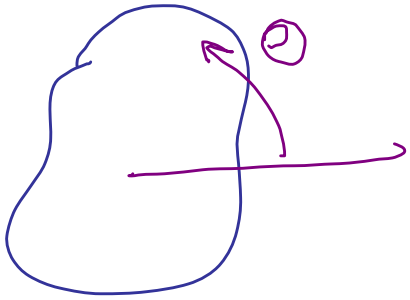
Chap 10 Rotational Motion



Kiematics Ang. Accel α

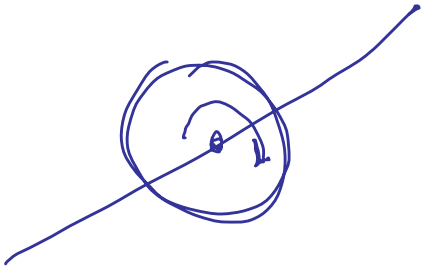
Dynamics Torque, Rot'l KE

Ch 11 More topics (Ang. Mom)



θ is in radians

$$\omega = \frac{d\theta}{dt} \qquad \alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$$



special

Imp't case: α is const.

10.19 A ~~merry-go-round~~ turbine starts from rest & accelerates with ang. accel $0.52\ rad/s^2$ a) How long it take to reach 3600 rpm op. speed. b) What's its avg. angular speed?

const. α

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

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

$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

$$3600\ \frac{rev}{min} \cdot \frac{1\ min}{60\ s} \cdot \frac{2\pi\ rad}{1\ rev}$$

$$= 377\ rad/s$$

$$= \omega$$

Solve for t:

$$\omega = 377 \frac{rad}{s} = \omega_0 + \alpha t = 0 + \left(0.52 \frac{rad}{s^2}\right) t$$

$$t = 725\,s \cong 12\,min$$

$$\omega_a = \frac{1}{2}\left(377 \frac{rad}{s}\right) = 188 \frac{rad}{s}$$

b) Right question: How many rev's it make?

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\left(0.52 \frac{rad}{s^2}\right)(725\,s)^2$$

($\theta_0 \to 0$, $\omega_0 t \to 0$)

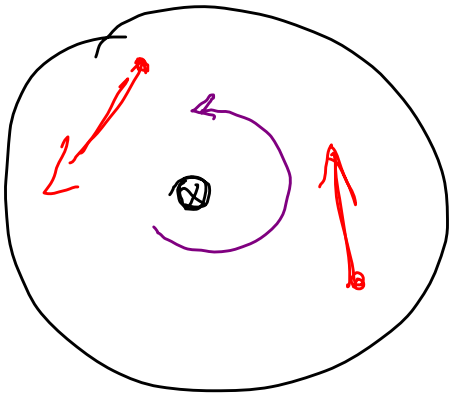
$$= 137\,rad \left(\frac{1\,rev}{2\pi\,rad}\right) = 2.2 \times 10^4\,rev$$

$\times 10^5$

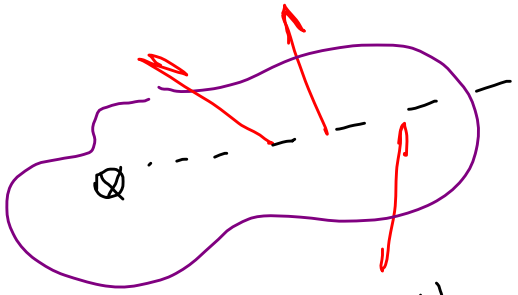
10.19 M-g-R Accel's at $0.01\ rad/s^2$ for 14 s. Starts from rest

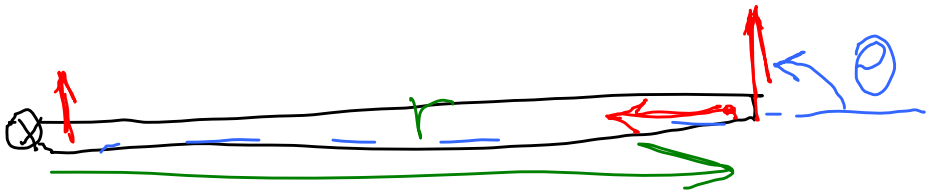
$\omega_0 = 0$ $\alpha = const = 0.010\ rad/s^2$

θ, etc $\omega_{avg} = \frac{\Delta\theta}{\Delta t} = \frac{1}{2}(\omega_0 + \omega)$



Why does it speed up? (Forces)





What matters:

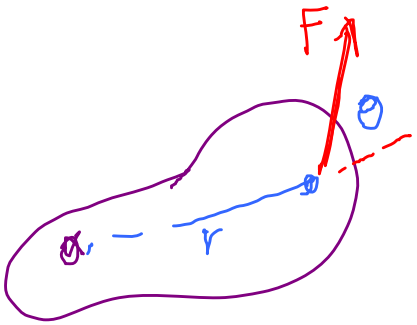
r distance from hinge

θ angle of push, sin θ

Important quantity is product:

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

(tau) torque, moment of the force



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

Sign: + if ccw
— if cw

pos or neg

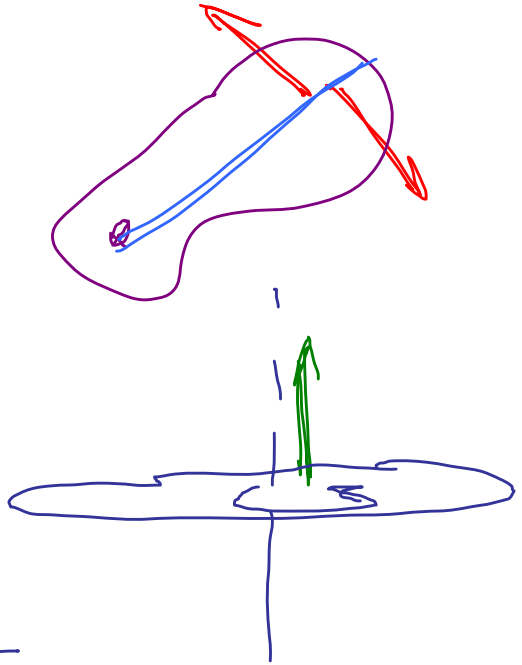
Scalar (Really vector!)

