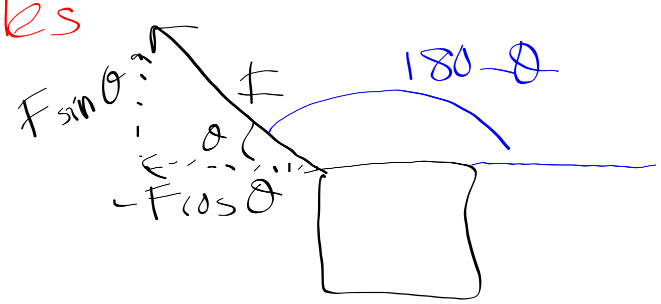
Show work:

(,)(,)(,)

- → System of variables
- → Diagrams
- → Equations
- → Use words, arrows, etc.

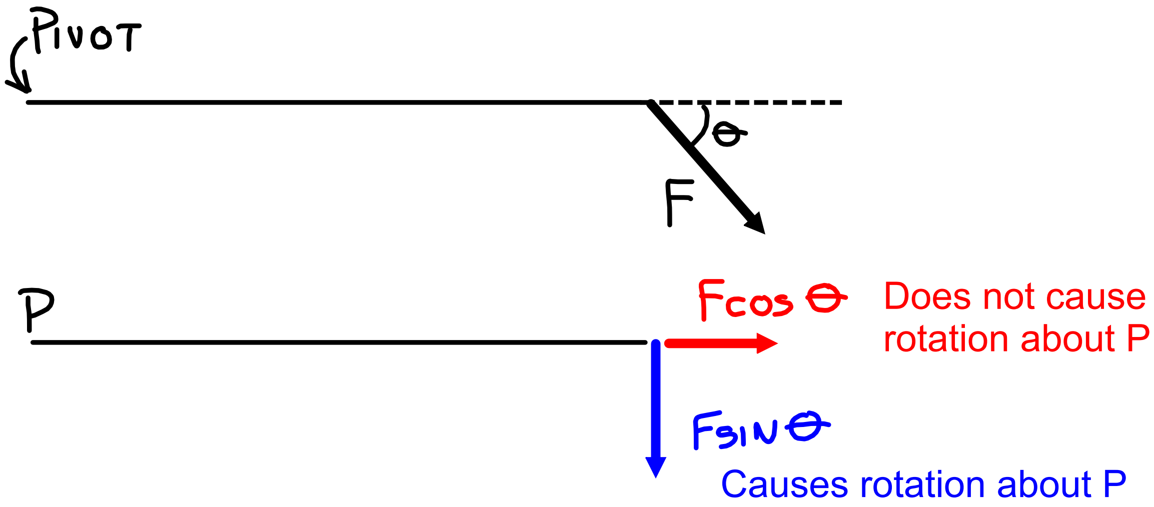


$\Sigma F_x = 0$

Torque
and
Rotational Equilibrium

Torque:

A torque is required to cause something to rotate.



In general:

