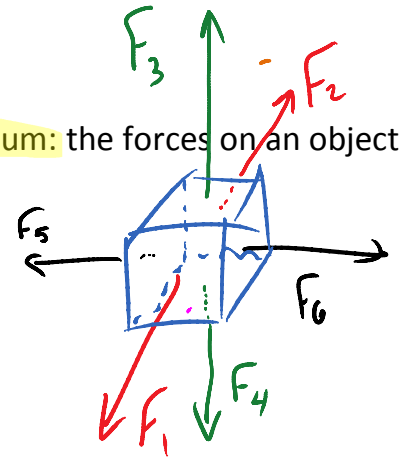
Static Equilibrium 1

Monday, October 04, 2010
9:04 AM

Static equilibrium is the condition such that an object neither moves, nor rotates.

In order to be in static equilibrium 2 conditions must be met:

1st: Fnet = 0
Translational equilibrium: the forces on an object in all directions are exactly balanced
side to side



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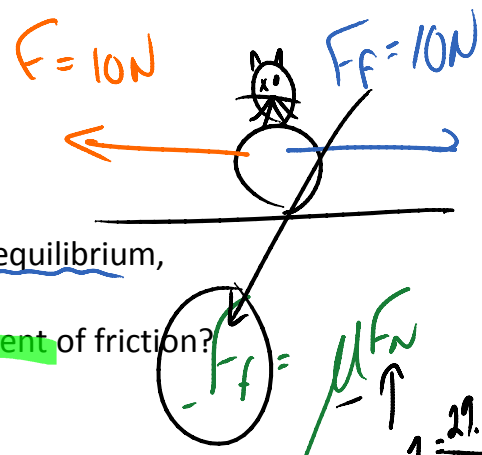


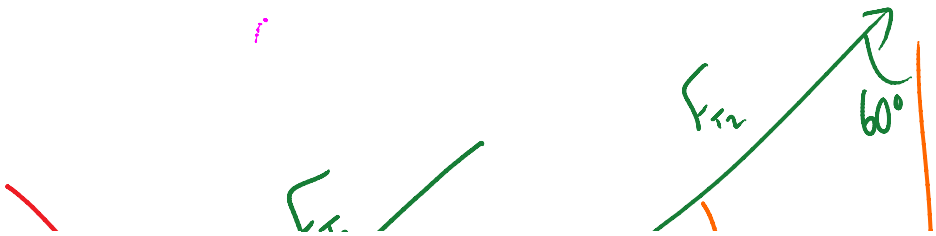
A cat of mass 3.0 kg is known to be in translational equilibrium,
if it is pulled with a force of 10 N
left, and is on a horizontal table, what is the coefficient of friction?

$\frac{10}{29.4} = \mu$ ~~29.4~~ $= 0.34$

$1 = 29.4$

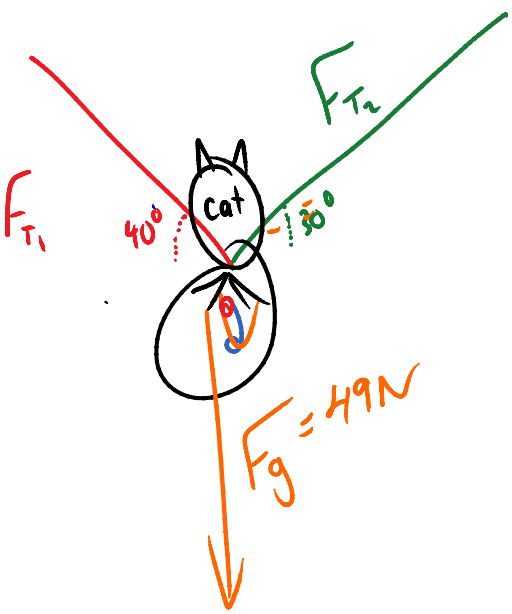
.4

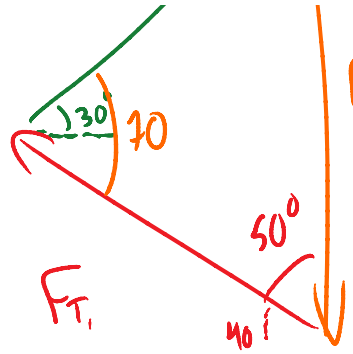
A cat of mass 5.0 kg is hung by two cables as shown,
find the force of tension in each cable.



