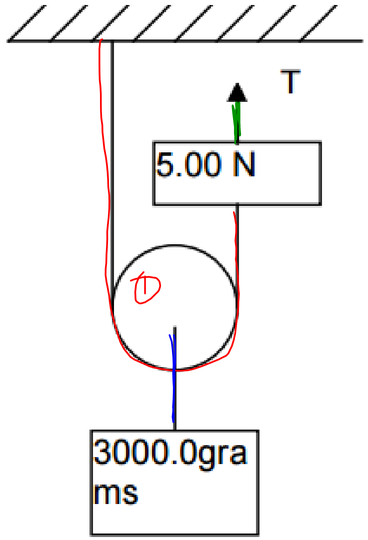
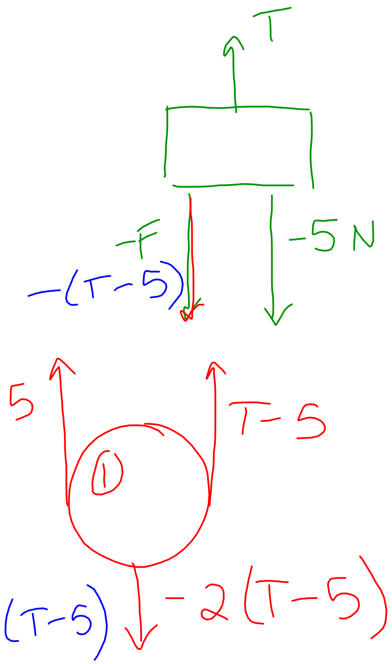
a)





$$\Sigma F_y = 0$$

$$T + {}^-F + {}^-5 = 0$$

$$F = T - 5$$

$$\boxed{3000\,g = 3\,kg}$$

$$-mg = -(3)(9.8) = -29.4\ N$$

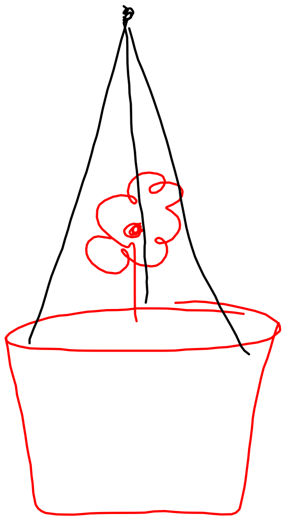
$$\Sigma F_y = 0$$

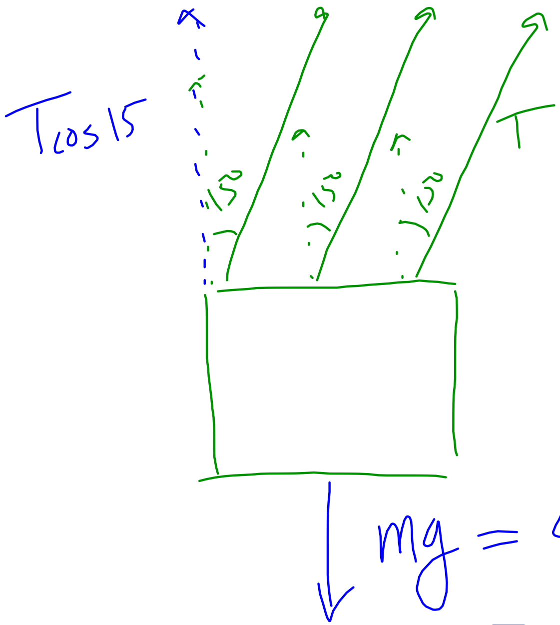
$$2(T-5) - 29.4 = 0$$

$$2T = 39.4$$

$$T = 19.7\ N$$

1. A flower pot of mass 4.20 kg is hung above a window by three ropes, each making an angle of 15.0 degrees with the vertical. What is the tension in each rope supporting the flower pot? [14.2 N]





