PHYS 2010 LECTURE 30

[EXAM APRIL 11: SPECIAL CASES NEED TO INFORM ME NOW. MATERIAL THROUGH CHAPTER 8. INCLUDES THIS LECTURE!]

Starting to address the physics of rigid bodies. These are objects that can not only translate (move through space) but also rotate.

Start with no motion:

For an object to be in static equilibrium, it must be neither translating nor rotating.

Not translating: $\Sigma \vec{F} = 0$ Net force is zero

Not rotating: $\Sigma \vec{\tau} = 0$ Net torque is zero

Torque is the rotational equivalent of force. It is a vector, but we won't use its vector properties very much.

Torque has to be defined about an axis — pick it for calculation convenience:

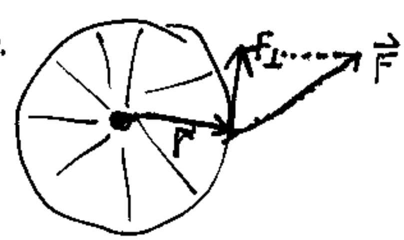
$$|\tau| = r F_{\perp}$$

Unit: τ = (length)(force) = N·m (or ft·lbs)

r = lever arm: distance from axis to force action point

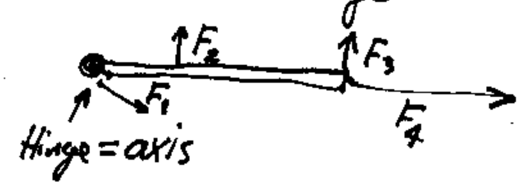
$F_{\perp}$ = component of force perp. to both $\vec{r}$ and axis.

Example: wheel on a fixed axis:



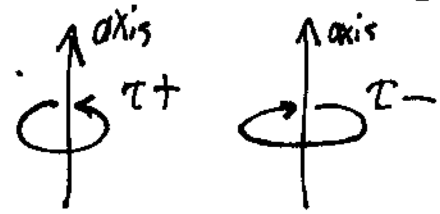
$\vec{F}$ Components in $\vec{r}$ direction or into the page have no effect on torque.

Example: Door on hinge

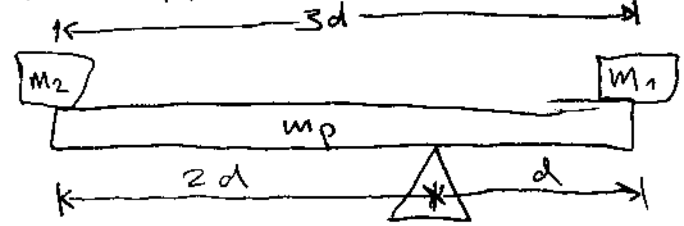


Which is the biggest torque?

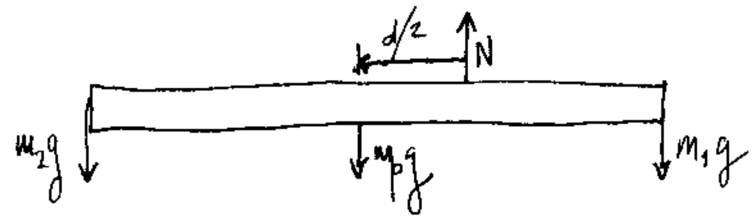
Sign of torque: right-hand rule.



Torque in static equilibrium: Example of a plank on a fulcrum:



Where are forces acting? View using <u>extended</u> free-body diagram:



* Gravity can be treated by assuming it acts at the <u>center of mass</u>. Can often be found easily by symmetry.

Static equilibrium conditions: $\sum F = 0 \Rightarrow N - (m_1 + m_p + m_2) g = 0$.

$\sum \tau = 0$: Calculate torques about <u>fulcrum</u> axis.

$$0 = (+m_2 g)(2d) + (+m_p g)\left(\frac{d}{2}\right) - (m_1 g)(d)$$

Cancel g, d by dividing both sides by gd.

$$2m_2 - \frac{1}{2} m_p - m_1 = 0 \Rightarrow m_1 = 2m_2 + \frac{1}{2} m_p$$