$$\boxed{\text{Torque} = \tau = F \times \ell}$$

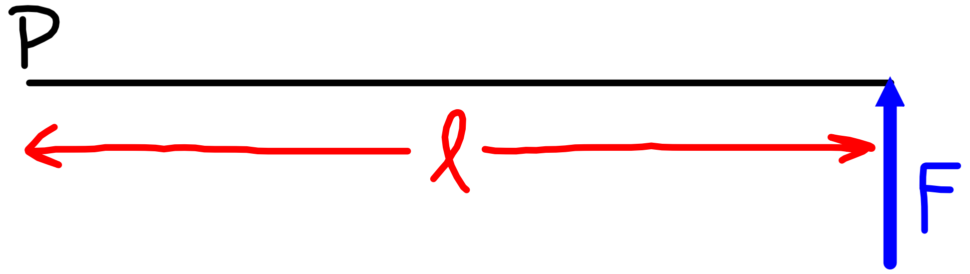
N & m: N·m

lbs & ft: lb·ft

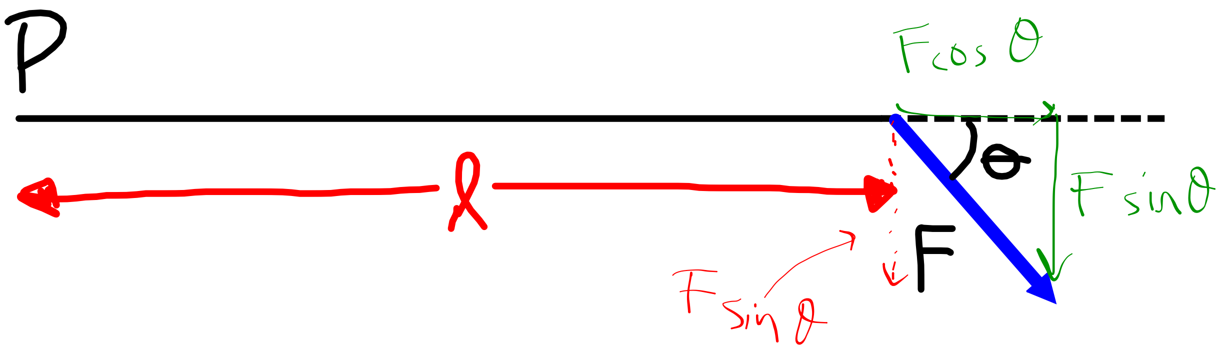
F = A Force ⊥ to ℓ

ℓ = Lever Arm (The displacement between the "pivot" and the location where the force is being applied)

Examples of determining torque:



$$\boxed{\tau} = F \times \ell$$



$$\tau = F\sin\theta \times \ell$$

Rotational Equilibrium

When considering cases of **translational** equilibrium, the location on a body at which a force acts is not important.

$$\Sigma F_x = 0$$

$$\Sigma F_y = 0$$

When considering cases of **rotational** equilibrium, the location at which a force acts is important.

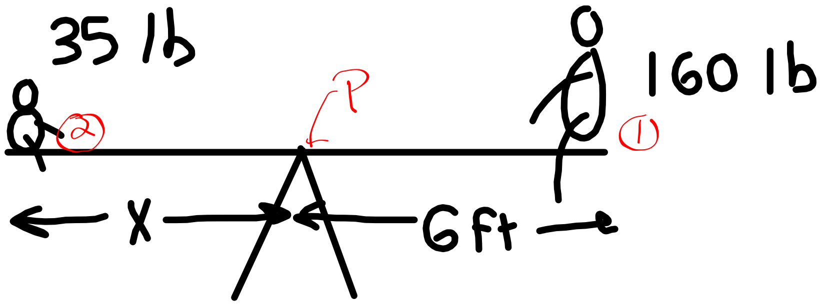
$$\Sigma F_x = 0$$

$$\Sigma F_y = 0$$

$$\Sigma \tau = 0$$

(No matter what point is taken to be the pivot. Rotational equilibrium exists only when the sum of the torques about ALL points on an object is zero).

EXAMPLE 1:



WHAT MUST X BE TO ACHIEVE EQUILIBRIUM?

$\tau_1 = 160\text{ lb} \cdot 6\text{ ft}$

$= \boxed{960\text{ lb}\cdot\text{ft}}$

$\tau_2 = \boxed{35\text{ lb} \cdot x}$

$35x = 960$

$x = 27.4\text{ ft}$

Using Rotational Equilibrium as a problem-solving tool:

1. Draw a FBD. ↳ try to locate forces ≈ correctly

2. Identify a point to serve as a pivot. (Note: if in equilibrium, the object will NOT be pivoting. Also, ANY point could serve as a reference for lever arms).

