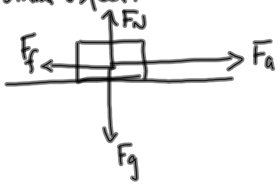
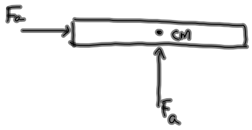
Static Equilibrium + Torque

Consider a small object:

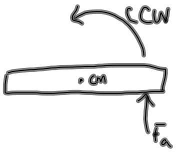


When we draw a FBD we draw all the forces acting through the centre of mass.

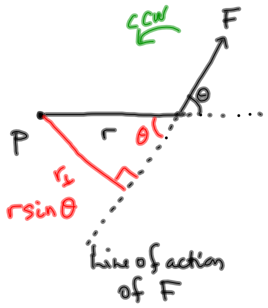
When we are dealing with a large object like a log on ice:



If the force is applied through the centre of mass, then there will be no twisting.



When a force is not applied through the centre of mass, then a twisting occurs. This is referred to as torque.



A force (F) is acting on an object at a distance (r) from the pivot point (P). A twisting action occurs

Torque is found by:

$$\tau = r_\perp F$$

$$\tau = rF\sin\theta$$

where τ is the torque (N·m)
r is the distance from the pivot (m)
F is the force (N)
θ is the angle between F (or the line of action of F) and the object.

By convention,

* torque is + for a CCW rotation
* torque is − for a CW rotation.

If torque is +, then the torque vector is pointing out of the board and if the torque is −, the torque vector is pointing into the board.

(Right-Hand Rule)

* curl your fingers on your right hand in the direction of the twisting..... the direction your right thumb points, is the direction of the torque vector.

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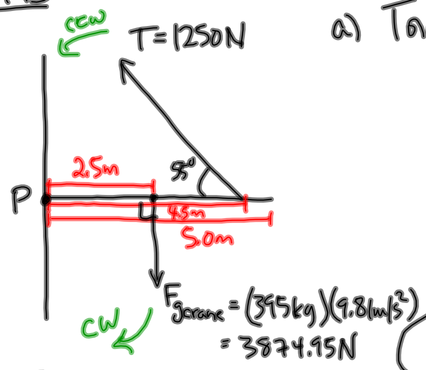

a) Torque due to the Cable:

$\tau = r_{\perp} F$

$\tau = rF\sin\theta$

$\tau = (4.5m)(1250N)\sin 55°$

$\tau = 4.6\times10^3$ N·m

$\tau = +4.6\times10^3$ N·m

↑ + torque since the rotation would be CCW

b) Torque due to weight of crane:

$\tau = r_{\perp} F$

$\tau = (2.5m)(3874.95N)$

$\tau = 9.7\times10^3$ N·m

$\tau = -9.7\times10^3$ N·m

↑ negative since the rotation would be CW

Since the torque from the crane's weight is greater than the torque from the tension in the cable, the crane is <u>not</u> in static equilibrium and the crane would be rotating CW.

In order for there to be static equilibrium:

① $\vec{\tau}_{net} = 0 \quad \left(\Sigma\tau_{ccw} = \Sigma\tau_{cw} \right)$

② $\vec{F}_{net} = 0 \rightarrow \begin{cases} \Sigma\vec{F}_x = 0 \\ \Sigma\vec{F}_y = 0 \end{cases}$

TO DO:

① FOP|86-3|#1

② PP|495

* #30 (take the bottom of the ladder as your pivot)