$F_{T_2} = \frac{49 \sin 50}{\sin 70}$ $\frac{49}{\sin 100}$

$F_G = 49$ $F_{T_2} = 40$ N





$F_{T_2} = 40N$

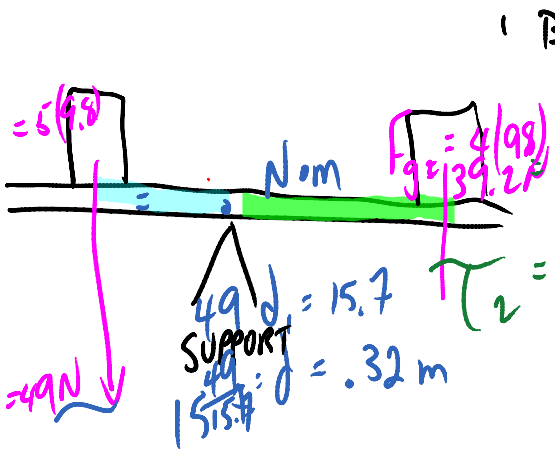
$\sin 100$

$\sin 50$

$F_{T_1} = \frac{49 \sin 60}{\sin 70} = 45N$

$= 38N$

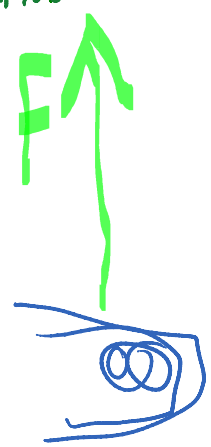
$= \frac{\quad}{\sin 100} = 24.8N$



$\tau = F \times d$

$39.2\ (.4)$

$\tau_2 = F\ 15.7\ N \cdot m$

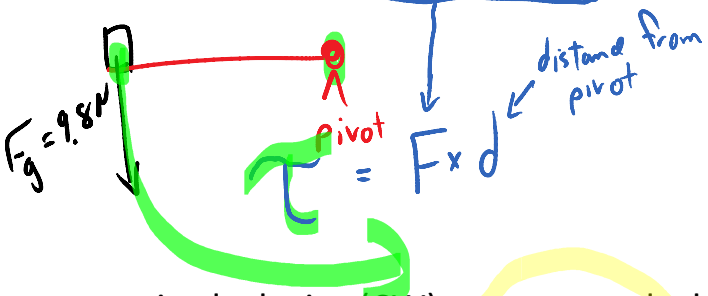


2nd condition for static equilibrium : the total torque must equal zero

ROTATIONAL EQUILIBRIUM

torque is a rotational effect causing motion in an arc

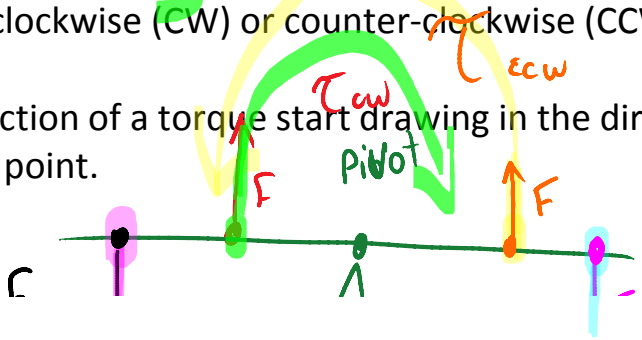
Torque is caused by a force acting at 90º to some rotational radius