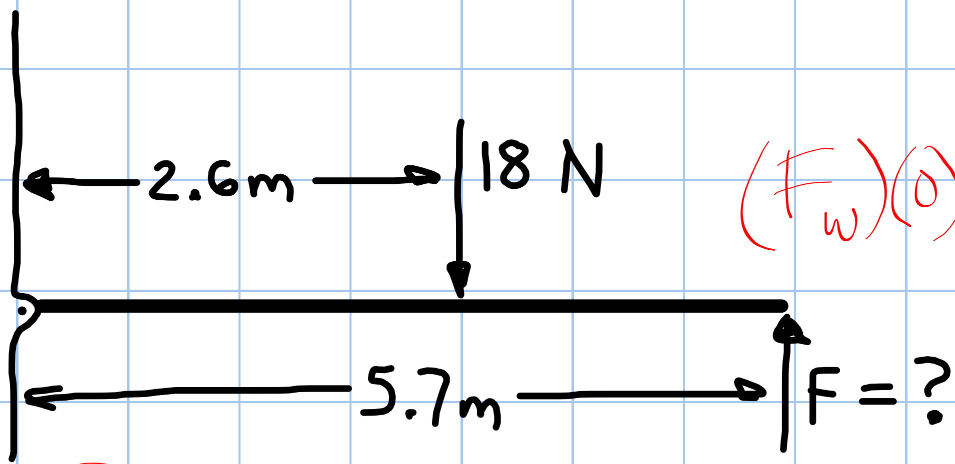
3. Establish a reference rotation (+/-). +

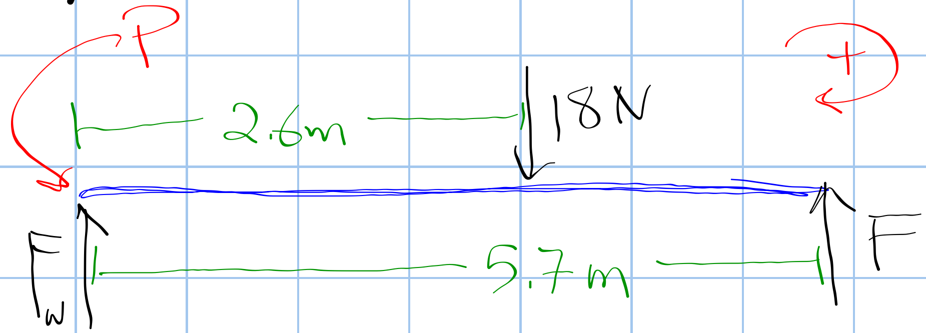
4. Resolve all forces into components:
- One perpendicular to the lever arm
- One parallel to the lever arm ← important for translation

5. The sum of all torques about any (and every) point on the object must equal zero. $\Sigma \tau = 0$

6. Solve for unknowns.

EXAMPLE 2





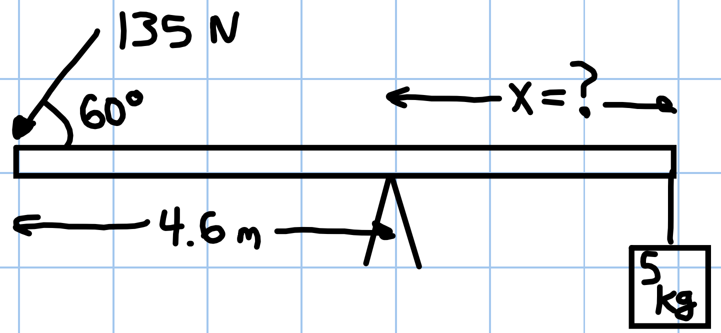
$$\Sigma \tau = 0$$

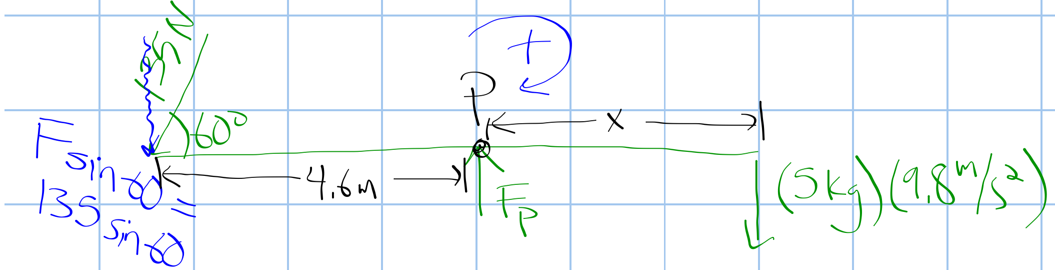
$$(F_w)(0) + (18)(2.6) + -(F)(5.7) = 0$$