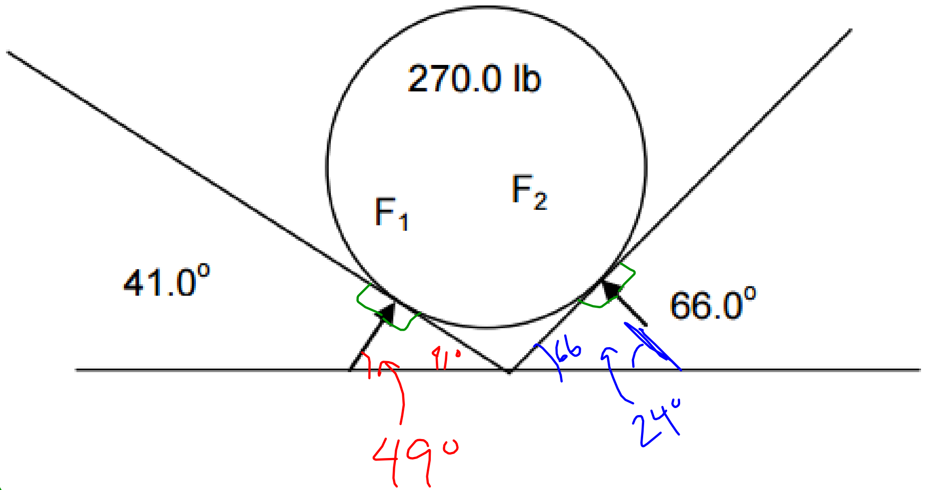
$$mg = 4.2(9.8) = -41.16\text{ N}$$

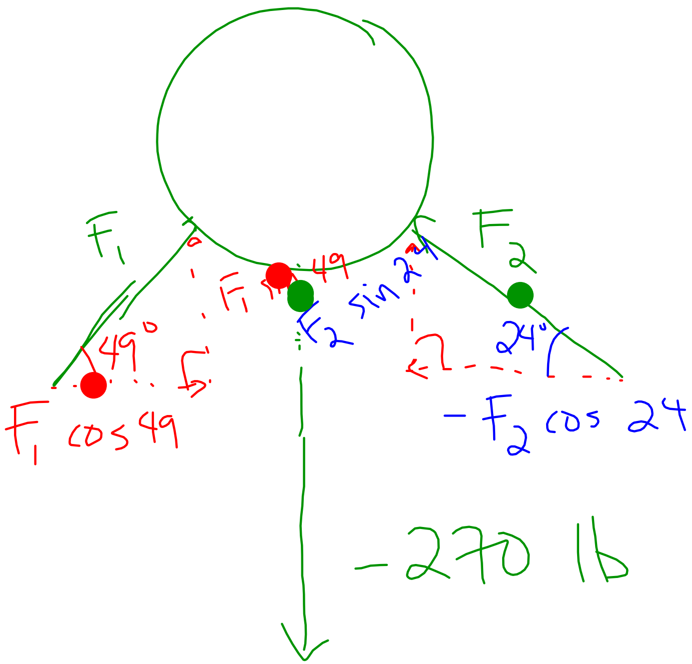
$$\Sigma F_y = \varnothing$$

$$3(T\cos 15) - 41.16 = \varnothing$$

$$T = \frac{41.16}{3(\cos 15)} = \boxed{14.2\text{ N}}$$

6. The 270.0 lb ball rests in a V-shaped, frictionless crevice. Find F_1 and F_2. [F_1 = 258 lb, F_2 = 185 lb]





$\sum F_x = \emptyset$

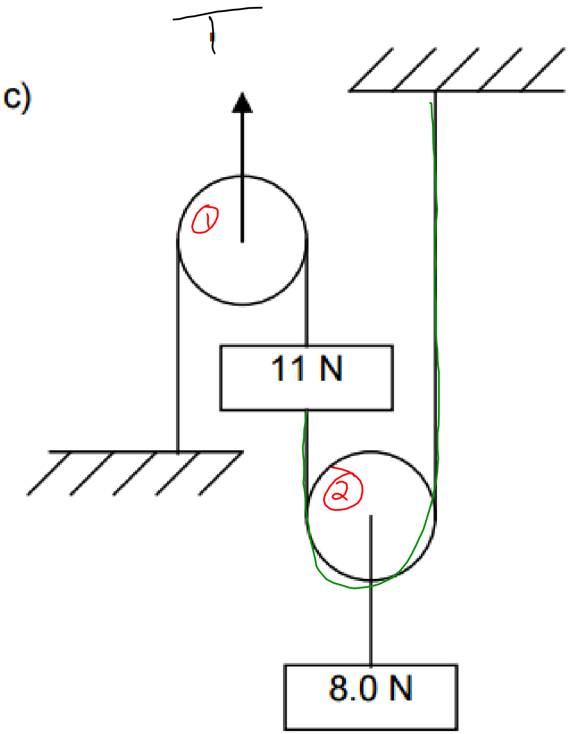
$F_1 \cos 49 - F_2 \cos 24 = \emptyset$

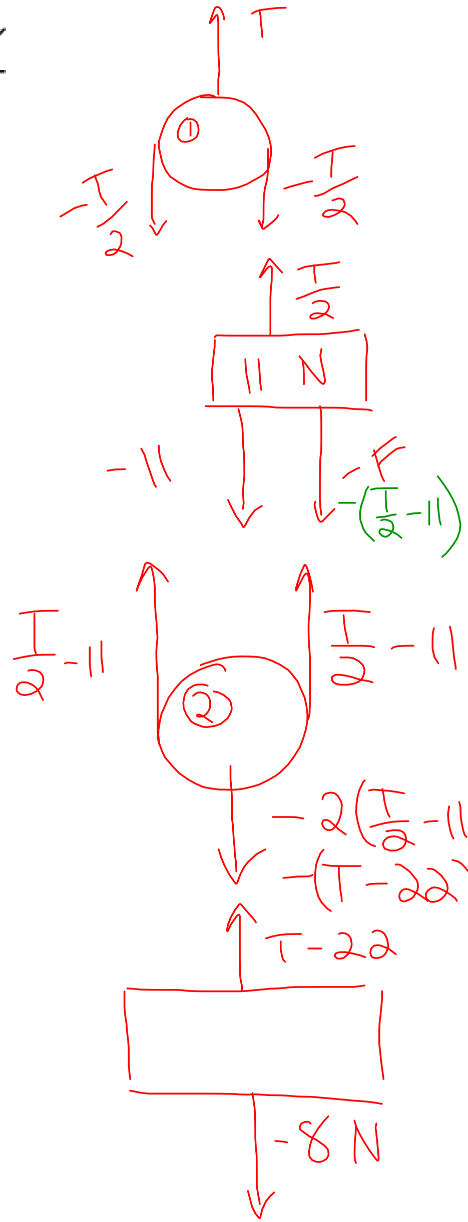
$\sum F_y = \emptyset$

$F_1 \sin 49 + F_2 \sin 24 - 270 = \emptyset$

