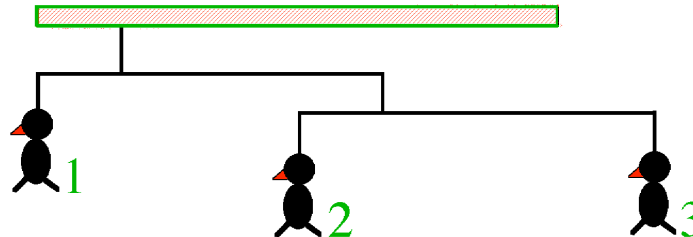


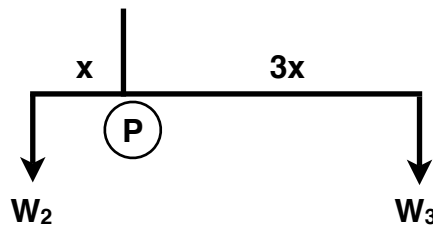
Torque problem: Penguin mobile

A toy "mobile" of penguins hangs motionless. Each cross-bar is horizontal, of negligible mass & extended 3 times as far to the right of the supporting wire as to the left. Mass of penguin 1 is $9.6g$.

What are the masses of penguins 2 & 3?



Solution: First look at just the wire holding penguins 2 and 3:



Because the penguins are in equilibrium, the net torque on the system is 0. Calculate the torque due to the weight of each penguin about point P, the suspension point: take anti-clockwise torques to be positive

penguin 2: force W_2 is acting at perpendicular distance x from P so

$$\tau_2 = + x W_2 = + m_2 g x$$

penguin 3: force W_3 is acting at perpendicular distance $3x$ from P so

$$\tau_3 = - 3x W_3 = - 3m_3 g x$$

equilibrium $\Rightarrow \tau_2 = \tau_3$

$$\text{so } m_2 g x - 3m_3 g x = 0$$

$$m_2 g x = 3m_3 g x$$

$$m_2 = 3m_3$$

Now do the same for the wire holding penguin 1 and penguins 2 and 3 together:

penguin 1: force W_1 is acting at perpendicular distance y from P so

$$\tau_1 = + y W_1 = + m_1 g y$$

penguins 2+3: force W_{2+3} , (combined weight), is acting at perpendicular distance $3y$ from P so

$$\tau_{2+3} = - 3y W_{2+3} = - 3(m_2 + m_3) g y$$

$$\text{equilibrium } \Rightarrow m_1 g y - 3(m_2 + m_3) g y = 0$$

$$\text{so } m_1 = 3(m_2 + m_3) = 3(3m_3 + m_3) = 12m_3$$

$$\text{so } m_3 = m_1 / 12 = 0.8 \text{ g, } m_2 = 3m_3 = 2.4 \text{ g}$$