$$F = \frac{(18)(2.6)}{5.7}$$

$$= 8.21\ N$$

Example 3





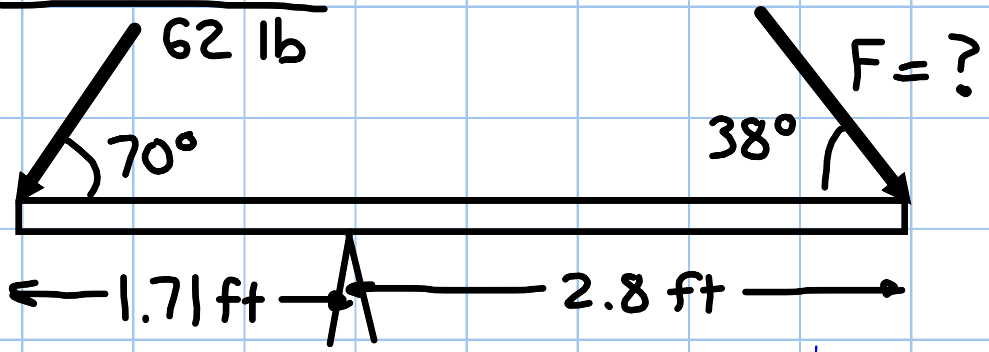
$$\Sigma \tau = 0$$

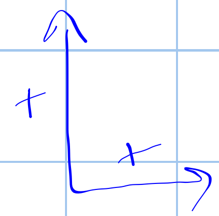
$$-(135 \sin 60)(4.6) + (5)(9.8)x = 0$$

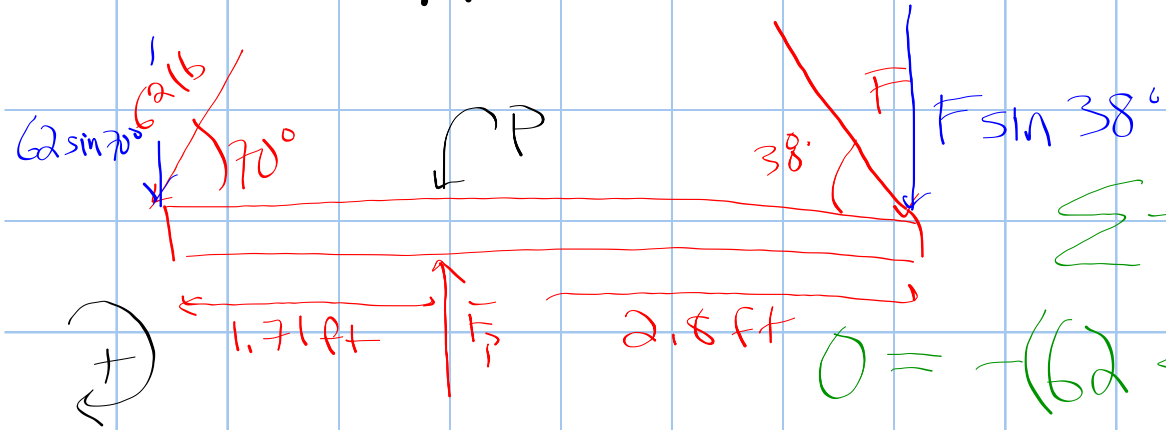
$$x = \frac{(135 \sin 60)(4.6)}{5(9.8)}$$

