$\vec{\tau} = \vec{r} \times \vec{F}$ → $\tau = rF_\perp$

ABRHS PHYSICS

NAME: KEY

# Torque Problems

1. For each of the following diagrams, calculate the torque:

a. 5 N, 0.25 m

$\tau = rF_\perp$

$= (.25)(5)$

$\tau = 1.25$ Nm

OUT OF PAPER

b. 5 N, 2 m

$\tau = rF_\perp$

$= (2)(5)$

$\tau = 10$ Nm

INTO PAPER

c. 3 m, 20 N, 25°

$\tau = rF_\perp$

$= (3)(20)\sin 25$

$\tau = 25.4$ Nm

INTO

d. 2.5 m, 15 N (out of paper)

$\tau = rF_\perp$

$= (2.5)(15)$

$\tau = 37.5$ Nm

TO TOP OF PAPER

e. r = 20 cm, 3.5 N

$\tau = rF_\perp$

$= (.2)(3.5)$

$\tau = 0.7$ Nm

OUT

f. 50 N, r = 30 cm

$\tau = rF_\perp$

$= (.3)(50)$

$\tau = 15$ Nm

INTO

g. 7 N, 40°, 1.5 m

$\tau = rF_\perp$

$= (1.5)(7)\sin 40$

$\tau = 6.75$ Nm

INTO

h. 5 N, 75 cm, 55°

so $\theta = 35°$

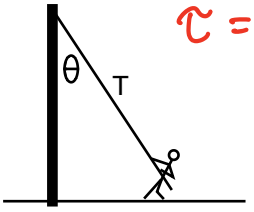
$\tau = rF_\perp$

$= (.75)(5)\sin 35$

$\tau = 2.15$ Nm

OUT

2. A flagpole is 25 meters high. Someone is trying to pull it down by pulling on the ropes, which attach at the top and make an angle of 15° between the pole and the rope. The tension in the rope is 500 N. What is the resulting torque (about its base) on the flagpole? How could the person increase the torque, without increasing the tension in the rope?




$\tau = rF_\perp$

So $T_\perp = T\sin\theta$

($\perp$ means $\perp$ to $\vec{r}$)

$\tau = (25)(500)(\sin 15)$

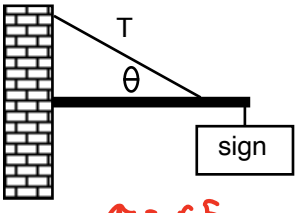
$\tau = 3235$ Nm

INTO

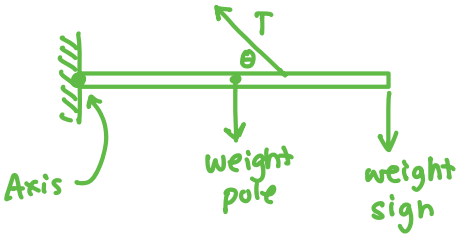
- making $\theta$ bigger (longer rope) could increase the torque without increasing the tension.

3. A sign of mass 75 kg is hung from a pole of mass 15 kg and length 1.5 meters as shown. The pole is hung from a wall so that it is horizontal, and there is an additional support wire, also shown. If the angle between the wire and the pole is 30°, and it attaches to the pole 1 meter from the wall, what is the tension in the wire? (It is probably easiest to consider the base of the pole attached to the wall as the rotation point.)

- remember: gravity acts on center of mass!




$\tau = rF_\perp$




Everything is balanced,

so $\Sigma\tau = 0$ $\quad \tau_1 + \tau_2 + \tau_3 = 0$

(weight!)

$(.75)(15)(10) + (1.5)(75)(10) - (1)T\sin\theta = 0$

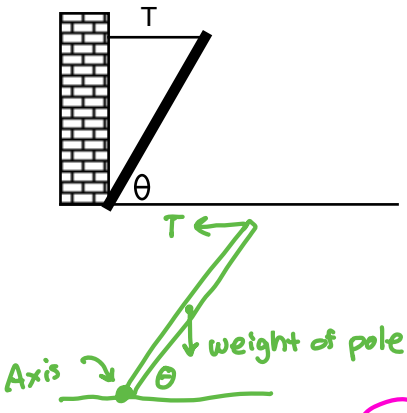
$112.5 + 1125 = T\sin 30$

$T\sin 30 = 1237.5$

$T = 2480$ N

# Torque Problems

4. A rod of length of 3 meters is leaning at an angle of ~~25°~~ 65°, as shown. It is also supported by a horizontal wire attached to its end. If the tension in the wire is 400 N, what is the mass of the rod?




$\Sigma\tau = 0 \rightarrow \tau_1 + \tau_2 = 0$

$\frac{L}{2} mg\cos\theta - LT\sin\theta = 0$

$mg\cos\theta = 2T\sin\theta$

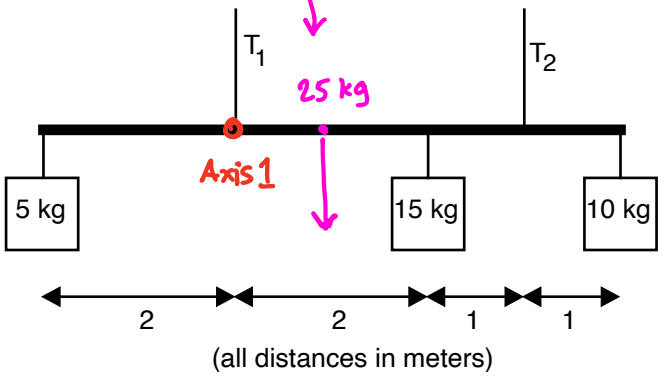
$m = \frac{2T\sin\theta}{g\cos\theta} = \frac{2(400)}{10}\tan 65$

$m = 171.6\ kg$

5. A horizontal bar of mass 25 kg is suspended from two wires as shown. There are also three masses hanging from the bar, as shown. What are the tensions in the two wires?