∴ 2 equations, 2 unknowns

c)





$\Sigma F_y = \emptyset$

$\frac{T}{2} - 11 - F = \emptyset$

$F = \frac{T}{2} - 11$

$\Sigma F_y = \emptyset$

$T - 22 - 8 = \emptyset$

$T = 30N$

Torque and Rotational Equilibrium

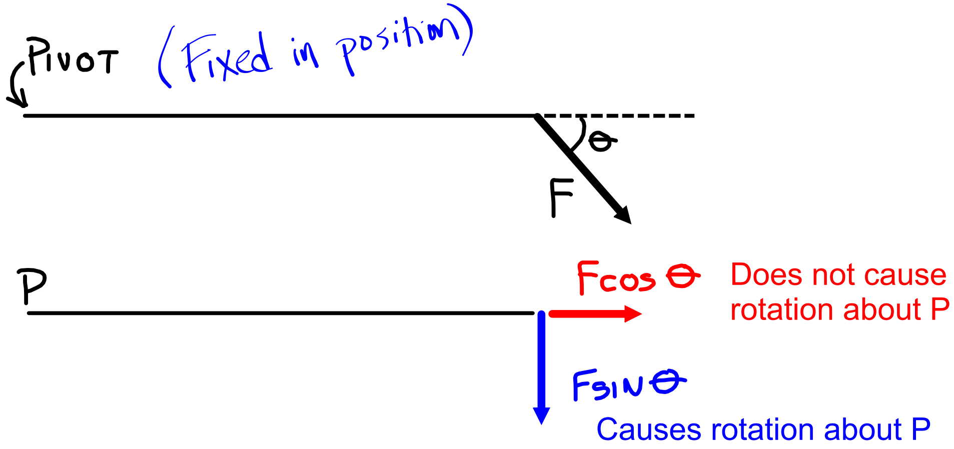
Objectives:

- Students will understand what torque is and how it relates to forces.
- Students will know what rotational equilibrium is and what it implies about torques.
- Students will be able to use the concepts of torque and rotational equilibrium to solve statics problems.

not rotating, for now.

