Making Things Rotate

How do you make an object rotate?

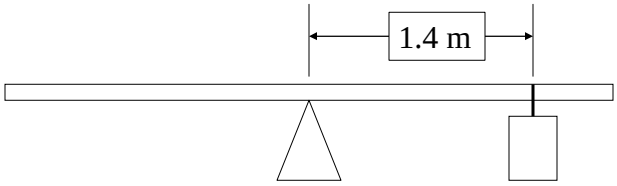
- Apply a force at point on the object other than its center of gravity.
- This quantity is defined as the torque on an object.

$$\tau = Fr$$

Where F is the force applied perpendicular to the surface of the object and r is the distance from the center of gravity to the point the force is being applied,

Example

- What torque will applied by the 5.3 kg bucket when it is placed on the lever?



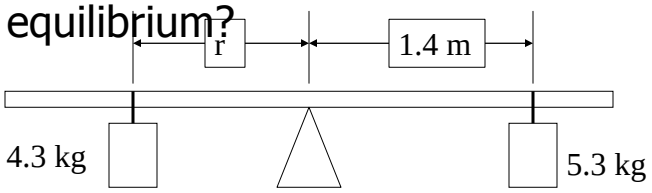
$$\tau = Fr = (5.3kg)(9.8\frac{m}{s^2})(1.4m) = 72.7N \cdot m$$

Rotational Equilibrium

- Like translational equilibrium and net force, rotational equilibrium is the non-rotating state of an object when the net torque is zero.

Example

- Where would a 4.3 kg bucket need to be placed to place this system in equilibrium?



$$\tau_{net} = 0$$

$$Fr = Fr$$

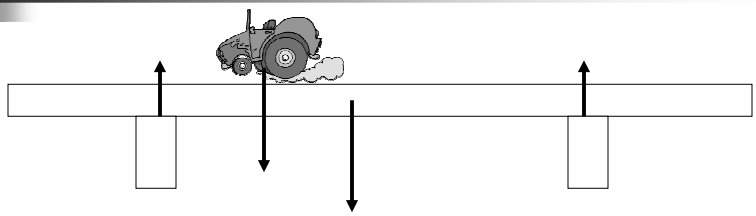
$$(4.3kg)(9.8\frac{m}{s^2})r = (5.3kg)(9.8\frac{m}{s^2})(1.4m) \Rightarrow \boxed{r = 1.7m}$$

Structures and Torque

- When constructing structures, especially bridges, engineers must be aware of all types of forces that may be applied.

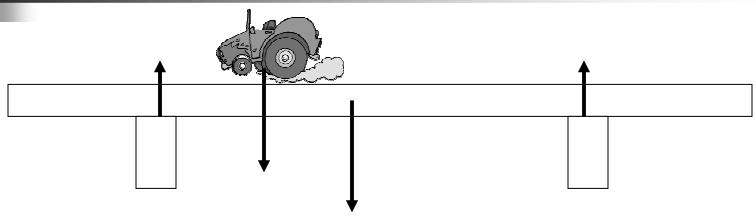
Torque on Bridges

or any other structure with two supports



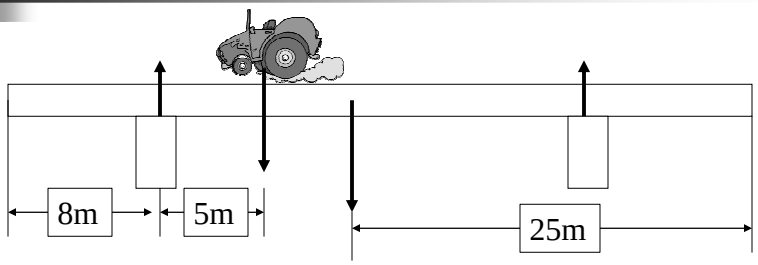
- What forces are acting in the vertical direction?
  - Car's weight
  - Bridge weight
  - Column support

Torque on Bridges



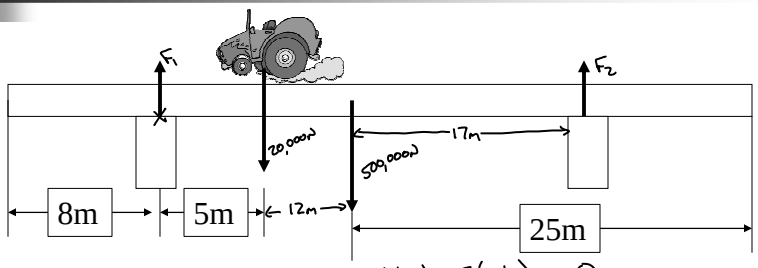
- The bridge must be in both translational and rotational equilibrium. Why?
  - It's not moving

Torque on Bridges



- Lets say that the car has a weight of 20,000 N and the bridge weighs 500,000 N, how is the weight distributed on the two columns?

Torque on Bridges



$(20{,}000\text{N})(5\text{m}) + (500{,}000\text{N})(17\text{m}) - F_2(34\text{m}) = 0$

$100{,}000\text{ N·m} + 8{,}500{,}000\text{ N·m} - 34F_2 = 0$

$-34F_2 = -8{,}600{,}000$

$F_2 = 252{,}941\text{ N}$

$F_1 + F_2 = 520{,}000\text{N}$

$F_1 + 252{,}941\text{ N} = 520{,}000\text{N}$

$F_1 = 267{,}059\text{ N}$

Other "Forces"

- Stress
  - The measure of force per unit area causing a deformation
- Strain
  - Relative measure of deformation a stress causes
  - Deformation can cause a change in length, shape, or volume

Other Rotational/Angular Motion

- Inertia
- Work and Energy
- Momentum

Return to Honors Physics Notes