Name_____

Rotational Equilibrium with a New York Balance

Introduction

A New York Balance is a simple instrument for demonstrating the principles of center of mass and torque. By hanging strategically placed masses on a balanced half-meterstick, rotational equilibrium can be achieved . Once the system is in equilibrium, Newton's second law (in rotational form) can be applied to find unknown quantities in the system.
According to Newton's second law(in rotational form):

$$\Sigma\tau = I\alpha$$

where the rotational analog of force is torque (τ):

$$\tau = r_{\perp}F$$

Equilibrium is achieved when torques are balanced and α is zero.

Procedure

Set up the balance as shown in **figure 1**:

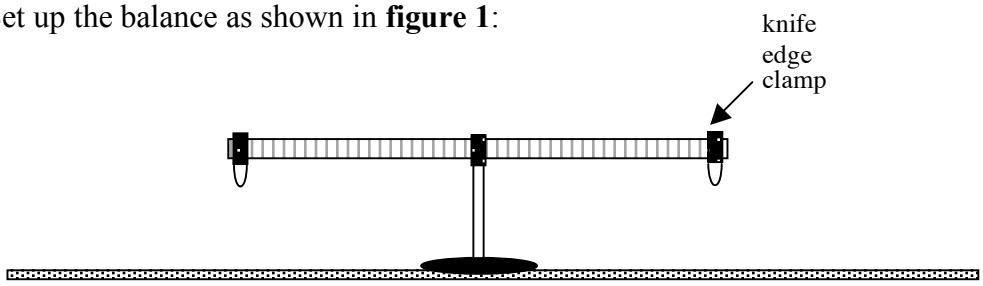

Figure 1: Initial configuration of balance apparatus in equilibrium

Assemble the cast iron base and stand first. Then, take a knife edge clamp without its hanger and clamp it onto the stick with the screw facing down(somewhere around the 25 cm mark). Balance the stick on the stand and move the clamp accordingly until the stick is balanced evenly on both sides. Then take the two masses, using the remaining clamps(with the screws facing up), and balance them on each side of the stick until you achieve equilibrium again. Use the 100 g mass on the left and the 50 g mass on the right. Draw a diagram of your apparatus including positions and masses. Record the data in **Table 1**.

Position of center clamp:_____cm

Mass of clamp:_____kg

Mass (kg)	*Force (N)*	*Position (m)*	*Torque (N• m)*

Table 1: Data for Calculating Static Equilibrium with both masses

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Now, remove the 100 g mass. Adjust the position of the center clamp until the system is balanced. Draw another diagram and record the data in **Table 2**.

Mass (kg)	***Force (N)***	***Position (m)***	***Torque (N• m)***

Table 2: Data for Calculating Static Equilibrium with one mass

Using the data gathered in **Table 1**, apply Newton's second law to confirm (or deny) that the net torque on the system is zero.(make sure to include forces on your diagram)
For the data gathered in Table 2, apply Newton's second law again to find the mass of the meter stick required to counterbalance the system.(make sure to include forces on your diagram)

Questions

1. In the calculations corresponding to the first setup did you have to worry about the mass of the half-meterstick? Did you have to worry about the mass of the clamps? Explain.

2. In the diagram of the second setup, where did you locate the force to balance the force of the 50 g mass? Explain. How can this system be balanced if there is no mass hanger on the right side of the apparatus?

3. Using your calculations for the second setup, what is the mass per unit length of the half-meterstick? If the accepted value is **.6 g / cm**, what is the percent error of your measurement?

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Sample Calculations
(include all work, diagrams, etc. attach additional sheets as necessary)