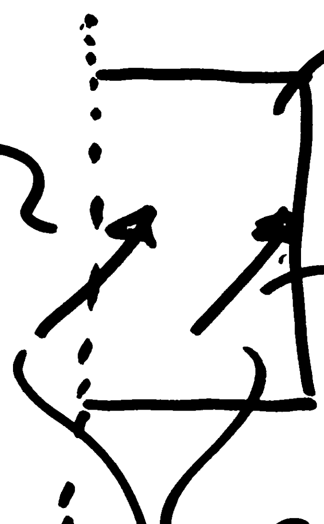
2013-10-24

Me : Gabe

Today : Torque and "Statics problems"

What *is* this?



free swinging door

hinge

"Leverage"

to have the door swing, I can apply a smaller force if the contact point is further from the hinge

Forces being applied "into the page", i.e. ⊥ door

Another way to think about this....

<u>If</u> <u>I</u> apply equal forces (not simultaneously), one close to the hinge and one far from the hinge, the door will "rotationally accelerate" more ~~due to~~ when the $\vec{F}$ is applied further from the hinge.

In principle, we could discuss the kinematics of rotation and define rotational versions of velocity and acceleration .... BUT we won't.

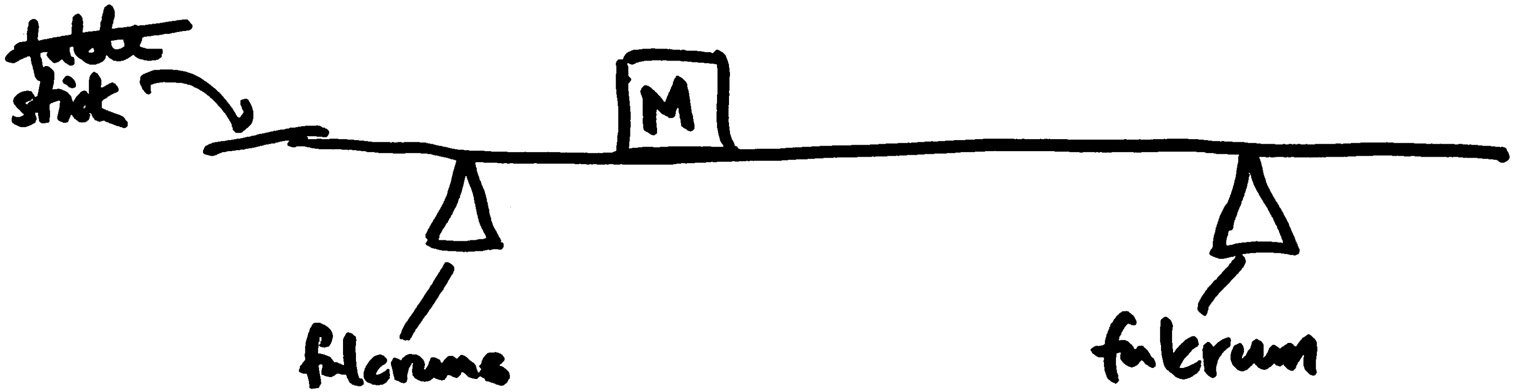
i.e. degrees/sec   i.e. degrees/sec^2

Instead, we're going to restrict attention to situations in which bunches of <u>extended objects</u> (non-point masses) could rotate but don't b/c of the way they're configured.

$\underbrace{\qquad\qquad\qquad\qquad\qquad\qquad}$

Statics problems

<u>Quintessential</u> <u>example</u>: Sawhorse



what I meant above:

Say I kick out the right fulcrum... everything would rotate. But it isn't → statics :)

We need to introduce a new concept in order to analyze statics problems.... namely, torque.

