Physics 101

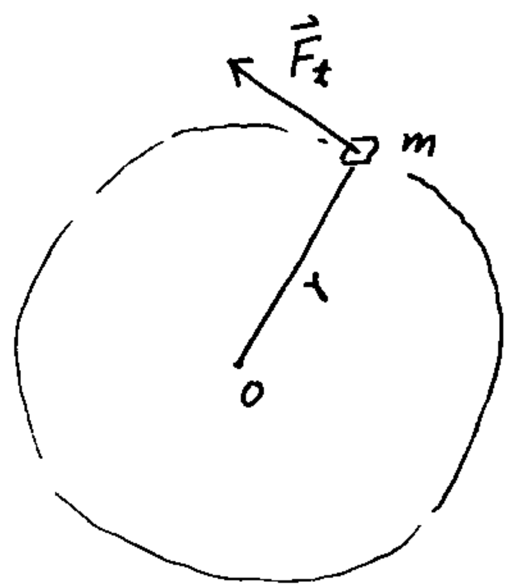
Lecture 17

Wed. Feb. 11, 2004

Topics : Rotational Dynamics
static equilibrium of a rigid body

Ref : 11-1, 2, 3, 4, 5.

- Tangential acceleration



$$a_t = \frac{F_t}{m}$$

$$r\alpha = \frac{F_t}{m}$$

$$\alpha = \frac{F_t}{mr} = \frac{rF_t}{mr^2} = \frac{\tau}{I}$$

α — angular acceleration
I — moment of inertia
τ — rF_t Torque

all about the same axis of rotation.

- Newton's Law for rotation

$$\tau = I\alpha.$$

(1-D. linear case $F = ma$)

τ — Net torque

- Sign of Torques : + c.c.w. ↺
  − c.w ↻.

- Torque of a force

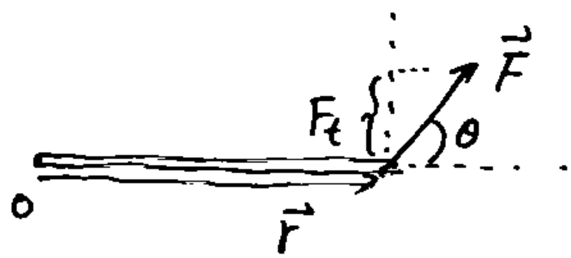
e.g.: Opening a Door.

<1>. when $\vec{F} \perp \vec{r}$.

i.e., $\vec{F} = \vec{F}_t$.

$\tau = r \cdot F_t$ $\qquad$ F_t — tangential force.

<2>. when $\vec{F}$ is not $\perp$ $\vec{r}$.



Only the tangential component of the force contribute to the torque:

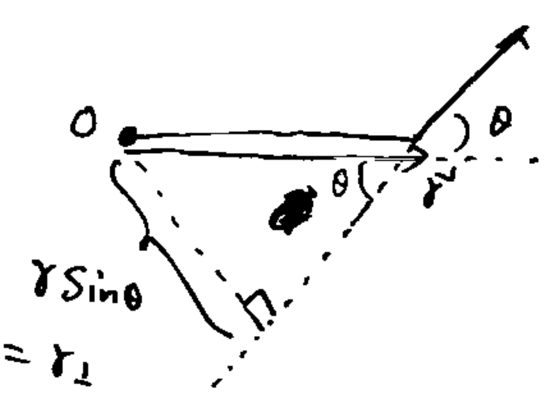
$\boxed{\tau = r F_t} = r \cdot F \cdot \sin\theta$. $\left(\begin{array}{c}\theta \text{ is the angle between} \\ \vec{F} \text{ and } \vec{r}\end{array}\right)$

— Another way to view $r \cdot F \cdot \sin\theta$

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

$$= F \cdot r \cdot \sin\theta$$

$$\boxed{\tau = r_\perp F}.$$



$r_\perp$ —— moment arm.

Perpendicular distance from O to the $\vec{F}$-line.

e.g. #19. of Fall-2002 final exam. (a)

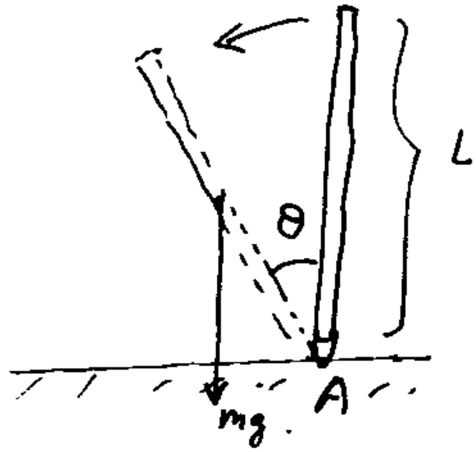
A 16-cm pencil. (uniform rod) is released.

Q: $\alpha = ?$ when $\theta = 30°$.

↑

rotational dynamics problem.

$$\alpha = \frac{\tau}{I}.$$



[redacted] Fixed point : A — axis of rotation.

τ — from gravity only.

(Normal force, frictional force go through A).

$$\boxed{I = \frac{1}{3} m L^2}.$$

$$\tau = mg \underbrace{\frac{L}{2} \cdot \sin\theta}_{r_\perp \text{ — moment arm}}.$$

$$\therefore \quad \alpha = \frac{mg \frac{L}{2} \cdot \sin\theta}{\frac{1}{3} m L^2}$$

$$= \frac{3 g \sin\theta}{2L}$$

$$= 46 \text{ rad/s}^2.$$