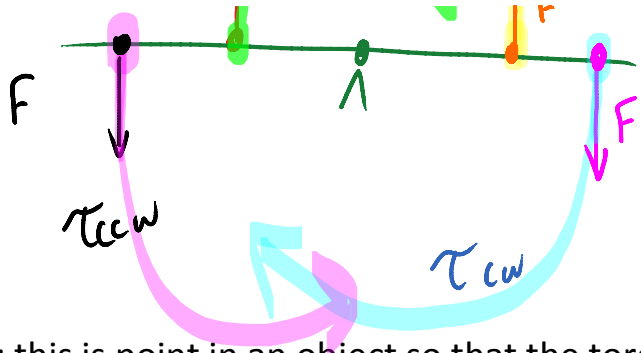


$\tau = F \times d$

Torques act in clockwise (CW) or counter-clockwise (CCW) directions

To find the direction of a torque start drawing in the direction of the force,
Circle the pivot point.

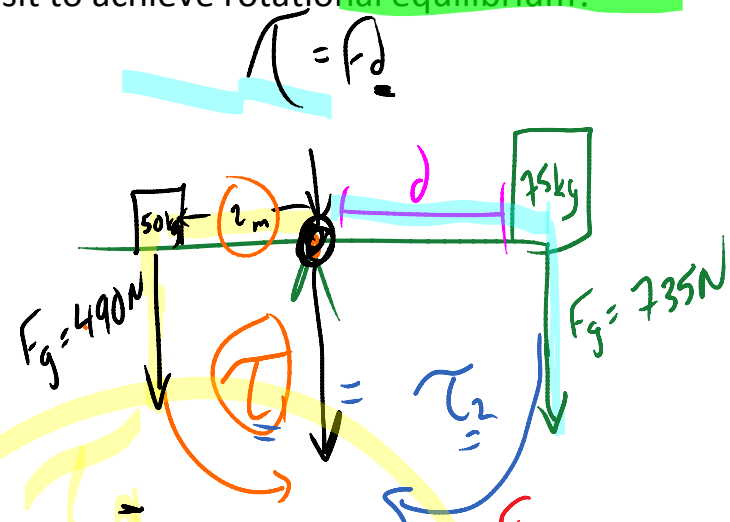




Centre of mass: this is point in an object so that the torques on either side of The object caused by its mass are equal.

Uniform objects have their center of gravity in their center.

A see-saw of length 6.0 m is pivoted in the middle, a 50 kg child sits on the Left side, 2.0 m from the pivot, how far from the pivot must the 75 kg other Person sit to achieve rotational equilibrium?

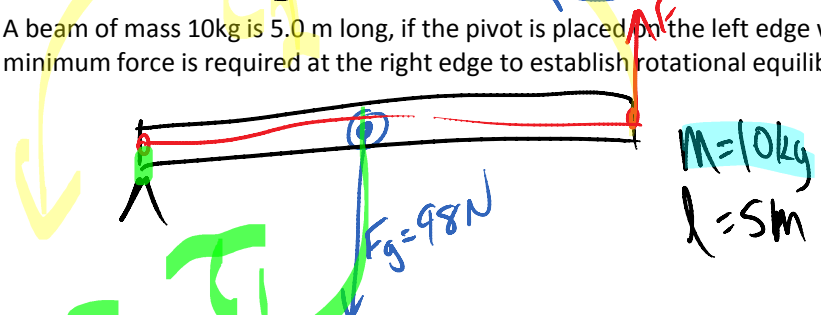


$F_1 d_1 = F_2 d_2$

$\frac{(490)(2)}{735} = \cancel{735}\, d = 1.33\,m$

ccw]

A beam of mass 10kg is 5.0 m long, if the pivot is placed on the left edge what minimum force is required at the right edge to establish rotational equilibrium?



m=10kg
l=5m

$\tau_1 = \tau_2$

$98\left(\frac{5}{2}\right) = F(5)$

Did you need to know the length of the beam?

Did you need to know the length of the beam?

