

STATIC EQUILIBRIUM

OBJECTIVE

To show that if a body is in Static Equilibrium it must satisfy the following conditions:

1. The vector sum of all the external forces must be zero.
2. The vector sum of all the external torques about any point must be zero.
3. The body must NOT have translational or rotational motion (the body must be at rest).

EQUIPMENT

1. meter stick
2. hangers (4)
3. large rods (2)
4. small clamps (3)
5. large clamp (2)
6. set of masses
7. triple-beam balance
8. protractor

THEORY

The conditions for static equilibrium are the following:

1. The vector sum of all the external forces must be zero.

$$\sum \vec{F} = 0$$

In component form:

$$\sum F_x = 0, \quad \sum F_y = 0, \quad \sum F_z = 0$$

2. The vector sum of all the external torques about any point must be zero.

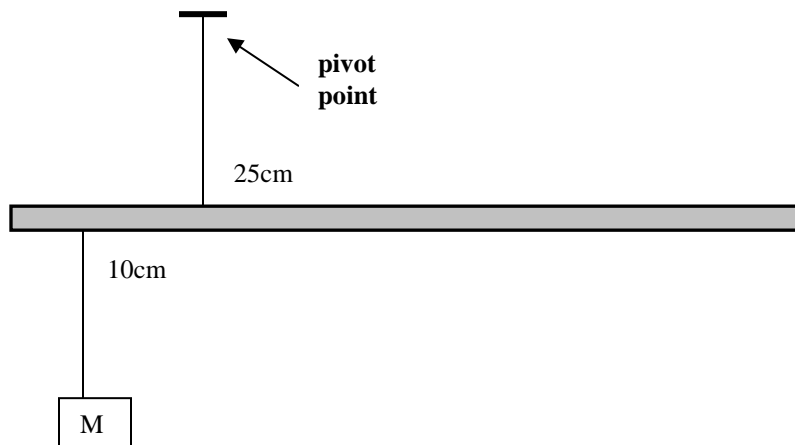
$$\sum \vec{\tau} = 0 \text{ (about any point)}$$

3. The body must NOT have translational or rotational motion. That is, the body must be at rest.

PROCEDURE

Part 1

1. Weigh the meter stick with the triple-beam balance.
2. Locate the center of mass of the meter stick by balancing with a small clamp.
3. Pivot meter stick about the 25cm mark. Add mass to the 10cm mark until the stick is balanced horizontally (see figure below).



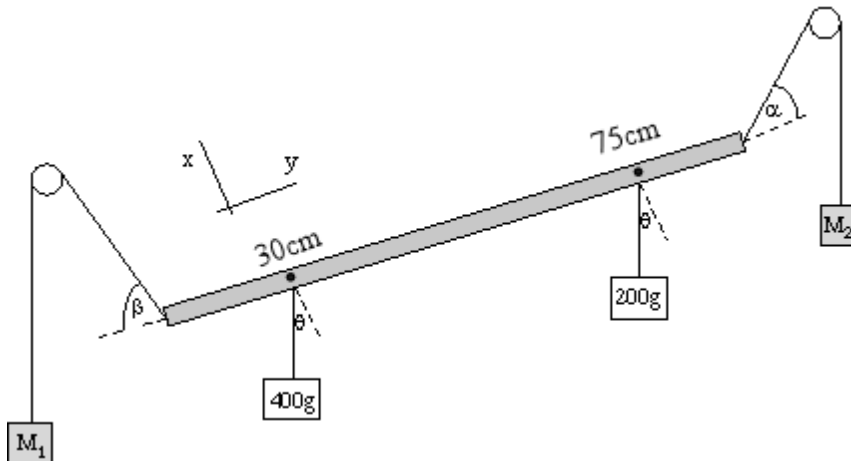
4. Draw a Free-Body Diagram for the meter stick.
5. Calculate the net torque (sum of the torques) about the 25 cm mark. Do not forget to include the mass of the small clamp used to attach the mass at the 10cm mark.
6. Calculate the tension in the string supporting the meter stick by using $\sum F_y$.

Part 2

1. Pivot meter stick about the 40cm mark. Add 200g to the 95 cm. Add mass to the 10cm mark until the stick is balanced horizontally.
2. Draw a Free-Body Diagram for the meter stick.
3. Calculate the tension in the string supporting the meter stick by **FIRST** calculating the net torque (sum of the torques) about the 75 cm mark. Do not forget to include the mass of the small clamps used to attach the masses at the 95cm and 10cm marks.
4. Calculate the tension in the string supporting the meter stick by calculating $\sum F_y$.
5. Compare results for the tension in the string. Take the result from (4) to be the expected value.

Part 3

1. Setup the meter stick as shown below:



2. Attach the string supporting M_1 at $x = 10$ cm on the meter stick.
3. Attach the string supporting M_2 at $x = 95$ cm on the meter stick.
4. Adjust M_1 and M_2 so that α and β are approximately less than 60° .
5. Calculate $\sum \tau$ about the 20cm mark.
6. Calculate $\sum F_x$ and $\sum F_y$ using the coordinate system shown on diagram above.