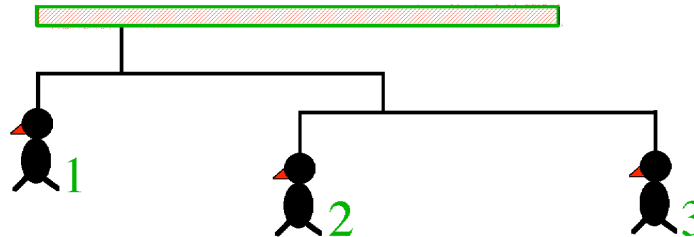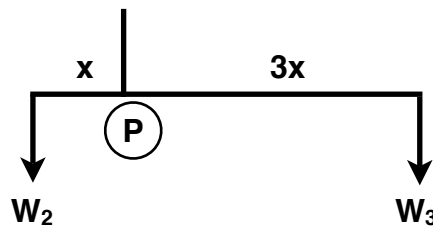# Torque problem: Penguin mobile

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?

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 $\Rightarrow$ $\tau_2 = \tau_3$

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

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

so $m_1 = 3(m_2+m_3) = 3\,(3m_3+m_3) = 12m_3$
so $m_3 = m_1/12 = 0.8$ g, $m_2 = 3m_3 = 2.4$ g