1-4 p. 29

$\frac{98(2.5)}{5} = F = 49N$

~~What force is exerted at the pivot?~~

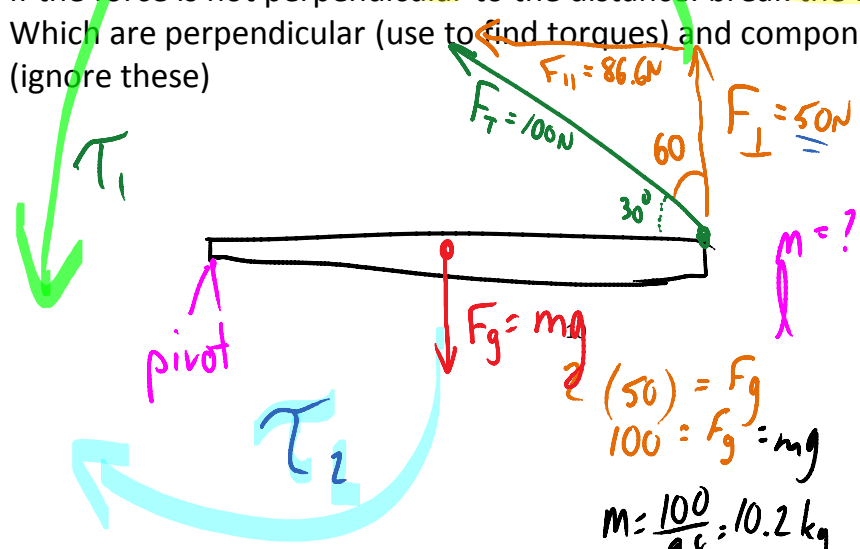
Tips:

1 unknown force and 1 unknown distance: balance the forces using translational Equilibrium to find the unknown force. THEN balance torques to find the unknown Distance.

2 unknown forces: Place a pivot at one unknown force (τ there = 0 N·m) then balance The remaining torques to find the other unknown force. Then recalculate moving the Pivot to the location of the force you just found and repeat.

was at the

If the force is not perpendicular to the distance: break the force into components Which are perpendicular (use to find torques) and components which are parallel (ignore these)



