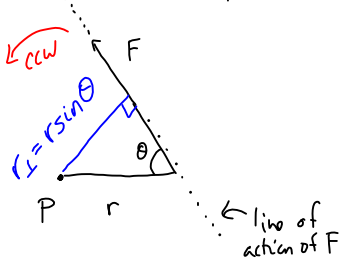
Torque

Torque is the twisting or turning motion of an object. It is caused when a force does not act through the centre of mass of the object.

examples- opening a door, teeter-totter, mobile
lifting a weight with your forearm (elbow is a pivot)
braces, wrench

Consider a force F acting on the object below at a distance r from the pivot point at an angle θ:



$\tau = r_\perp F$

where τ is torque (N·m)

$r_\perp$ is the perpendicular distance to the line of action of the force (m)

F is the force (N)

Torque is a vector quantity. It is perpendicular to the plane that r and F are in. The torque vector is out of the board or into the board and is a result of the twisting motion. By convention a CCW twisting motion corresponds to a positive torque which is a vector point out of the board.

CCW rotation → torque is positive → out of the board ⊙

CW rotation → torque is negative → into the board ⊗

A more general expression for torque:

$\tau = r_\perp F$ but $r_\perp = r\sin\theta$

so $\tau = (r\sin\theta)F$

$\tau = rF\sin\theta$ ← θ is the angle between F and the object.

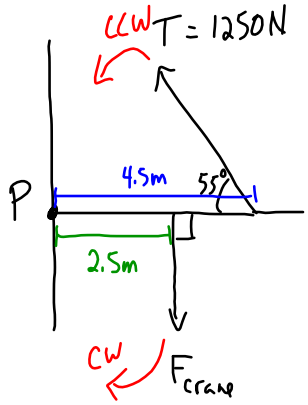
A maximum torque occurs when $\theta = 90^\circ$

A torque of zero occurs when $\theta = 0^\circ$ or 180°

when $r = 0$

when $F = 0$

MP|493



$(395kg)(9.81m/s^2)$
$= 3874.95N$

a) $\tau = rF\sin\theta$

$\tau_T = (4.5m)(1250N)\sin 55^\circ$

$\tau_T = 4.6\times10^3\ N\cdot m$

Since T causes CCW rotation this torque is positive

$\tau_T = +4.6\times10^3\ N\cdot m$

(the torque vector is out of the board)

b) $\tau = rF\sin\theta$ or $r_\perp F$

$\tau_{crane} = (2.5m)(3874.95N)\sin 90$

$\tau_{crane} = 9.7\times10^3\ N\cdot m$

Since the rotation caused by F_{crane} is CW, the torque is negative.

$\tau_{crane} = -9.7\times10^3\ N\cdot m$

(The torque vector is into the board)

Since $\tau_T \neq \tau_{crane}$ (in magnitude)

the crane is NOT in static equilibrium.

Since $\tau_{crane} > \tau_T$ (in magnitude) the crane will be rotating CW (i.e. the net torque $\neq 0$)

TO:

① FOP|§6-3| #1 only.

② PP|495 (hint choose bottom of ladder as pivot in #3)