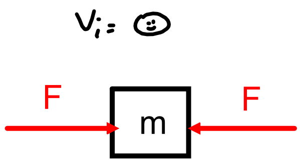
Introduction to Torque and Rotational Statics

Outcomes:

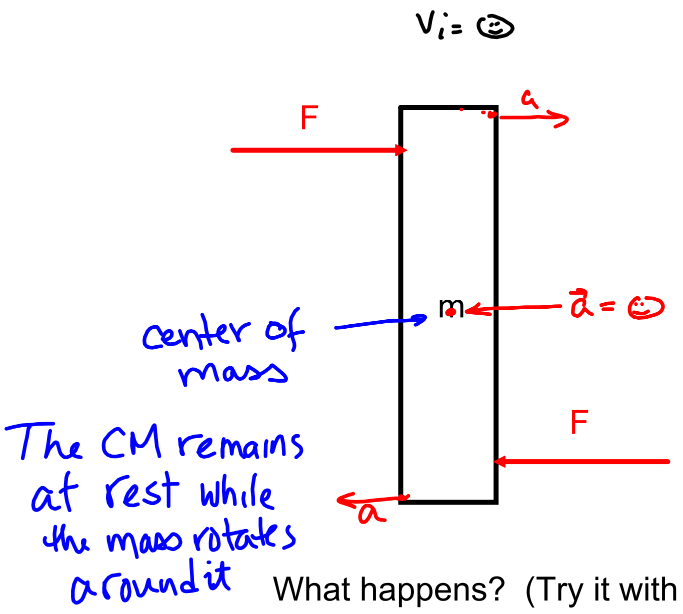
- Students will know and be able to explain the difference between translational and rotational motion and the conditions under which they occur.
- Students will be able to calculate torque in simple situations

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

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



Consider the following situation:



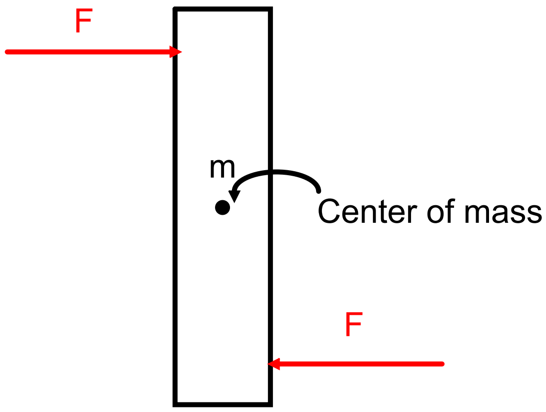
Newton's 2nd law isn't sufficient for static equilibrium

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

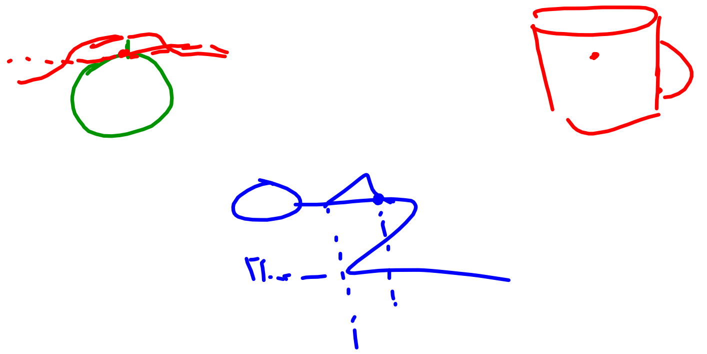
Was Newton wrong???

Rotational vs. Translatory motion

↳ linear



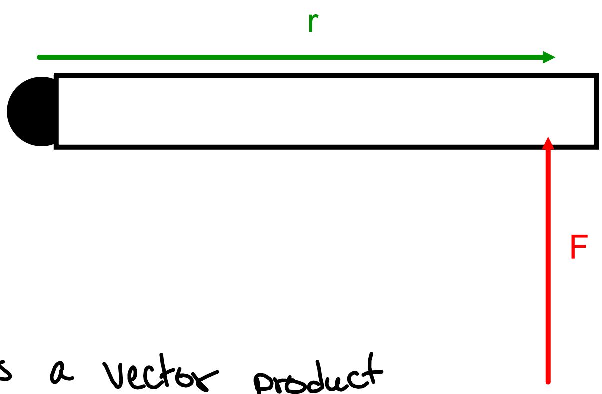
A couple of center of mass experiments....



Torque

$$\tau = r_\perp F = r F_\perp$$

τ = tau



Recall

$W = F_\parallel d$

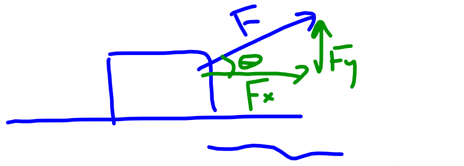
$W = F d_\parallel$

really

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

scalar product ↑ dot product

$W = F_x d_x + F_y d_y + F_z d_z$



$d = d_x$ $d_y = 0$

$W = F_x \cdot d$

$W = (F\cos\theta)\, d$

$= F d \cos\theta$

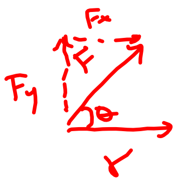
Units: N·m = J

Torque is a vector product

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

↑ cross product

$|\vec{\tau}| = |\vec{r}||\vec{F}| \sin\theta$

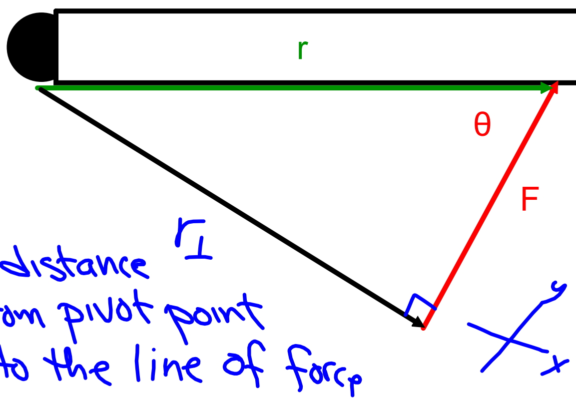


$|\vec{\tau}| = r F_y$

$F_y = F \sin\theta$

Units: N·m ≠ J

Force at a non-90° angle



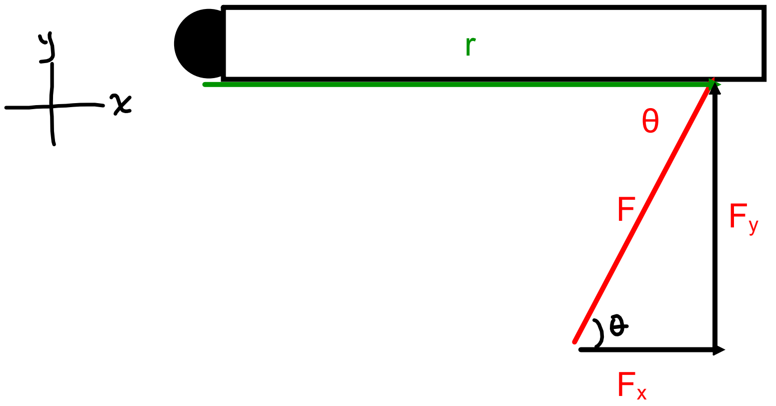
$r_\perp$ = ⊥ distance from pivot point to the line of force

$r_\perp = r\sin\theta$

$\tau = r_\perp F$

$= rF\sin\theta$

Or Alternatively



$$\tau = rF_\perp$$
$$= rF_y$$
$$= rF\sin\theta$$

Homework: 1, 3-5