find the mass of the

$2(50) = F_g$

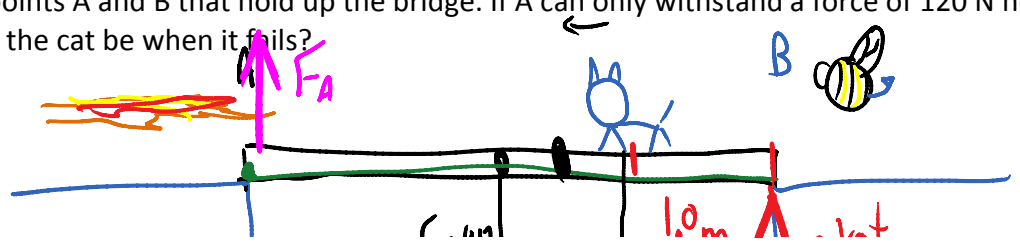
$100 = F_g = mg$

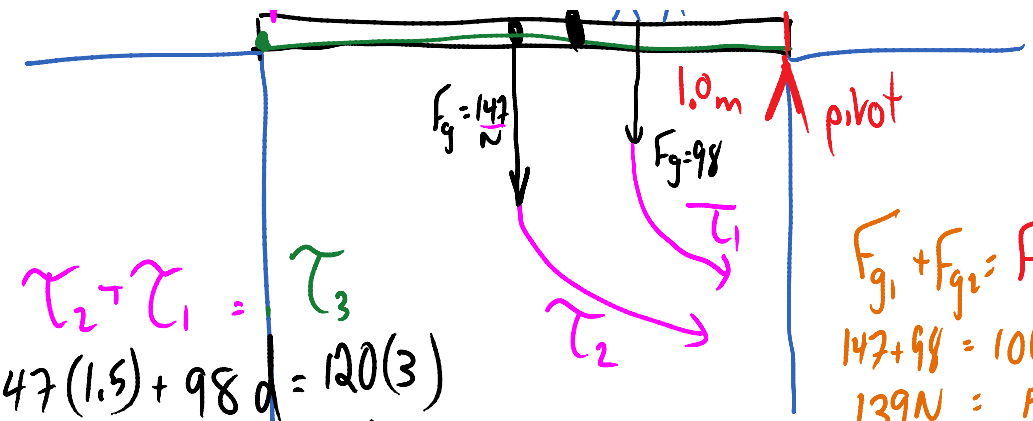
$m = \frac{100}{9.8} = 10.2\ kg$

ch is as though

τ_3

A cat of mass 10 kg walks along a bridge of mass 15kg and length 3.0 m. Calculate the force At points A and B that hold up the bridge. If A can only withstand a force of 120 N how far along Will the cat be when it fails?





$\tau_2 + \tau_1 = \tau_3$

$147(1.5) + 98d = 120(3)$

$220.5 + 98d = 360$

$98d = 360 - 220$

$98d = 140$

$d = \frac{140}{98} = 1.42\,m$

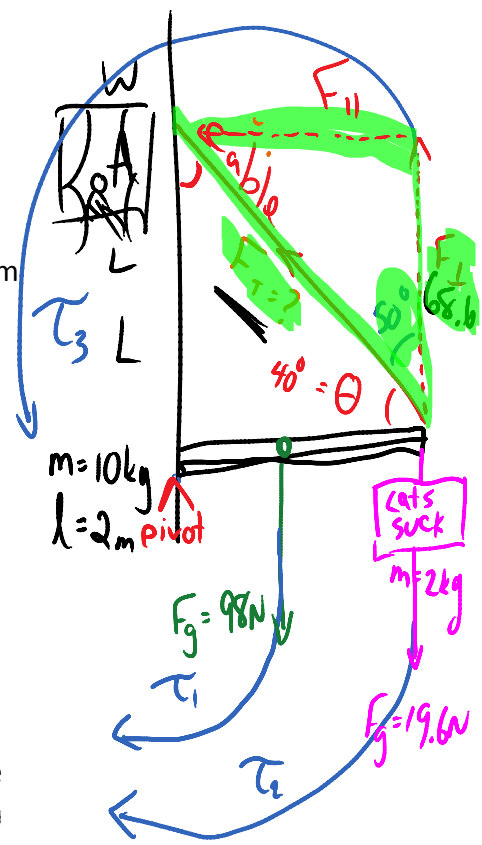
$F_{g_1} + F_{g_2} = F_A + F_B$

$147 + 98 = 106 + F_B$

$139N = F_B$

#4 p30

Beam perpendicular to a wall with an angled cable:



1) Find all Fg's (label them)
2) Break the F_T into components that Are perpendicular and parallel to the beam
3) Label torques using the wall as the pivot
4) Write the condition for rotational equilib.

$\tau_1 + \tau_2 = \tau_3$

5) Find the unknown perpendicular force

$98(1) + 19.6(2) = F_\perp(2)$

$F_\perp = 68.6N$

6) Now use angle functions to F_T in the cable

$\frac{F_\perp}{F_T} = \cos 50 \quad \frac{68.6}{\cos 50} = F_T = 107N$

Angled beams….the challenge is the force of gravity will not be perpendicular to the distance along the beam. Remember all vectors can be broken into 2 components.

· Torque causes g of the

Angled beams....the challenge is the force of gravity will not be perpendicular to the distance along the beam. Remember all vectors can be broken into 2 components.

1) Find all Fg's
2) Break the Fg's into components that are Perpendicular and parallel to the beam
3) Label the torques created by the perp comps
4) Break the F_T in perpendicular and parallel Components.
5) Write the condition for Rotational equilibrium