To help explain torque, let me ask a refresher question:

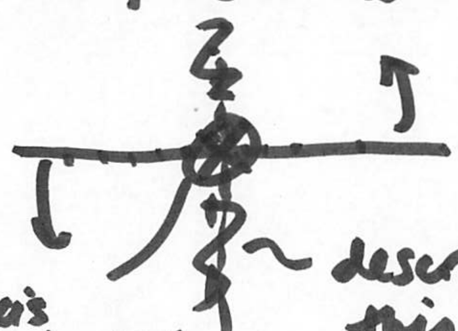
Why / when do objects accelerate?

When there's a net Force on the obj

Rotational version:

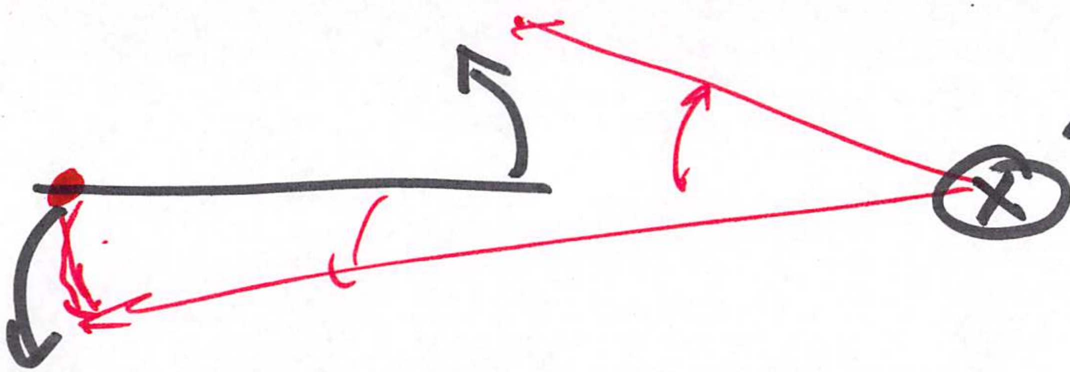
Why / when do extended objs rotationally accelerate?

Before we answer... there's a subtlety.



axis into the page

~ described as rotation around the dashed axis, this motion ~~[illegible]~~ can be described simply



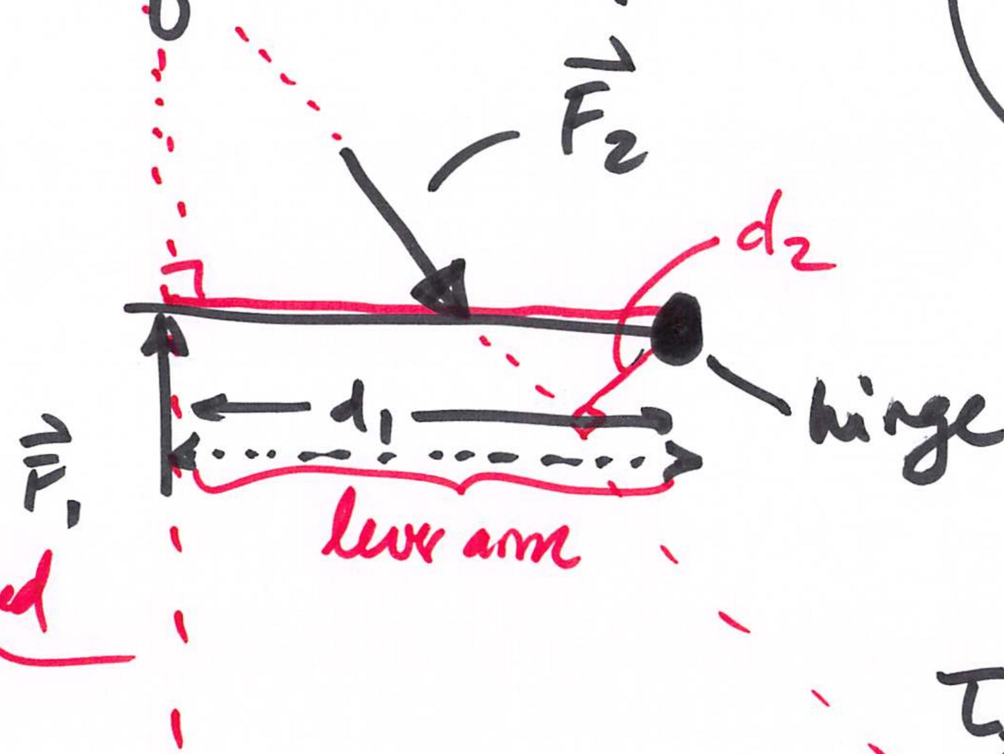
Around this axis, things are messier to describe .. but it's doable in principle.