Torque:

A torque is required to cause something to rotate.



In general:

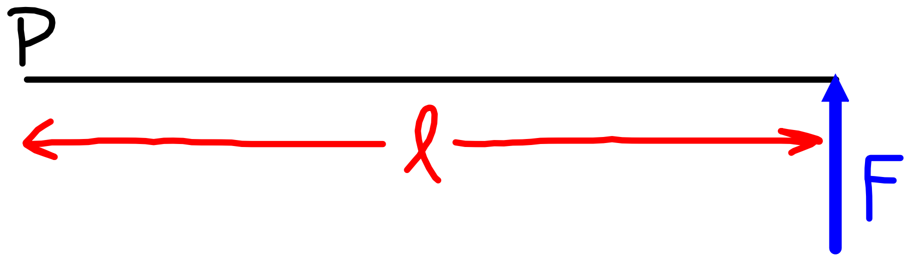
$$\boxed{\text{Torque} = \boxed{\tau = F \times \ell}}$$

F = A Force $\boxed{\perp \text{ to } \ell}$

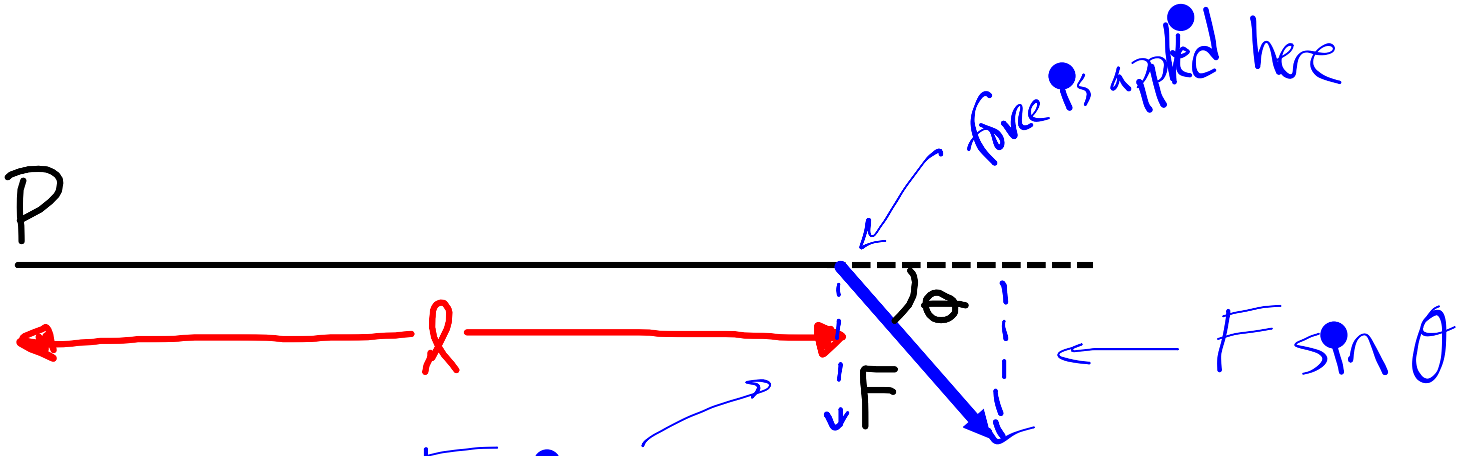
ℓ = Lever Arm (The displacement between the "pivot" and the location where the force is being applied)

τ (greek letter tau = torque) $= F \cdot \ell$ (units = N·m)

Examples of determining torque:



$$\tau = F \times \ell$$



$F_{\perp}$ is applied here as well

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

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.

