LAB 8: Static Equilibrium*

Equipment List:

meter stick
2 hangers
long rod
short rod
right angle rod clamp
3 knife edge clamps
set of masses
triple-beam balance
ruler (optional)

Purpose: To study an object (the meter stick) in static equilibrium and explore how the equations from the theory predict values for forces on such an object. You will confirm that the vector sum of all the forces on the meter stick is zero and the net torque about an arbitrary point on the meter stick is zero, to support the idea that the net torque on the meter stick about any point is zero.

Theory: An object is in static equilibrium if it meets the following conditions:

1. The net force on the object is zero, $\sum_i \vec{\mathbf{F}}_i = 0$. Equivalently, this means that the sum of the x, y, and z components of the forces are all zero. $\sum F_x = \sum F_y = \sum F_z = 0$
2. The net torque on the object about any point must be zero, $\sum_i \vec{\boldsymbol{\tau}}_i = 0$.
3. The object is at rest, $\vec{\mathbf{v}} = 0$ and $\vec{\boldsymbol{\omega}} = 0$.

Procedure:
Part 1

1. Weigh the meter stick with the triple-beam balance.
2. Set up the vertical rod and use the right angle clamp to attach the horizontal rod over your lab bench
3. Locate the center of mass of the meter stick by balancing on the edge of a ruler, or by hanging the ruler from the horizontal rod using the knife edge clamp and adjusting the location of the clamp so that the meter stick balances horizontally.
4. Suspend the meter stick from the 25cm mark. Add mass suspended from the 10 cm mark until the stick is balanced horizontally (see Figure 1).

*Based on the lab by Prof. Luna.

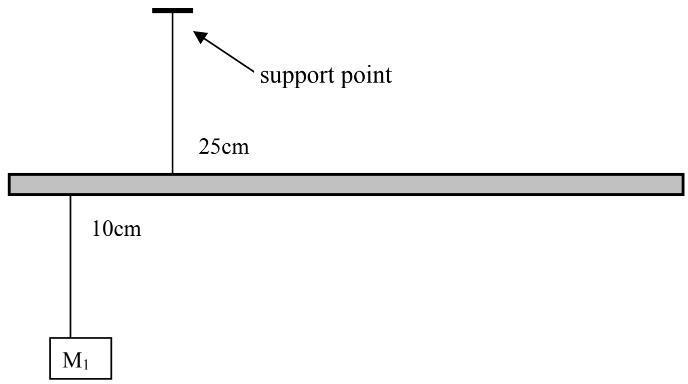

Figure 1: The setup in part 1.

5. Take all the masses, hanger, and knife edge clamp (and string if used) used at the 10 cm mark and weigh them all together on the triple beam balance. Call this measurement mass m_1.

6. Draw a Free-Body Diagram for the meter stick in your lab book.

7. Calculate the net torque (sum of the torques) about the 25 cm mark.

8. Calculate the tension in the string supporting the the meter stick by using the fact that $\sum F_y = 0$, where y is the vertical direction.

Part 2

1. Pivot meter stick about the 40 cm mark.

2. Using your triple beam balance, place your knife edge clamp on the balance pan the add a hanger and masses on the hanger until the total is as close to 200 g as possible. Record this exact value as m_2. Attach this mass collection to the 95 cm mark.

3. Add mass to the 10 cm mark until the stick is balanced horizontally.

4. Weigh the masses, hanger, and knife edge clamp used at the 10 cm mark and record this value as m_1.

5. Draw a Free-Body Diagram for the meter stick.

6. Calculate the tension in the string supporting the meter stick by using the constraint that the net torque (sum of the torques) about the 75 cm mark must be zero.

7. Calculate the tension in the string supporting the meter stick by using $\sum F_y = 0$.

8. Compare the tensions by calculating the percentage error, taking the result from the force equilibrium condition to be the expected value.