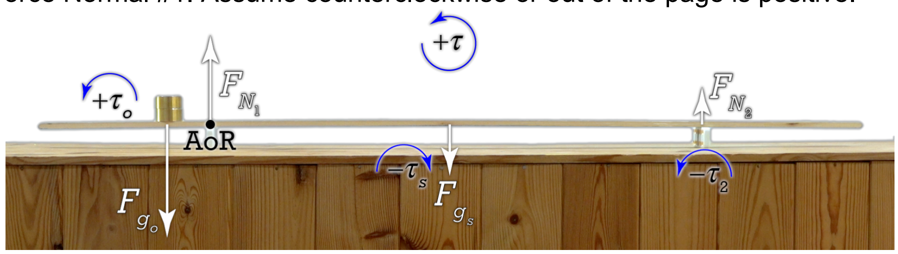
Flipping Physics Lecture Notes:

Painter on a Scaffold – Don't Fall Off!!

Example: What is the closest to the end of a 93 g uniform meterstick you can place a 200.0 g object and have the system stay balanced? The meterstick is supported at the 20.0 cm and 80.0 cm marks.

$m_s = 93g$; $m_o = 200.0g$; supports at 20.0cm and 80.0 cm; $x = ?$

The system is at rest, so it is in both translational and rotational equilibrium. Therefore, the net force equals zero and the net torque about any axis of rotation equals zero. This special case is called *static* equilibrium. Let's sum the torques on the meterstick about the 20.0 cm mark which is location of one of the supports, Force Normal #1. Assume counterclockwise or out of the page is positive.



$$\sum \tau_{\substack{AoR\,@\\20.0cm}} = \tau_o + \cancel{\tau_1} - \tau_s + \cancel{\tau_2} = I\alpha = I(0) = 0 \Rightarrow \tau_o - \tau_s = 0 \Rightarrow \tau_o = \tau_s$$

Torque directions:

- The Force of gravity of the object would cause the meterstick to rotate counterclockwise or out of the page, so the torque caused by force of gravity of the object is positive.
- Force normal #1 acts right at the axis of rotation, therefore, the "r" value for force normal #1 is zero, and the torque caused by force normal #1 is zero and has no direction.
- The force of gravity of the stick and force of gravity 2 would both cause the meterstick to rotate clockwise or into the page, so the torques caused by force of gravity of the stick and force of gravity #2 are both negative.

As we move the object closer to the left end of the meterstick, the magnitude of force normal #2 decreases. When force normal #2 is reduced to zero, the object has reached it closest point to the left end of the meterstick, any farther left and the system would unbalance. Therefore, in this problem, force normal #2 is zero and the torque caused by force normal #2 is also zero.

$$\Rightarrow r_o F_{g_o} \sin\theta_o = r_s F_{g_s} \sin\theta_s$$

$$\Rightarrow r_o m_o \cancel{g} \sin(90) = r_s m_s \cancel{g} \sin(90) \;\&\; \theta_o = \theta_s = 90^\circ \;\&\; \sin(90^\circ) = 1$$

(everybody brought g, the acceleration to gravity, to the party!)

$$\Rightarrow r_o m_o = r_s m_s \Rightarrow r_o = \frac{r_s m_s}{m_o} = \frac{(30)(93)}{(200)} = 13.95cm$$

Note: $50 = 20 + r_s \Rightarrow r_s = 50 - 20 = 30cm$

$$20 = x + r_o \Rightarrow x = 20 - r_o = 20 - 13.95 = 6.05 \approx 6.0cm$$

Answer: $\boxed{6.0cm \text{ from the end of the meterstick}}$