$$\Sigma F_x = 0$$

$$\Sigma F_y = 0$$

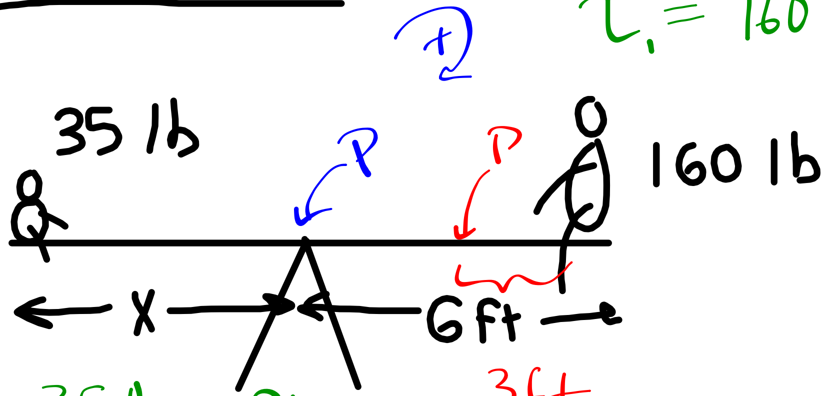
$$\Sigma \tau = 0$$

(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).

we can pick the pivot point

EXAMPLE 1:

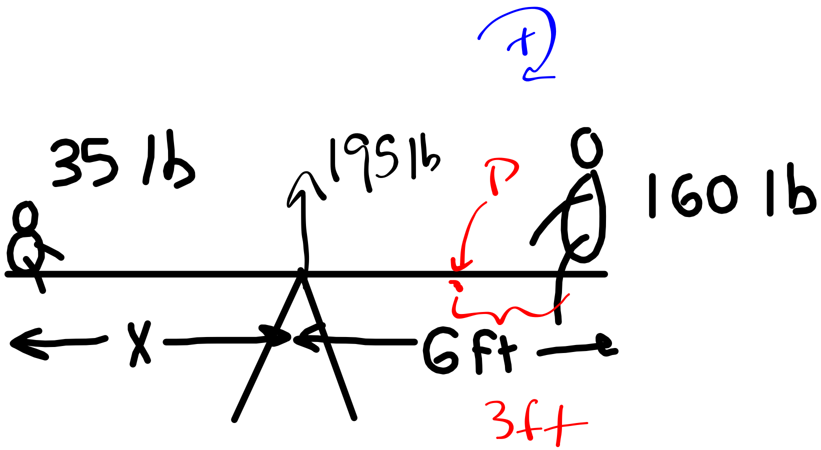
$\tau_1 = 160\text{ lb}\cdot 6\text{ ft} = 960\text{ lb}\cdot\text{ft}$



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

WHAT MUST X BE TO ACHIEVE EQUILIBRIUM?

$$\tau_1 + \tau_2 = 0$$
$$\tau_1 = -\tau_2$$
$$960 = -(35\cdot x)$$
$$x = -27.4\text{ ft}$$