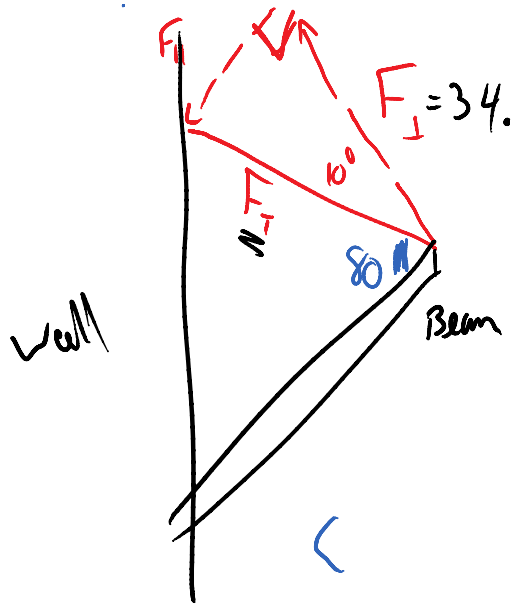
$$\tau_1 + \tau_2 = \tau_3$$

6) Substitute and solve for $F_\perp$

$$(49)\frac{\cancel{2}}{2} + 9.8 = F_\perp$$

$$F_\perp = 34.3N$$

7) Do angle functions to find F_T

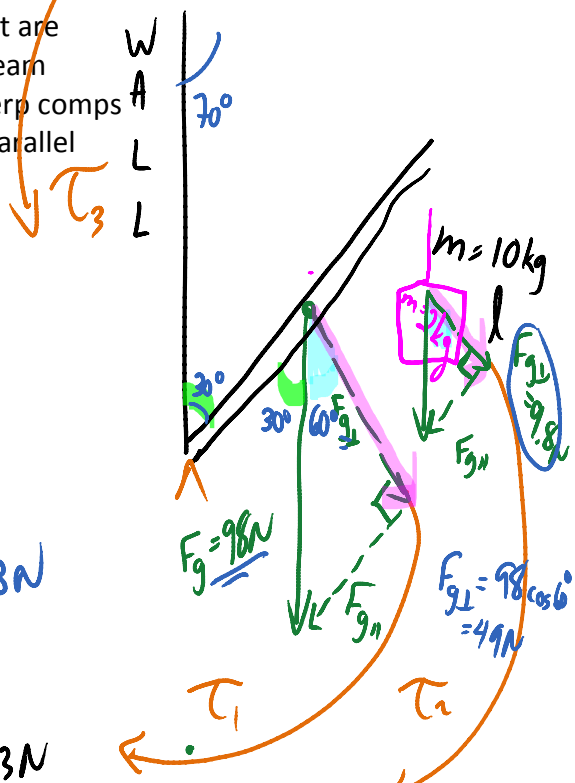


$$\frac{F_\perp}{F_T} = \cos 10$$

$$\frac{34.3}{\cos 10} = F_T = 34.9\ N$$

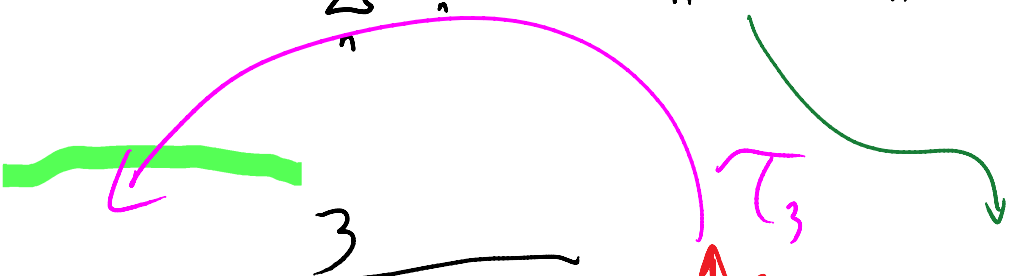
$$\tau_{total} = \tau_1 + \tau_2 = 264.6$$