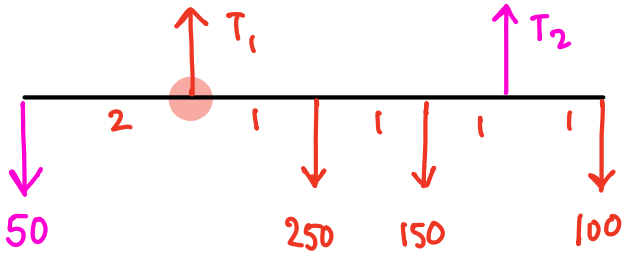
KEY IDEA!

You get to pick the axis of rotation! So pick two easy ones!




Need the WEIGHTS!

Axis 1:




← 2 tensions

← distances between

← the 4 weights

$\Sigma\tau = 0 = (50)(2) + T_2(3) - (250)(1) - (150)(2) - (100)(4)$

$0 = 100 + 3T_2 - 250 - 300 - 400$ $(100 - 950)$

$3T_2 = 850$ $T_2 = 283\ N$

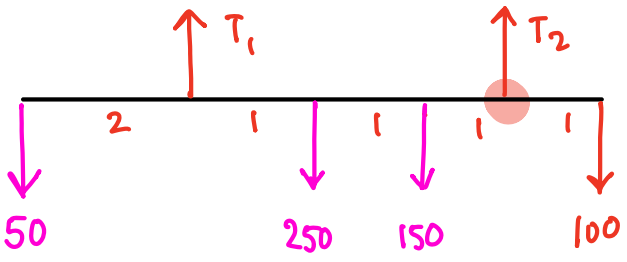
continued below!

*Answers:*

*1. a)*

*2) t = 3240 Nm* *3) T = 2480 N* *4) M = 37.3 kg* *5) $T_1$ = 267 N & $T_2$ = 283 N*

Axis 2




$$\Sigma\tau = 0 = (50)(5) + (250)(2) + (150)(1) - T_1(3) - (100)(1)$$

$$0 = 250 + 500 + 150 - 3T_1 - 100$$

$$3T_1 = 800$$

$$\boxed{T_1 = 267\ N}$$

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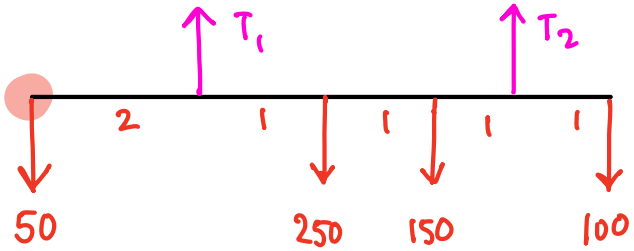
Also could have done:

Axis 3




$$\Sigma\tau = 0 = T_1(2) + T_2(5) - 250(3) - 150(4) - 100(6)$$
$$-750 \quad -600 \quad -600$$

$$\boxed{2T_1 + 5T_2 = 1950}$$

But we need a 2nd equation! So pick another axis!

Also could have said:

Since everything is @ rest $\Sigma F = 0$!

So $T_1 + T_2 - 50 - 250 - 150 - 100 = 0$

$$\boxed{T_1 + T_2 = 550}$$

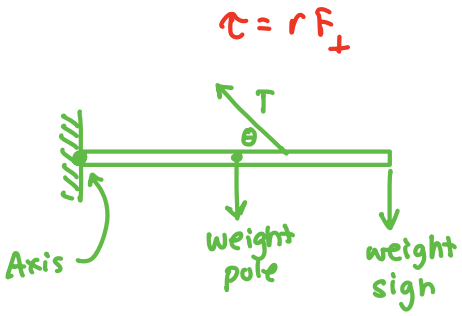
this could be 2nd equation!

notice $267 + 283 = 550$ ☺

Then just do the algebra to solve for $T_1$ & $T_2$.

# Another Look at Question 3:

- remember: gravity acts on center of mass!




Everything is balanced,

so $\Sigma\tau = 0$ $\quad \tau_1 + \tau_2 + \tau_3 = 0$

weight! weight!

$(.75)(15)(10) + (1.5)(75)(10) - (1)T\sin\theta = 0$

$112.5 + 1125 = T\sin 30$

$T\sin 30 = 1237.5$

$\boxed{T = 2480\ N}$

.....

what is $\Sigma F$ on bar?

$\Sigma F_y = T\sin\theta - mg - Mg$

$= 1237.5 - 150 - 750$

$= \underline{337.5\ N}$ huh?

$\Sigma F_x = T\cos\theta = 2480\cos 30 = \underline{2148\ N}$ ??

I hope those answers don't make sense! The net force should be ZERO!! The pole is @ rest → since it has no acceleration, there is no net force!