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

$[\tau] = m \cdot N \cdot = N \cdot m \stackrel{?}{=} J$

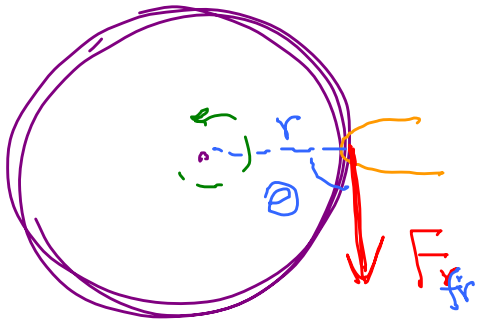
Use this

English Work ft·lb (!)
Torque lb·ft



Later (Ch 11) $\vec{\tau} = \vec{r} \times \vec{F}$

10.20 A 320-N frictional force acts on rim of 1.0 m – diameter wheel to oppose its rot. motion. Find the toque.



$\tau = (0.50\text{m})(320\text{N})(-1)$

$= -160\ \text{N}\cdot\text{m}$

10.22 You need tighten spark plugs to a torque of 35.0 N·m. To achieve this with what force you pull on end of 24-cm long wrench if

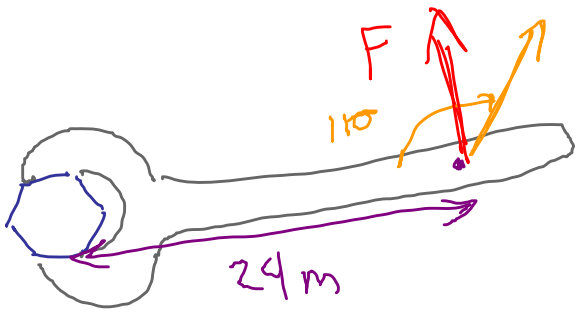
a) Pull at rt. angle

b) Pull at 110° from wrench shaft:

a) $35\ \text{N m} = Fr\sin\theta$

$= F(0.24\ \text{m})(1)$

$F = 146\ \text{N}$



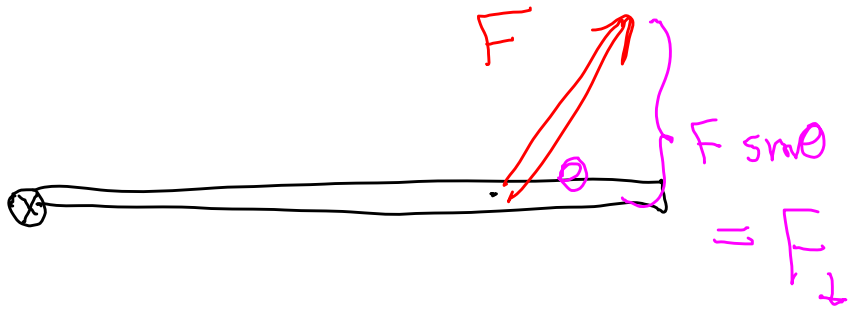
$$\tau = 35\ \text{N}\cdot\text{m} = F r \sin\theta$$

$$= F\,(0.24\,\text{m})(\sin 110^\circ)$$

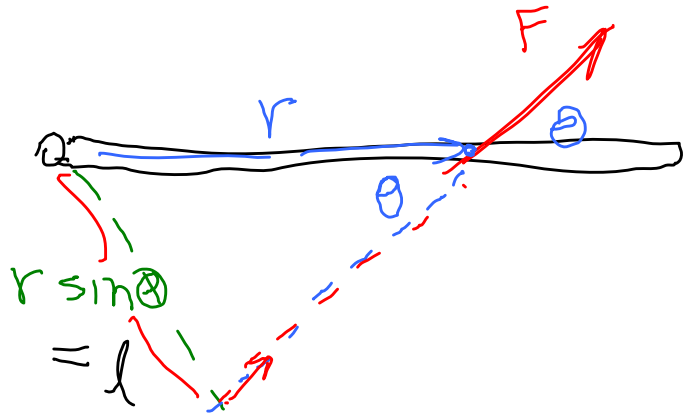
$$\boxed{F = 155\ \text{N}}$$

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

$$= r F_\perp$$



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

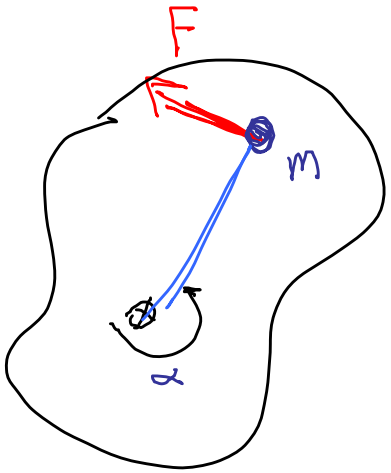


What gives angular accel?

$F_t = m a_t$ $\qquad a_t = r\alpha$

$F_t = m r \alpha$

Multiply by r



$$r F_{\perp} = m r^2 \alpha$$

τ — angular

Recast Newton's law in rotational language

$$\tau = m r^2 \alpha$$

F — m — a

Do more next

$\Longrightarrow$ Moment of Inertia.