Torque + Static Equilibrium in Large Bodies

For small objects => $\vec{F}_{net} = 0$ $(\Sigma \vec{F} = 0)$

this is a sufficient condition for static eq.

For larger objects => $\vec{F}_{net} = 0$ and $\vec{\tau}_{net} = 0$

↳ because $(\Sigma \vec{F} = 0)$ $(\Sigma \vec{\tau} = 0)$

of the twisting, we need more than $\vec{F}_{net} = 0$

* all the forces do not act through a common point

$\tau = r_\perp F$

$\tau = r F \sin\theta$

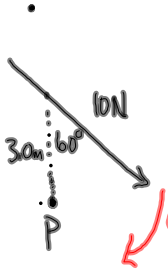
↑ always $\sin\theta$ if you use the angle between the force or line of action of the force and the object.

Torque will be a maximum when the force acts on the object perpendicularly.

Torque will be ZERO when θ is $0°$ or $180°$

FOP

1. b)



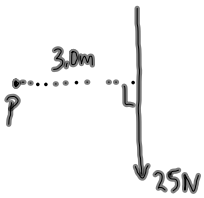
$\tau = r F \sin\theta$

$\tau = (3.0\text{m})(10\text{N})\sin 60°$

$\tau \doteq 26\text{ N·m}$

CW (neg Torque)

a)



$\tau = r F \sin\theta$

$\tau = (3.0\text{m})(25\text{N})\sin 90°$

or

$\tau = r_\perp F$

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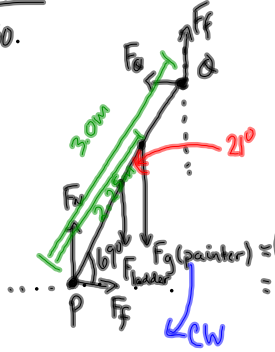
30.



$\tau_{painter} = r F \sin\theta$

$= (2.25\text{m})(627.84\text{N})(\sin 21°)$

$\doteq 506.24\text{ N·m}$

$F_{g(painter)} = (64\text{kg})(9.81\text{m/s}^2)$

$= 627.84\text{N}$

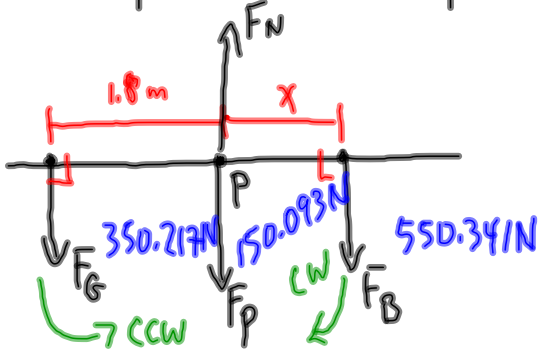
$\doteq 5.1 \times 10^2\text{ N·m}$

Example

Two children sitting on a teeter-totter made from a uniform 15.3kg plank that rests on a frictionless pivot. A 35.7kg girl sits at the left end, 1.8m from the point of rotation. A 56.1kg boy moves back & forth at the right end until the teeter-totter balances horizontally (static eq)

a) where does the boy finally sit?

b) What is the upward force of the pivot on the plank?



$\vec{\tau}_{net} = 0$ a) $\Sigma \tau_{CW} = \Sigma \tau_{CCW}$

$\Sigma \vec{\tau} = 0$ $\tau_B = \tau_G$ $\theta = 90°$

$r_B F_B \sin\theta_B = r_G F_G \sin\theta_G$

$x(550.341N) = (1.8m)(350.217N)$

$x = 1.1m$

b) $\vec{F}_{net} = 0$

$F_N = F_G + F_B + F_P$

$F_N = 350.217N + 550.341N + 150.093N$

$F_N = 1051\ N$