$$\tau_K = -35(x+3)$$

$$\tau_P = 195(3)$$

$$\tau_F = 160(3)$$

$$\Sigma F_y = \emptyset$$

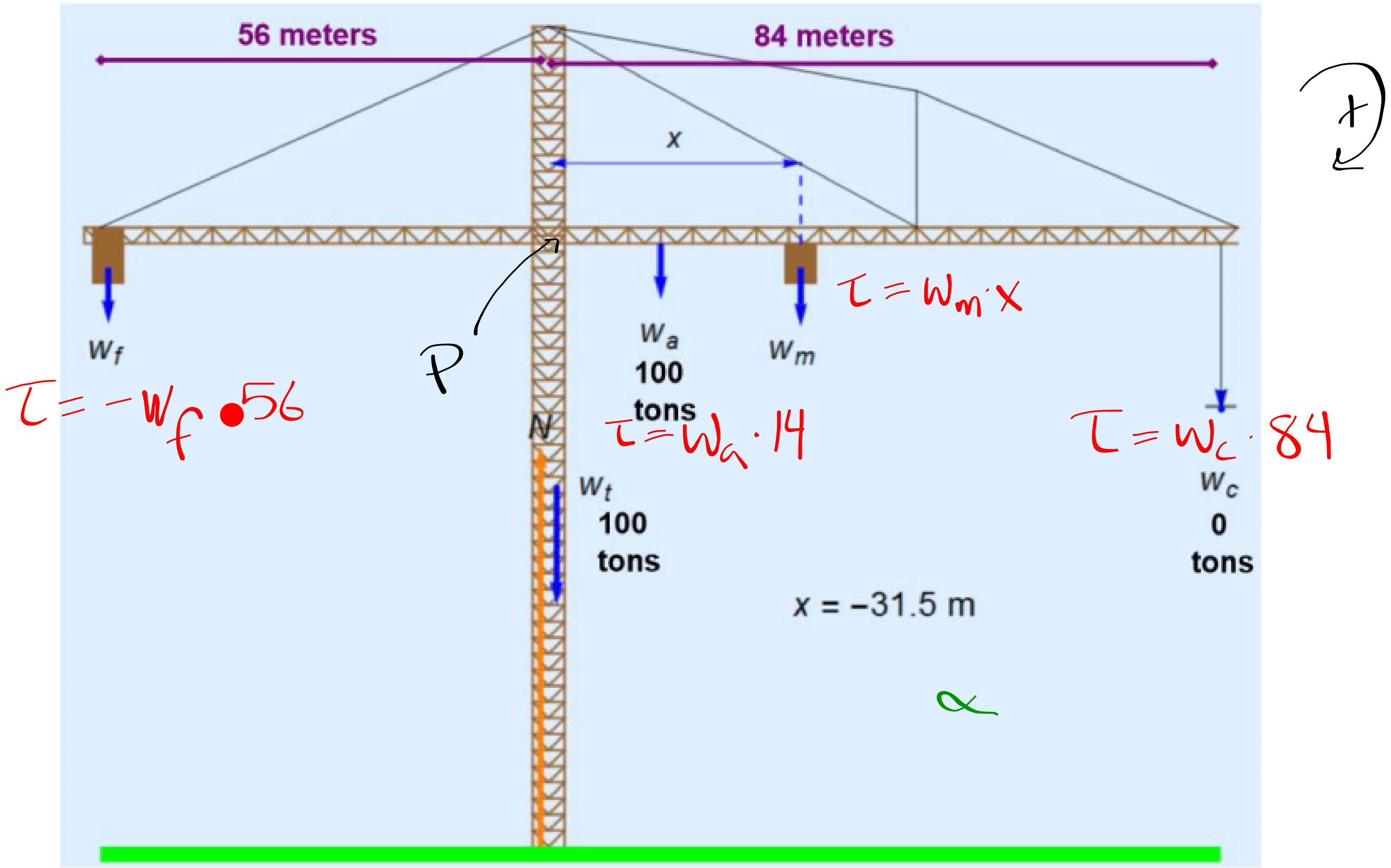
$$\Sigma \tau = \emptyset$$

$$-35(x+3) + 195(3) + 160(3) = \emptyset$$

$$-35x - 105 + 585 + 480 = \emptyset$$

$$-35x = -960$$

$$x = 27.4 \text{ ft}$$


56 meters
84 meters
x
W_f
W_a
100
tons
W_m
N
W_t
100
tons
W_c
0
tons
x = −31.5 m
P
$\tau = -W_f \cdot 56$
$\tau = W_a \cdot 14$
$\tau = W_m \cdot x$
$\tau = W_c \cdot 84$
+
α

Using Rotational Equilibrium as a problem-solving tool:

1. Draw a FBD. – show all forces in correct locations

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 (+/-). +

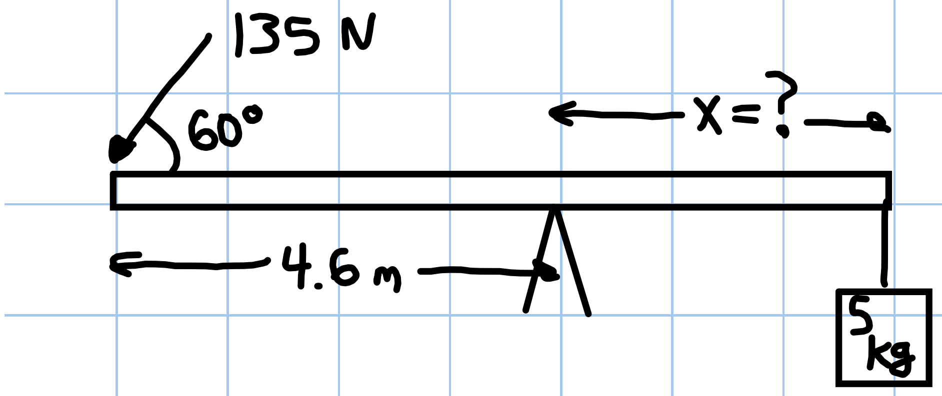
4. Resolve all forces into components:
- One perpendicular to the lever arm → will cause torque
- One parallel to the lever arm

