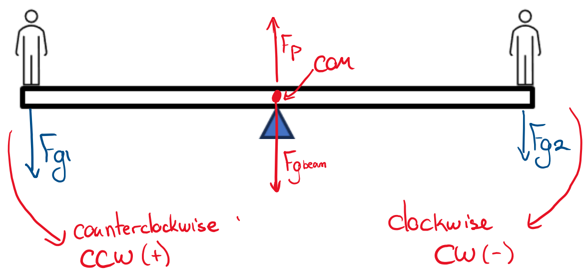
Lesson 2.5A – Rotational Equilibrium

Unit 2: Dynamics and Equilibrium

If a force is applied a distance from a pivot, a torque (moment) is produced.



*Torque causes rotation.

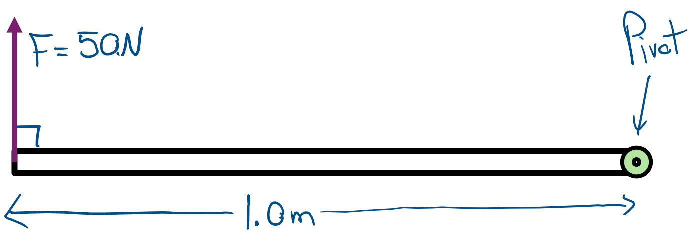
*Torque is the cross-product of force + distance (F is $\perp$ to that distance).

$$\text{Torque} = \tau = \vec{F}_{\perp} \cdot l$$

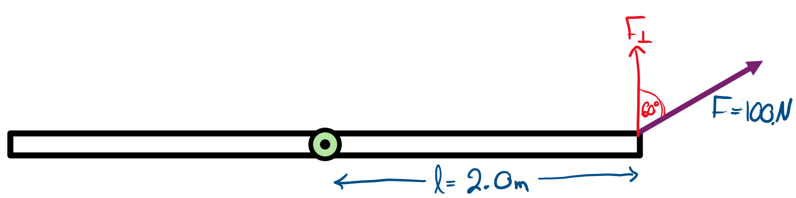
(or d or r)

τ = torque (N·m)
$F_{\perp}$ = force perpendicular to l
l = distance of force from the pivot. (m)

Example 1: Calculate the torque in the following



$$\tau = F_{\perp} \cdot l$$
$$= 50N(1.0m)$$
$$= 50\ Nm$$
$$\boxed{= 5.0 \times 10^{1}\ Nm}$$



$$\tau = F_{\perp} \cdot l$$
$$= F\cos\theta \cdot l$$
$$= 100\cos 60(2)$$
$$= 100\ Nm$$
$$\boxed{= 1.0 \times 10^{2}\ N\ m}$$

An object is in rotational equilibrium if it is not rotating.

$$\sum \tau = 0$$

Conventional signs

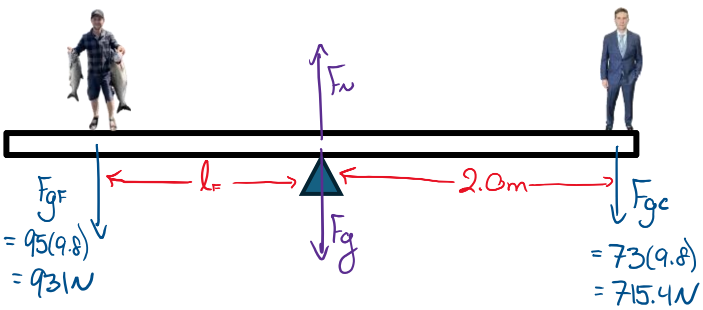
(−) (+)

$$\sum \tau_{clockwise} = \sum \tau_{counterclockwise}$$

$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum \tau = 0$$

An object is in total or static equilibrium only when it is in both translational and rotational equilibrium.

Example 2: Fishing Harris (95 kg) and Classy Harris (73 kg) sit on a seesaw together. If Classy Harris sits 2.0 m from the pivot, how far from the pivot must Fishing Harris sit?



$$\Sigma \tau = 0$$

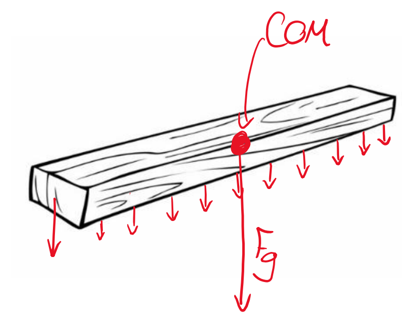
$$F_{gF} \cdot l_F - F_{gc} \cdot l_c = 0$$

$$931 l_F - 715.4(2.0) = 0$$

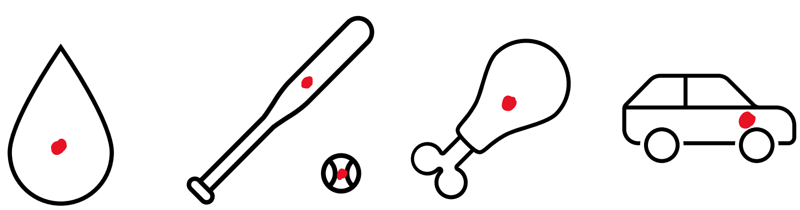
$$\boxed{l_F = 1.54m}$$

Centre of Mass and Gravity:

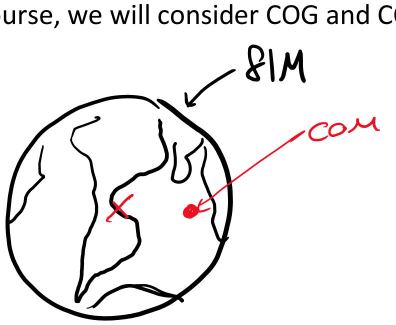
Every molecule of wood in a board has mass and therefore experiences gravity.



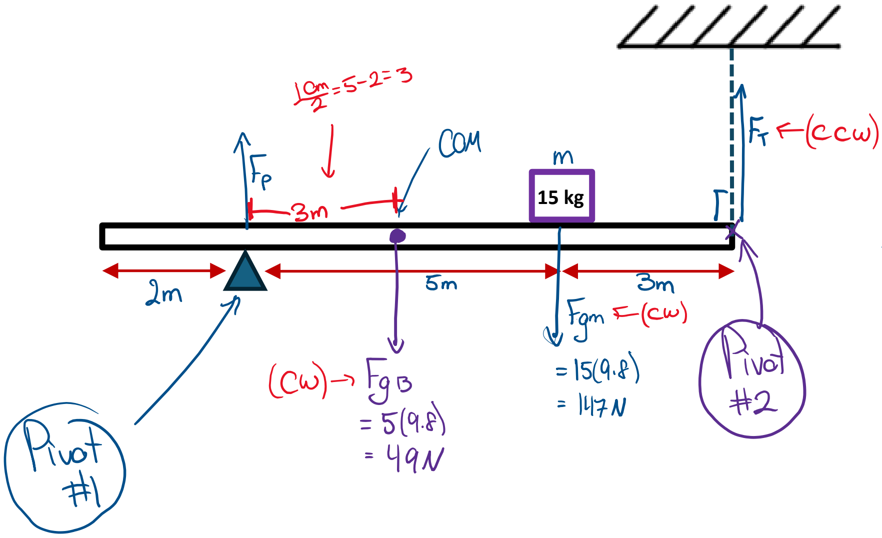
The centre of gravity is where resultant force appears to act on the entire board.



The Center of Mass will be the same as the Center of Gravity in a uniform gravitational field. For this course, we will consider COG and COM to be the same.



Example 3: A 5.0 kg beam has a 15 kg box on it between a pivot pint and a rope. Find the force of tension in the rope and the force on the pivot point to produce static equilibrium.



* you choose the pivot point

* torque at the pivot is always 0

↳ $\tau_p = F_p \cdot l = F_p(0) = 0$

* $\sum F_{x,y} = 0$

Pivot #1

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

$F_{gB} \cdot l_B + F_{gm} \cdot l_m = F_T \cdot l_T$

$\frac{49N(3m) + 147N(5m)}{8m} = F_T$

$F_T = 110.25N$

$\boxed{= 110N}$

OR

Find F_p

$\sum F_y = 0$

$F_p + F_T - F_{gB} - F_{gm} = 0$

$F_p + 110.25 - 49 - 147 = 0$

$F_p = 85.75N$

$\boxed{= 86N}$

OR

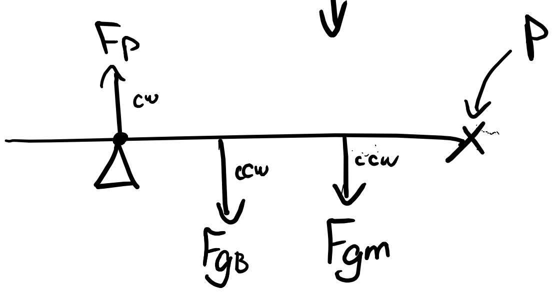
Pivot #2 - end of the rope.

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

$F_p \cdot l_p = F_{gB} l_B + F_{gm} \cdot l_m$

$F_p = \frac{49N(5m) + 147N(3m)}{8m}$

$F_p = 86N$



Assignment: Sander-Gore Pg. 27 # 1-4 and WS 2.5A