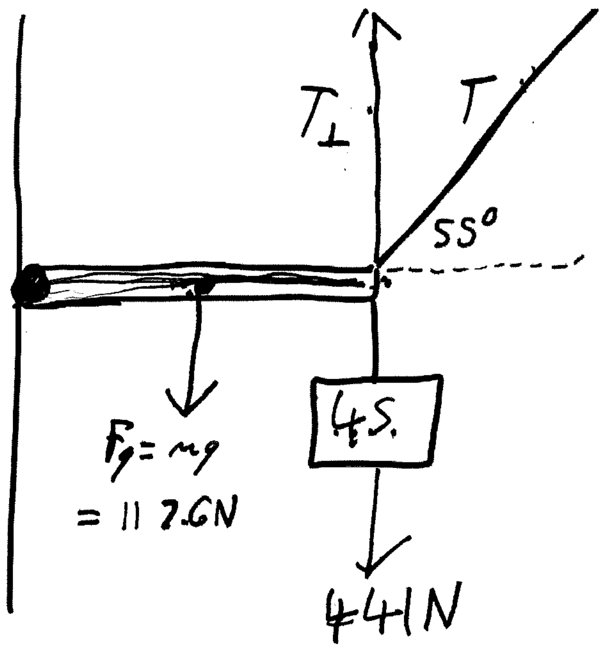
Rotational Equilibrium when torque is not at 90 degrees.

A 4.2 m long 12 kg beam is connected to a wall with a hinge, a 45 kg mass hangs from the end of the beam. A rope holds the beam horizontally as shown. What is the tension in the rope?



$$\tau_c = \tau_{cc}$$

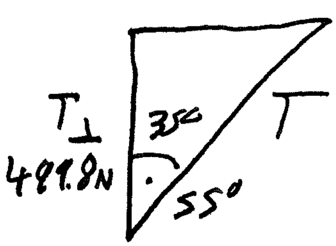
$$117.6 \times \frac{l}{2} + 441 \times l$$

* Only perpendicular component of tension affects torque

$$\tau_c = \tau_{cc}$$

$$117.6 \times \frac{l}{2} + 441 \times l = T_\perp \times l$$

$$499.8\ N = T_\perp$$

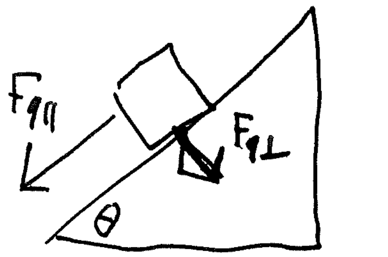


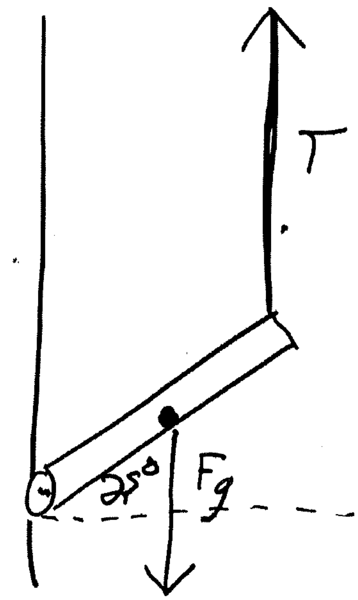
$$\cos 35° = \frac{499.8N}{T}$$

$$T = \frac{499.8N}{\cos 35°}$$

$$= 610\ N$$

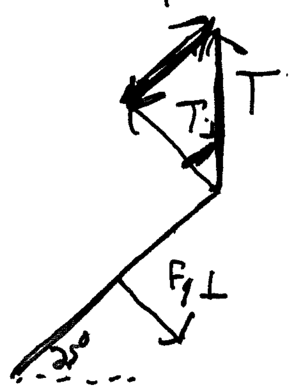
EXAMPLE: A 2.4 m long beam of mass 22 kg is attached to a wall with a hinge and is held at an angle of 25° above the horizontal by a rope. What is the tension in the rope? What is the force provided by the hinge?

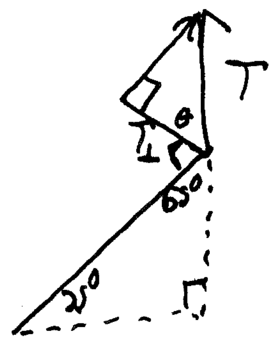




$\sin\theta \cdot F_g = F_{g\parallel}$

$\cos\theta \times F_g = F_{g\perp}$



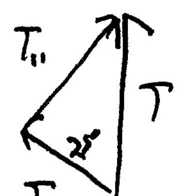


$T_c = T_{cc}$

$F_{g\perp} \times \frac{\ell}{2} = T_\perp \times \ell$

$\frac{\cos 25 \times 22 \times 9.8}{2} = T_\perp$

$97.70N = T_\perp$



$\cos 25 = \frac{97.70}{T}$

$T = 107.8N$

Total up = Total down

$F_{hinge} + 107.8N = F_g$
$= 215.6$

$F_{hinge} = 107.8N$