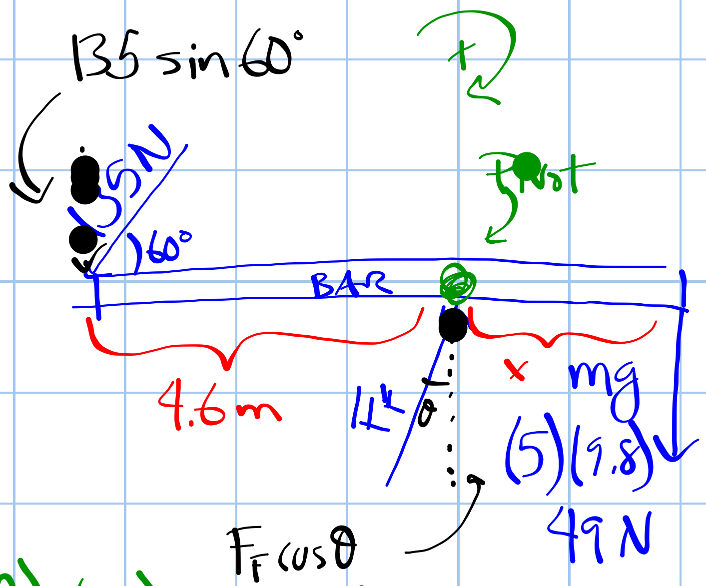
5. The sum of all torques about any (and every) point on the object must equal zero.

$$\Sigma \tau = 0$$

6. Solve for unknowns.

Example 3



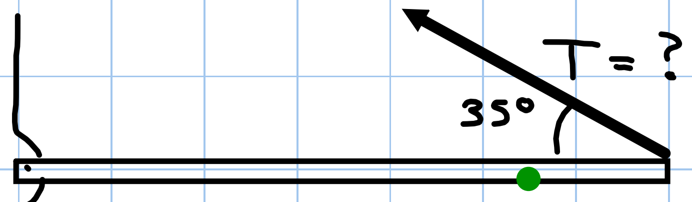


$$\sum \tau = 0$$

$$-(135 \sin 60)(4.6) + (F_F \cos\theta)(0) + (49)x = 0$$

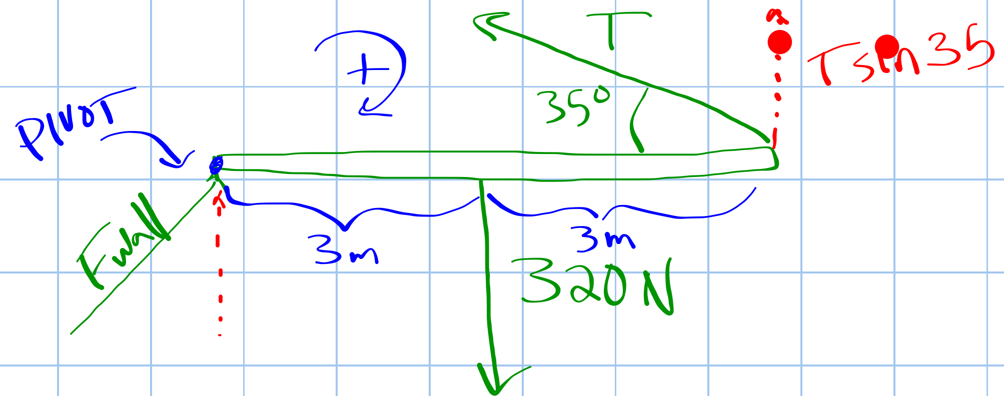
$$x = \frac{(135 \sin 60)(4.6)}{49} = \boxed{11\ \text{m}}$$

EXAMPLE 5



BAR WEIGHS $\boxed{320\ N}$ & IS 6.0 m LONG

act at C.O.M. = center of mass



$$\Sigma \tau = 0$$

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

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