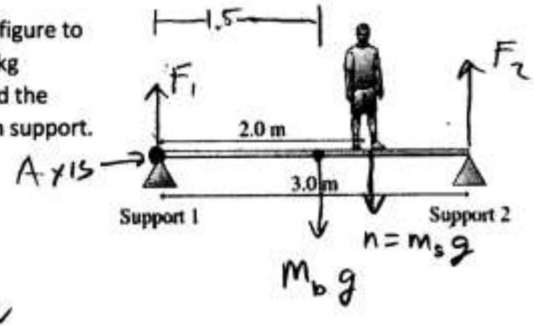
3. The 3.0-m-long, 100 kg rigid beam in the figure to the right is supported at each end. An 74kg student stands 2.0 m from support 1. Find the magnitudes of the forces exerted by each support. (10 points)



Place axis of rotation @ support 1. We know

$$\tau_{net} = 0 = -1.5m(m_b g) - 2m(m_p g) + 3m(F_2)$$

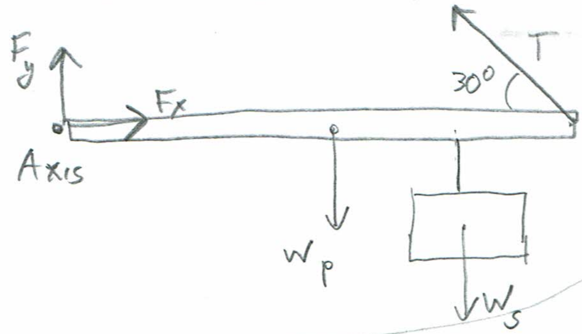
$$\Rightarrow F_2 = \frac{(1.5\,m) m_b g + (2\,m)\, m_p g}{3} = 973.5\,N$$

To find F_1, we know $F_{net,y} = F_1 + F_2 - m_b g - m_s g$

$$\Rightarrow F_1 = m_b g + m_s g - F_2 = 731.7\,N$$

3. Our system is the pole + the sign. Place axis at the left of the pole.

a)



$$\tau_{net} = \tau_T - \tau_{wp} - \tau_{w_s} = 0$$

$$\tau_T = r_T T \sin(30^\circ)$$

where $r_T = 2\,m$.

(Note it is 30° - not 60°)

$\tau_{wp} = r_p m_p g$ ($\theta = 90^\circ$ here). $r_p = 1.0\,m$ because the pole is uniform.

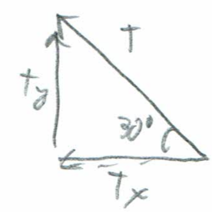
$\tau_{w_s} = r_{s\perp} m_s g$ (Using the moment arm $r_{s\perp} = 1.3\,m$)

$\theta = 90^\circ$ again.

so $r_T T \sin(30^\circ) - r_p m g - r_{s\perp} m_s g = 0$

$$\Rightarrow \quad T = \frac{r_p m_p g + r_{s\perp} m_s g}{r_T \sin(30^\circ)} = 352.8\,N$$

b) Now we'll need x and y components of T!



$T_x = T\cos 30^\circ = 305.5\,N$

$T_y = T\sin 30^\circ = 176.4\,N$

$F_{net,x} = F_x - T_x = 0 \quad \Rightarrow \quad F_x = T_x = 305.5\,N$

$F_{net,y} = T_y + F_y - w_p - w_s = 0$

$\Rightarrow \quad F_y = w_p + w_s - T_y = m_p g + m_s g - T_y = 117.6\,N$

4. We'll use conservation of angular momentum $L_f = L_i$

$L_i = L_{mouse} + L_{record}$.

For the mouse, a point particle $I = M_m R^2$.

so $L_i = I_i w_i = M_m R^2 w_i$

For the record

$L_i = I_r w_i$

$= \frac{1}{2} M_r R^2 w_i$

~~For the record~~: $L_f = I_f w_f = 0$ since $R = 0$

$L_f = I_r w_f$

$= \frac{1}{2} M_r R^2 w_f$.

$L_f = L_i$

$$\frac{1}{2} M_r R^2 w_f = \frac{1}{2} m_r R^2 w_i + M_m R^2 w_i$$

$$\Rightarrow w_f = \frac{m_r R^2 w_i + 2 m_m R^2 w_i}{m_r R^2}$$

$$w_f = \left(\frac{m_r + 2m_m}{m_r}\right) w_i$$

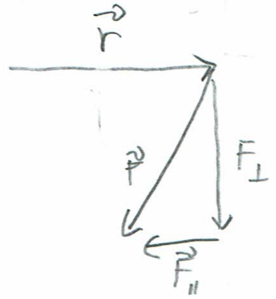
$$= (1.4)\, w_i = 46.2 \text{ RPM}$$

(curl fingers in direction of rotation and stick out thumb)

5. a) Using the RHR we find $\vec{L}$ points out of the page

b) $|\tau| = rF \sin\theta = (0.08\text{m})(3\text{N}) \sin 60° = 0.208$ Nm

Direction is best found by looking at $\vec{F}_\perp$, which is upwards:



So the RHR gives a torque into the page

(Thumb to the right, fingers downward, palm ~~faces~~ points down).

This makes sense since the torque opposes the motion