$$x = 10.98 \text{ m}$$

EXAMPLE 4





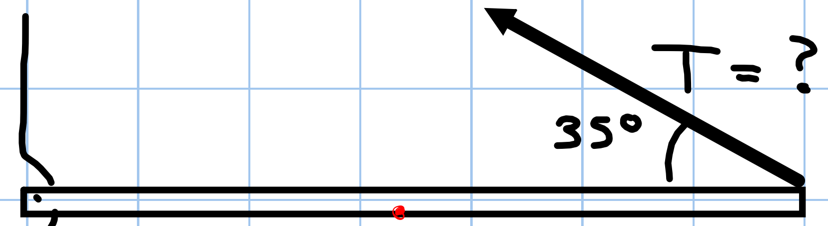


$$\sum \tau = 0$$

$$0 = -(62 \sin 70)(1.71) + F \sin 38 (2.8)$$

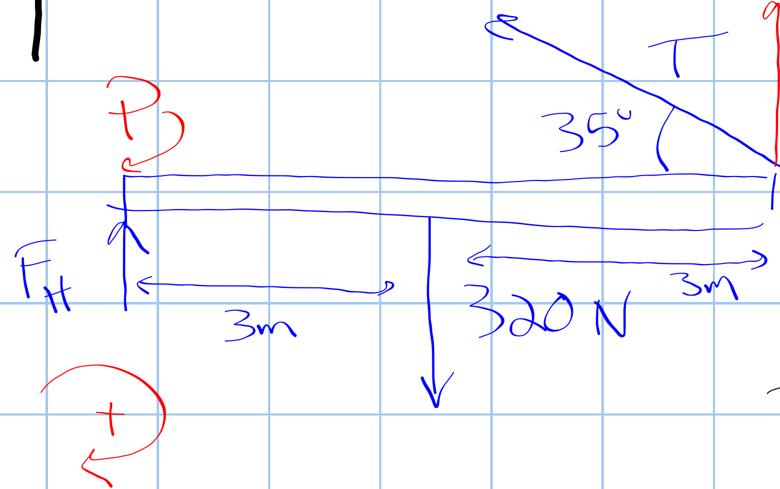
$$F = \frac{62(\sin 70)(1.71)}{(\sin 38)(2.8)} = \boxed{57.8 \text{ lb}}$$

EXAMPLE 5



Weight acts as a force at the object's center of mass ("C.O.M.")

BAR WEIGHS 320 N, & IS 6.0 m LONG



T sin 35°

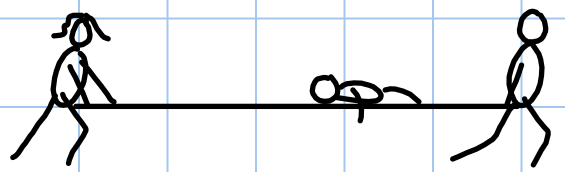
$$\Sigma \tau = 0$$

$$0 = (320)(3) + -(T \sin 35)(6)$$

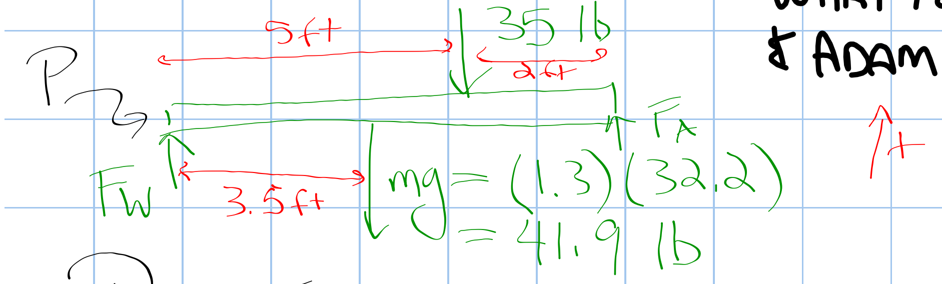
$$T = \frac{(320)(3)}{(\sin 35)(6)} = 279\,N$$

Example 6

- Stretcher (1.3 slugs) is 7.0 ft long
- Foster's (35 lb) C.O.M. is 2.0 ft from Adam
- What forces must Wendy & Adam apply?



WENDY ADAM



+

$$\Sigma \tau = 0$$

$$(41.9)(3.5) + (35)(5) + -F_A(7) = 0$$

$$F_A = \frac{(41.9)(3.5) + (35)(5)}{7} = 46 \text{ lb}$$

$$\Sigma F_y = 0$$

$$F_W - 41.9 - 35 + 46 = 0$$

$$F_W = 31 \text{ lb}$$