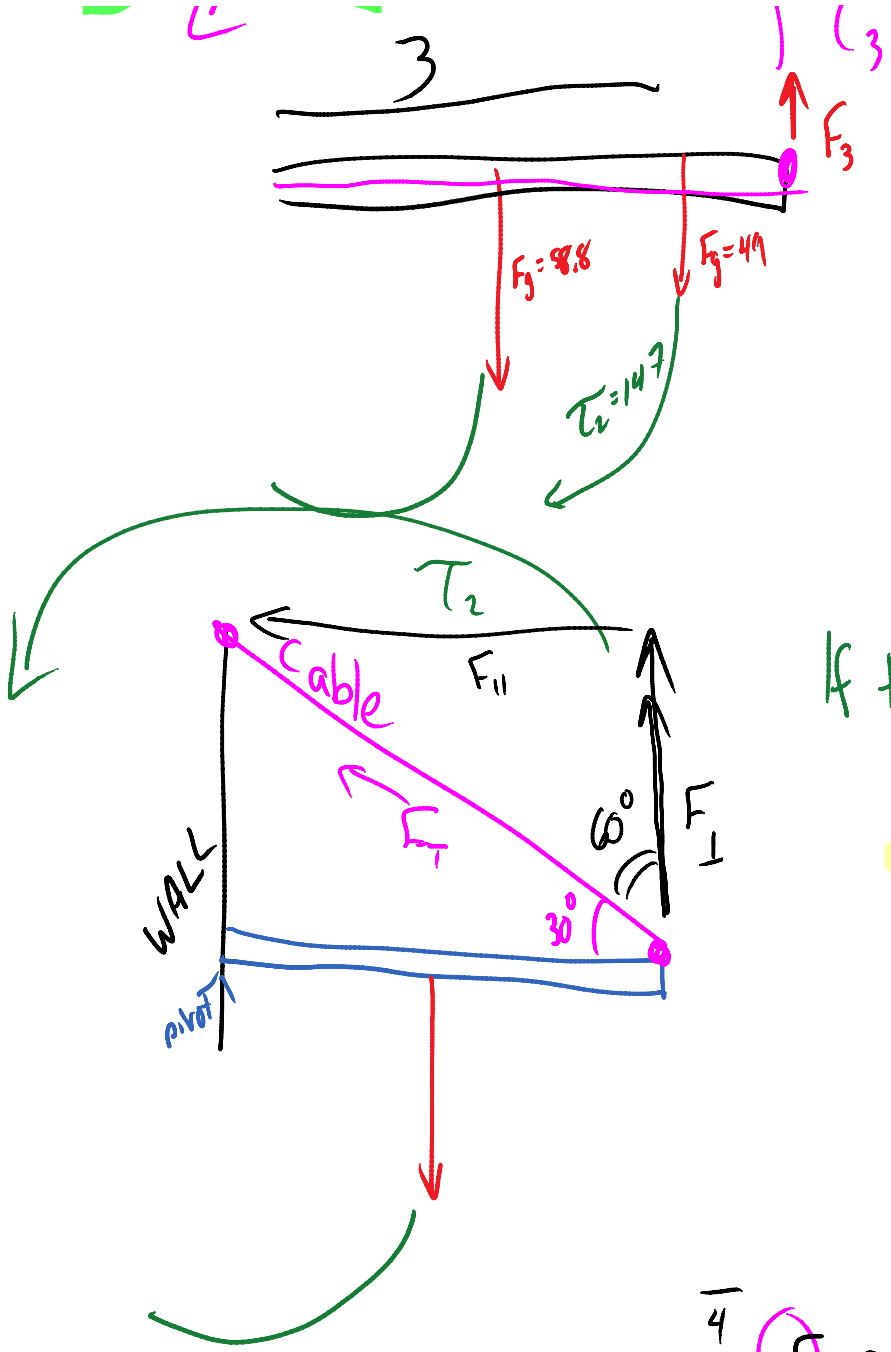
260 Nm



$$\sum_n^m \tau_n = 0$$

$$\sum_n^m \tau_{cw} = \sum_n^m \tau_{ccw}$$





τ_2

$264.6 = \tau_3$

$264.6 = F_3 d$

$\frac{}{4} = 66.1\ N$

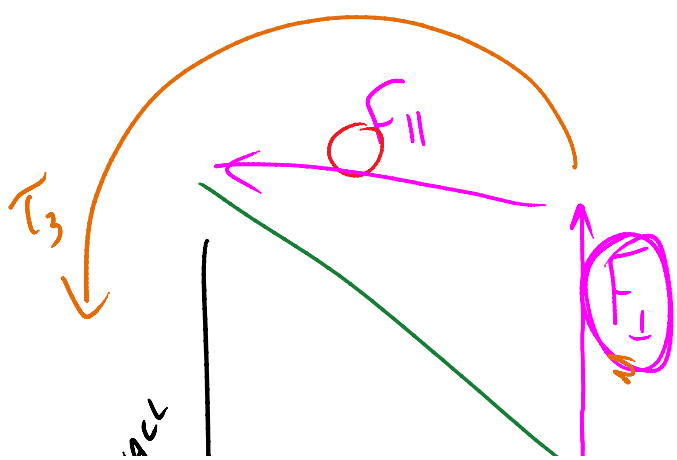
If the beam has length 4.0m and mass 10kg what Force of tension exists in the cable

$\frac{F_\perp}{F_T} = \cos 60$

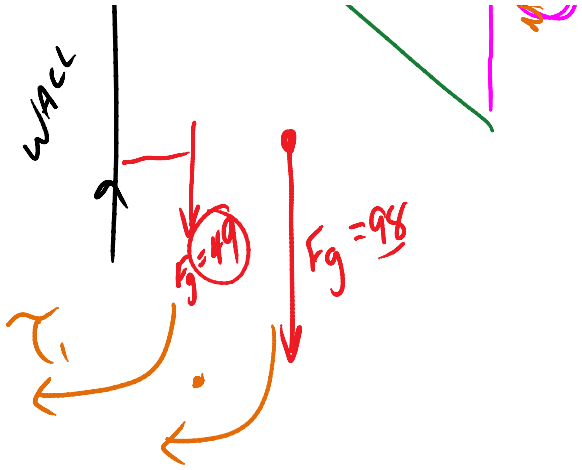
$\frac{F_\perp}{\cos 60} = F_T$

$98N = F_T$

$\frac{}{4}$ $F = 49$



