Rotational and Static Equilibrium

1. Find the force needed at the very left end of a lever in order to maintain rotational equilibrium of a 8 .0 m long lever.

8.0m lever = 0.3 + 2.8 + 3.5 + x

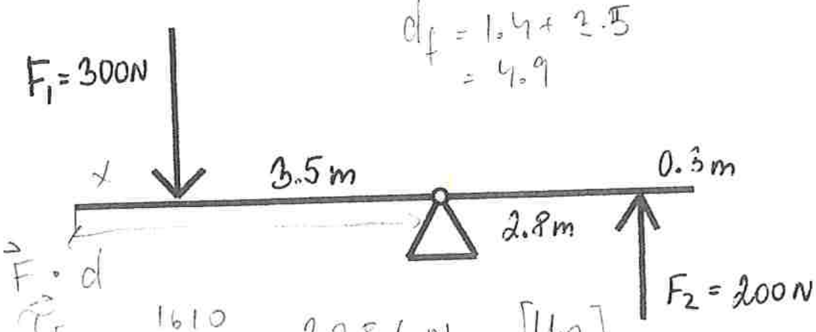
x = 1.4 m

$d_f = 1.4 + 3.5$
$= 4.9$

$\vec{\tau}_1 = (300)(3.5)$
$= 1050\ N\cdot m$ [CCW]

$\vec{\tau}_2 = (200)(2.8)$
$= 560\ N\cdot m$ [CCW]

$\vec{\tau}_F = 1050 + 560$ [CW]
$= 1610$ [CW] $N\cdot m$



$\vec{\tau}_F = \vec{F} \cdot d$

$\vec{F} = \frac{\vec{\tau}_F}{d} = \frac{1610}{4.9} = 328.6\ N$ [Up]

$= 3.3 \times 10^2\ N$ [up]

2. a) How far left from the fulcrum would you have to place an object with mass 50.0 kg in order to ensure a rotational equilibrium?

b) Predict how far right from the fulcrum would you have to place this 50.0 kg mass in order to ensure a rotational equilibrium? Why? Confirm your reasoning by calculating the $\sum \vec{\tau}$.

a) $\vec{\tau}_1 = (100)(3.0)$
$= 300\ N\cdot m$ [CW]

$\vec{\tau}_2 = (120)(4.0)$
$= 480\ N\cdot m$ [CW]

$\vec{\tau}_o = 480 + 300$ [CCW]
$= 780\ N\cdot m$ [CCW]

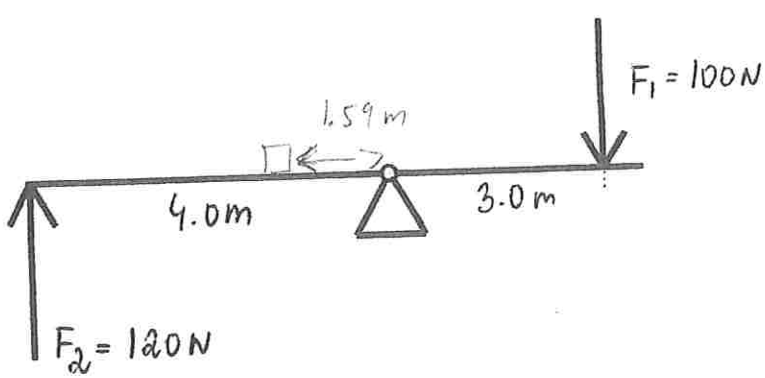
$F_{g_o} = (50.0)(9.8)$
$= 490N$

$d_o = \frac{\vec{\tau}_o}{F_{g_o}}$

$d_o = \frac{780}{490}$

$d_o \doteq 1.59\ m$

$d_o = 1.6\ m$



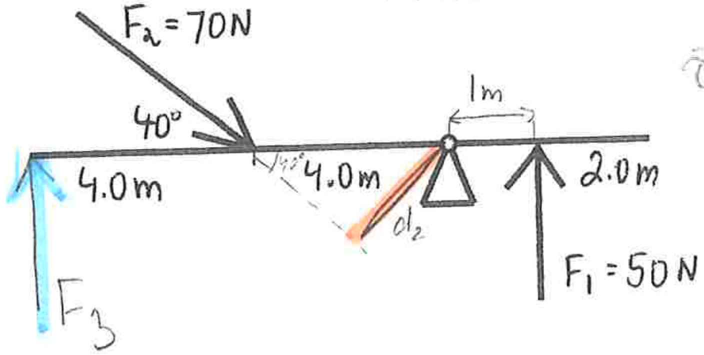
b) An object placed to the right of the fulcrum will create a clockwise torque which will yield a greater $\Sigma\vec{\tau}$ regardless of the distance from the fulcrum.

3. **Consider an 11.0-m long lever. Where and at what direction would you apply a smallest possible force that would ensure a rotational equilibrium of the system?**

$d_2 = (\sin 40^\circ)(4.0)$
$= 2.57 m$

$\vec{\tau}_1 = (50)(1)$
$= 50 \text{ N·m CCW}$

$\vec{\tau}_2 = (70)(2.57)$
$= 179.98 \text{ N·m CCW}$

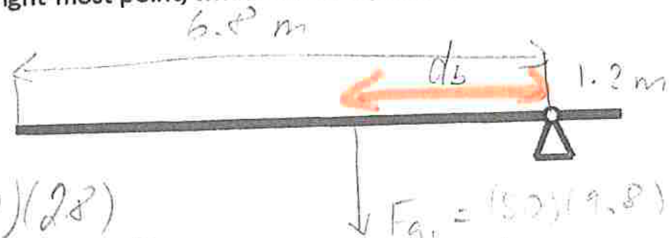


$\vec{\tau}_3 = 229.98 \text{ CW}$

$F_3 = \frac{\tau_3}{d_3}$

$F_3 = \frac{229.98}{8.0} = 28.7 \text{ N [up]}$

4. **Provided that the bar below is 8.0 m long, its mass is 50.0 kg, and the pivot point is 1.2 m from the its right-most point, what is the torque of the bar?**



$d_b = \frac{8.0}{2} - 1.2$

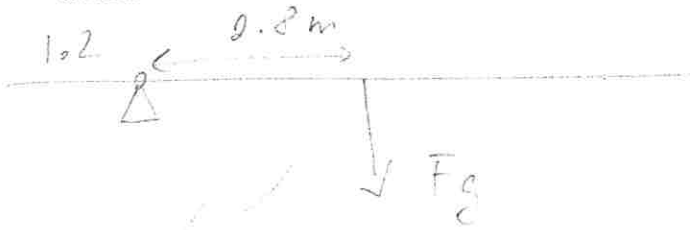
$d_b = 4.0 - 1.2$

$d_b = 2.8 m$

$\vec{\tau}_b = (490)(2.8)$
$= 1372 \text{ N·m [CCW]}$

$F_{g_b} = (50)(9.8)$
$= 490N$

5. **How would the torque from question 4 change if the pivot point was 1.2 m from the left-most point of the bar? Sketch a labelled diagram. And show calculation supporting your prediction.**



$F_g = (50)(9.8)$
$= 490N$

$d_b = 2.8m$

$\vec{\tau}_b = 1372 \text{ N m [CW]}$

$\vec{\tau}_b = (490)(2.8)$
$= 1372 \text{ N·m [CW]}$