Moral of the story: You can <u>CHOOSE</u> any axis you want to (even non-obvious ones that don't pass through a rotating body) to describe rotation. Some are easier to use than others. Choose wisely (just like coord systems in force problems)

So what's torque?

(τ) Torque (def'n) = Force applied × "lever arm" around your designated rotation axis

shortest dist b/w the "extended line" of the force and the rot. axis

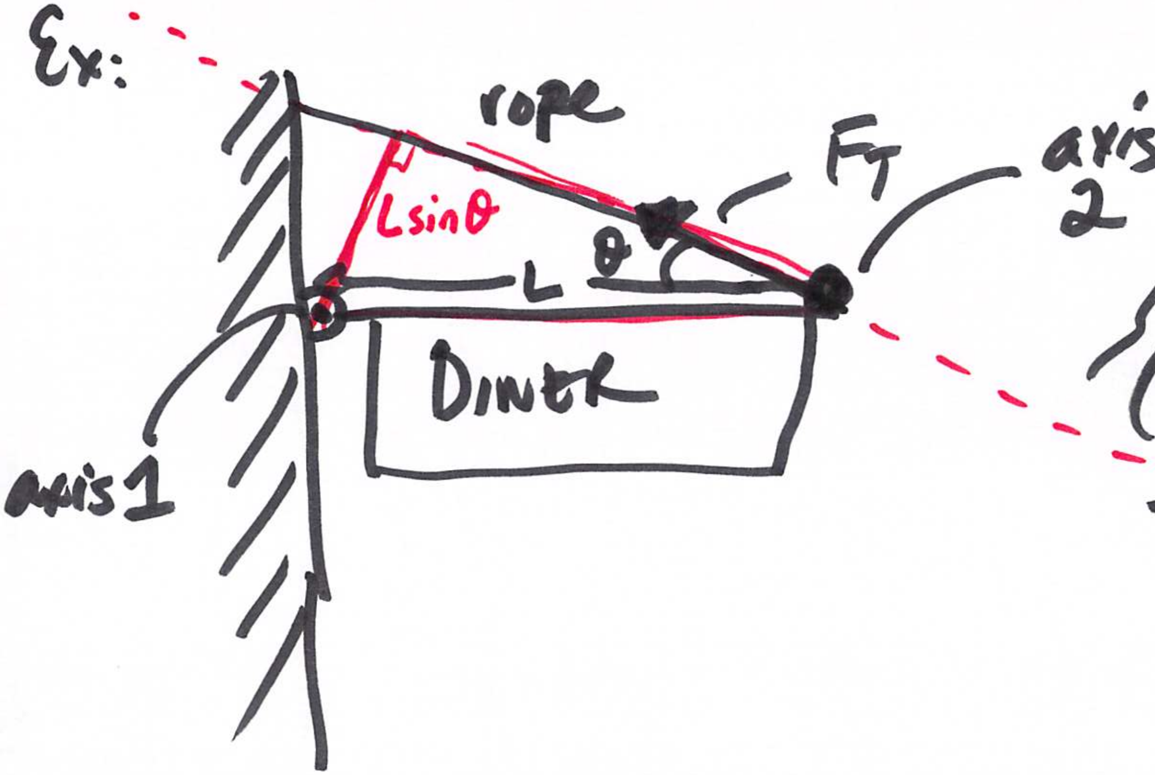


$\tau_2 = F_2 \cdot d_2$ (+)

$\tau_1 = F_1 \cdot d_1$

Torque also has a sign −, +
clockwise, counterclockwise
or vice versa (be consistent)

