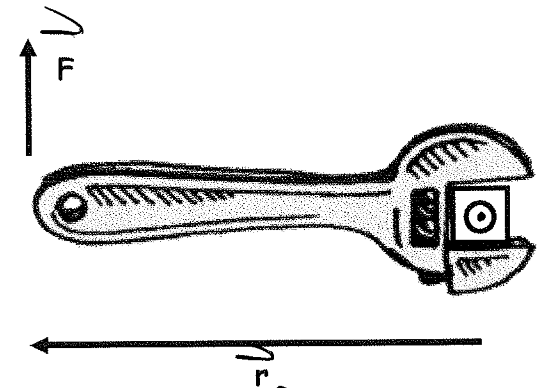
Torque

Key

I. Torque

A. The rotational equivalent of force is <u>torque</u>. Its symbol is <u>τ</u>. (tau)

applied force



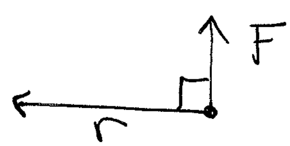
lever arm - distance from rotational axis

B. Torque = lever arm (r) x perpendicular force (F).

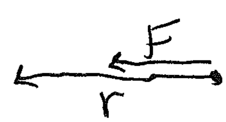
$$\boxed{\tau = rF\sin\theta}$$

Put $\vec{r}$ & $\vec{F}$ tail to tail

C. When θ = 90°, $\tau = rF$



When θ = 0°, $\tau = 0$



Torque is a maximum when θ = <u>90°</u>.

II. Rotational Equilibrium

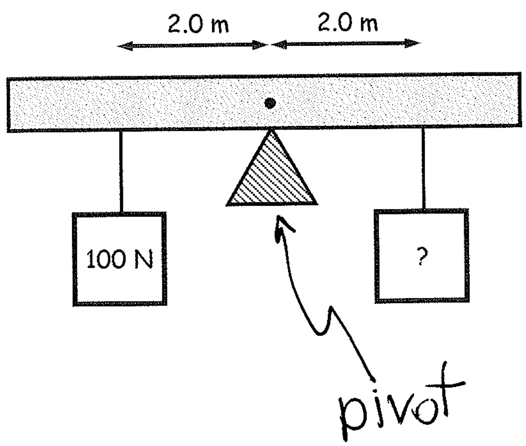
A. In rotational equilibrium, $\sum_i \tau_i = 0$

In other words, the clockwise torques = the counterclockwise torques

$$\tau_{cw} = \tau_{ccw}$$

B. Examples of rotational equilibrium: Balance the torques

1.

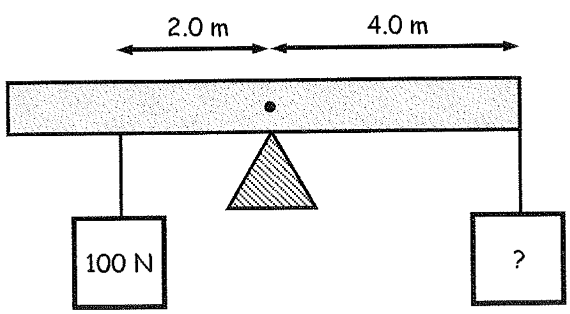


$$\tau_{cw} = \tau_{ccw}$$

$$(2.0\text{m})F = (2.0\text{m})(100\text{N})$$

$$\boxed{F = 100\text{N}}$$

2.

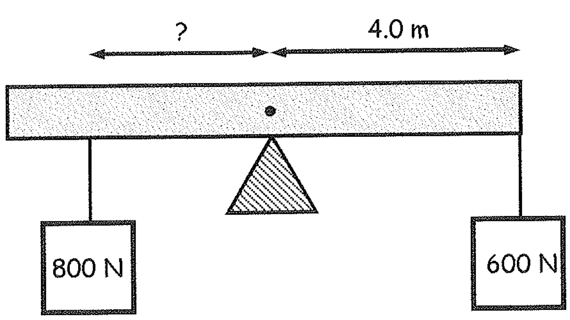


$$\tau_{cw} = \tau_{ccw}$$

$$(4.0\text{m})F = (2.0\text{m})(100\text{N})$$

$$\boxed{F = 50\text{N}}$$

3.

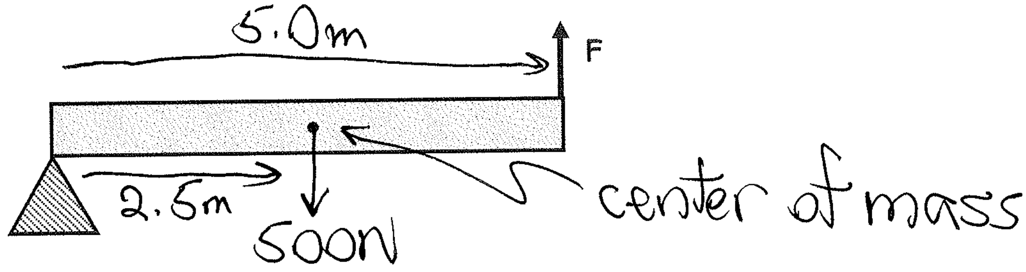


$$\tau_{cw} = \tau_{ccw}$$

$$(4.0\text{m})(600\text{N}) = r(800\text{N})$$

$$\boxed{r = 3.0\text{m}}$$

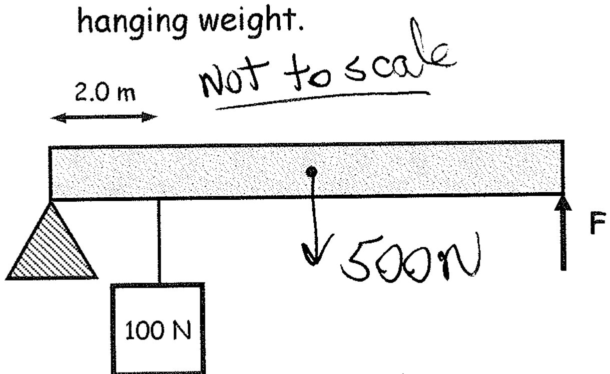
4. Find the force needed to hold the 5.0-meter beam that weighs 500 N level.



$\tau_{cw} = \tau_{ccw}$

$(2.5m)(500N) = (5.0m)F \Rightarrow \boxed{F = 250N}$

5. Find the force needed to hold the same beam level with the addition of a hanging weight.



$\tau_{cw} = \tau_{ccw}$

$(2.5m)(500N) + (2.0m)(100N) = (5.0m)F$

$\boxed{F = 290N}$