Introduction to Torque and Rotational Statics

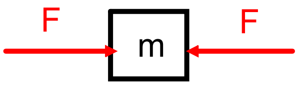
Outcomes:

- Students will know and be able to explain the difference between translational and rotational motion and the conditions under which they occur.
- Students will be able to calculate torque in simple situations

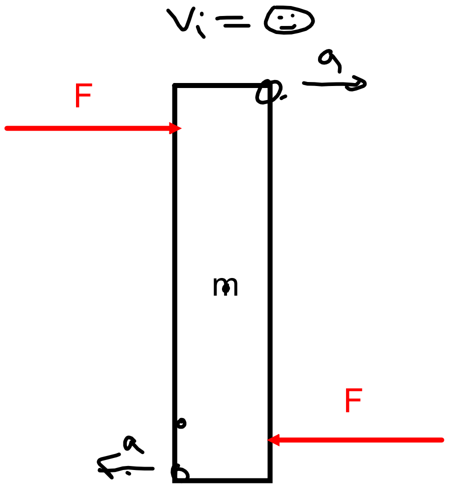
Recall: Newton's 2nd law (constant mass)

$$\Sigma\vec{F} = m\vec{a}$$

$v_1 =$ ☺



Consider the following situation:



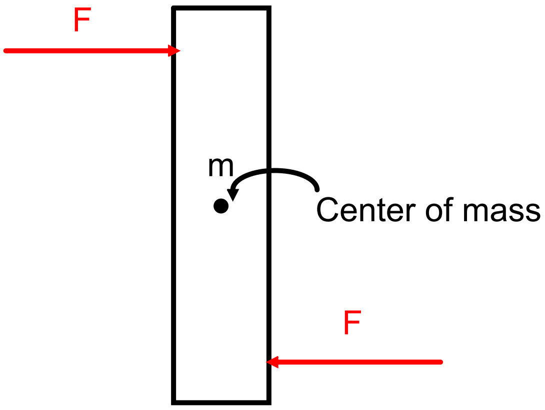
$\sum \vec{F} = m\vec{a}_{cm}$

However, Newton's 2nd Law is insufficient to define static equilibrium

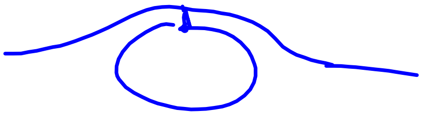
What happens? (Try it with a calculator or pencil....)

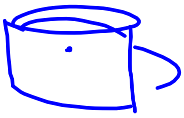
Was Newton wrong???

Rotational vs. Translatory motion



A couple of center of mass experiments....





Torque

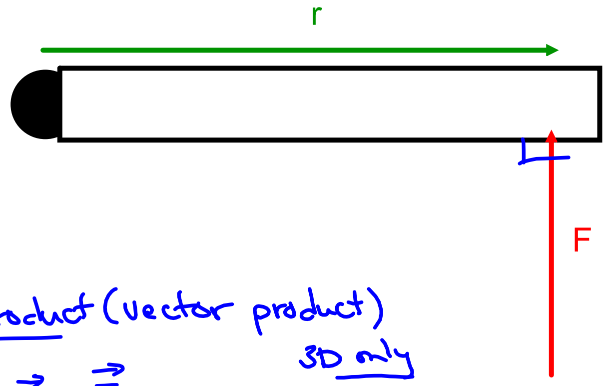
$$\tau = r_{\perp}F = rF_{\perp}$$

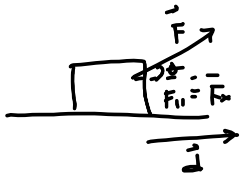
τ = tau

N·m ≠ J

$W = F_{\parallel} d$

units: N·m = J





$(|\vec{F}|\cos\theta)(|\vec{d}|)$

$|\vec{F}||\vec{d}|\cos\theta$

Cross product (vector product)

3D only

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

$|\vec{\tau}| = |\vec{r}||\vec{F}|\sin\theta$ ← angle between $\vec{r}$ and $\vec{F}$

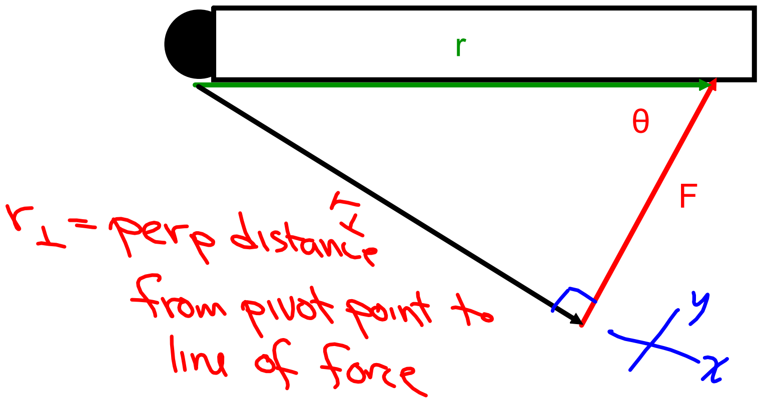
Dot product (scalar product)

$W = \vec{F} \cdot \vec{d}$

$= F_x d_x + F_y \cancel{d_y} + F_z \cancel{d_z}$

$= F_x d_x$

Force at a non-90° angle

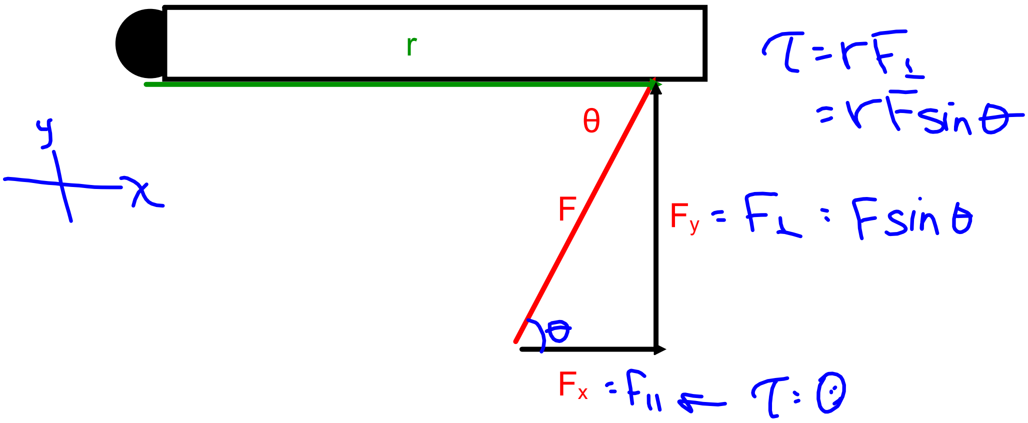


$r_\perp$ = perp distance from pivot point to line of force

$r_\perp = r \sin\theta$

$r_\perp F = rF \sin\theta$

Or Alternatively



$\tau = rF_\perp$

$= rF\sin\theta$

$F_y = F_\perp = F\sin\theta$

$F_x = F_\parallel \leftarrow \tau = 0$

Homework: 1, 3-5