$\tau_1 + \tau_2 = \tau_3$



$\tau_1 + \tau_2 = \tau_3$

$49(1) + (98)(2) = F_\perp(4)$

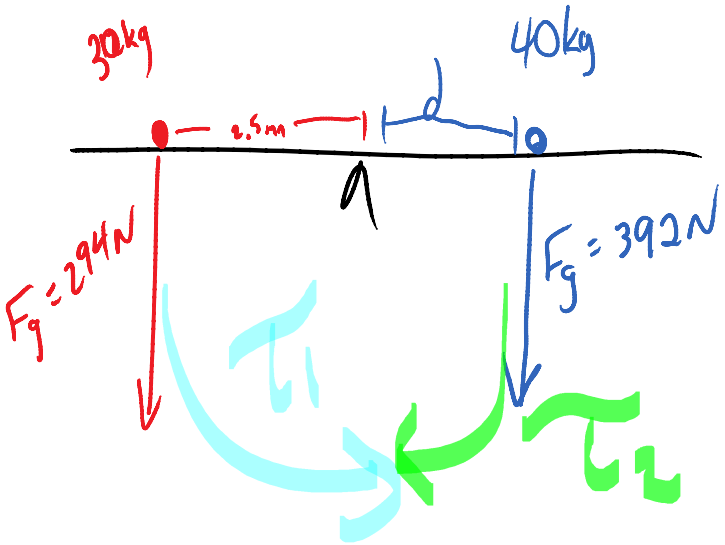
$49 + 196 = 4F_\perp$

$\frac{245}{4} = F_\perp$

$61.25 = F_\perp$

$\frac{F_\perp}{F_T} = \cos 50$

$\frac{F_\perp}{\cos 50} = F_T = 95.3N$



for any force at a pivot the Torque produced

$\tau = F \times d$

zero

$\tau = 0$

1-5 p 29

$\tau_1 = \tau_2$

$\frac{294(2.5)}{392} = \cancel{392}\, d = 1.875m = 1.88m$