Name: ____________________ Partner's Name: ____________________

Torque and Equilibrium of a Rigid Body

In this experiment, you will study the conditions necessary for rotational equilibrium of a rigid body.

APPARATUS:

Meter stick, 4 knife-edge supports, balance, masses, vertical rod and right angle clamp.

DISCUSSION:

A rigid body in Equilibrium has no translational nor angular acceleration. This leads to two necessary and sufficient conditions for a rigid body to be in equilibrium – there is no net Force or Torque acting upon the body, i.e.

$$\Sigma\vec{F} = 0 \quad \Longrightarrow \text{No Translational Acceleration}, \vec{a} = 0. \tag{1}$$

$$\Sigma\vec{\tau} = 0 \quad \Longrightarrow \text{No Rotational Acceleration}, \vec{\alpha} = 0. \tag{2}$$

The magnitude of the torque $\vec{\tau}$ is given by

$$\tau = rF\sin\theta, \tag{3}$$

where F is the force magnitude, r the distance from the chosen pivot point to the point of application of the force, and θ is the angle between $\vec{r}$ and $\vec{F}$.

PROCEDURE:

1. Determine the mass of the meter stick and each of the knife-edge supports. (Identify each knife-edge support by lettering or otherwise).

   Mass of meter stick, $M =$ ____________________

   Mass of Supports: $m_A =$ __________ $m_B =$ __________ $m_C =$ __________ $m_D =$ __________

2. Find the center of gravity of the meter stick by locating the point where it will balance in a horizontal position.

   Center of gravity of meter stick, $x =$ ____________________

3. Support the meter stick with one of the knife edges located at the center of gravity. Hang a 50 gm mass on the knife-edge support placed at the 10 cm mark and then find the position where a 75 gm mass on a knife-edge support will cause a horizontal balance. On the drawing below draw and label all the forces acting on the meter stick. Calculate the clock-wise and counter clock-wise torques about the supporting knife-edge and compute the percent difference between them. The weights of the knife-edge and the hanger must be included.

$\tau_{CW}=$

$\tau_{CCW}=$

% Difference =

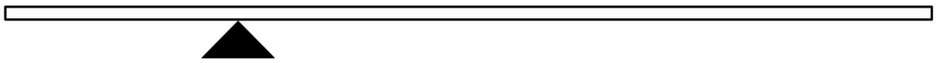
4. With supporting knife edge at the center of gravity of the meter stick, hang one mass of 100 gm at the 65 cm mark and a 50 gm mass at the 80 cm mark. Produce a horizontal balance by placing one 150 gm mass near the other end of the meter stick. Complete the drawing and perform the same calculations as in step 3 below.

$\tau_{CW}=$

$\tau_{CCW}=$

% Difference =

5. Move the supporting knife-edge to the 25 cm mark and balance the meter stick by using one mass that is about twice the mass of the meter stick. Complete the drawing and calculations below.



$\tau_{CW}=$

$\tau_{CCW}=$

% Difference =

QUESTIONS

1. When the meter stick is balanced, why does it assume a horizontal position rather than being at rest in any other position (i.e. tilted)? In other words, if you tilt a meter stick that is balanced, will it want to rotate back to being perfectly horizontal? Whys is that? Hint: Draw a full scale picture of the region around the center of gravity of the horizontal meter stick, including the knife edge support. Do this again with the meter stick not horizontal. Draw in the forces to explain why it assumes a horizontal position in equilibrium.

2. Assume that you are given only a meter stick in a knife-edge support, a hanger which can be hung on the meter stick by a light loop of thread, and a set of masses. Show how to determine the mass of the meter stick if it is not uniform, that is, its mass is not distributed uniformly over its volume.

DUE NEXT WEEK...

1. The lab manual pages all drawings and calculations in parts 1-4 completed.
2. Answers with drawings to Questions 1 and 2.

END LAB #8

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