Ex:



Rope applies a Force (tension)

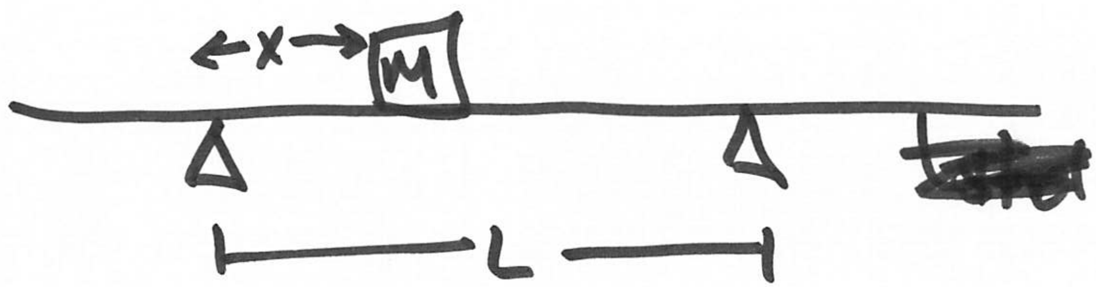
(other forces are here, ~~too~~ but just focus on the rope for now)

$\tau_{rope} = ?$ Around what axis???

$$\tau_{rope,\ axis\ 1} = F_T \cdot L\sin\theta \circlearrowright$$

$\tau_{rope,\ axis\ 2} = 0 \rightarrow$ if Force line passes thru an axis, torque around that axis = 0.

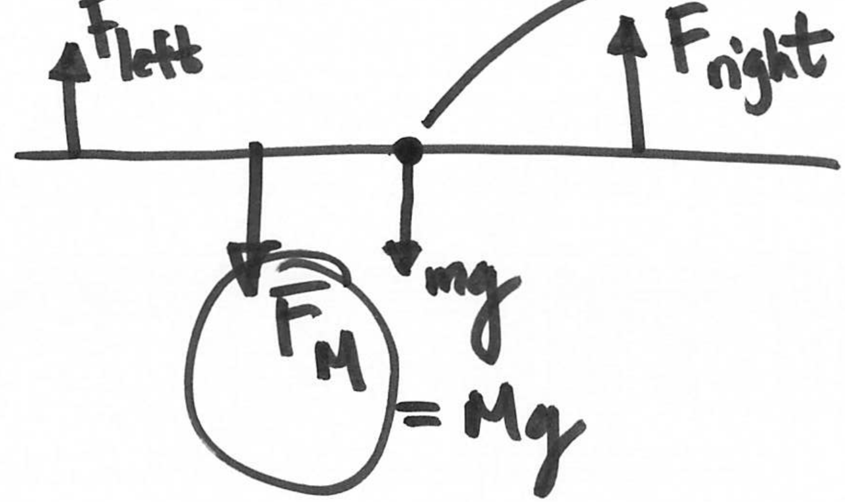
Back to the sawhorse . .



m = mass of stick
(m really small)

Questions:

- what are the forces on the stick ?



center of mass of stick (at middle b/c the stick is uniformly dense)

$F_{\substack{\text{right}\\ \text{on stick}}} = ?$

Problem solving options:

① $\vec{F}_{\substack{\text{net}\\ \text{on stick}}} = 0$

$F_{\text{left}} + F_{\text{right}} - mg - Mg = 0$

Not enough

NOTE: We choose the left fulcrum as our rotation axis so that F_{left} won't enter our eq'ns.

+

② $\underbrace{\tau_{\substack{\text{net on}\\ \text{stick}}}}_{\text{(around left fulcrum)}} = F_{\text{right}} \cdot L - mg\frac{L}{2} - Mgx + F_{\text{left}} \cdot \underline{\underline{0}}$

$\therefore 0 = F_{\text{right}} \cdot L - mg\frac{L}{2} - Mgx$ → solvable for F_{right}.