LAB 8, TORQUE, CENTER OF GRAVITY, EQUILIBRIUM

Name _____ Period_____

To attain equilibrium with parallel forces, two conditions must be met.

(1) The sum of the forces acting downward must equal the sum of the forces adding upward. (2) The sum of the clockwise torques must equal the sum of the counterclockwise torques.

If the torques are acting on a rigid beam, the weight of the beam (effectively concentrated at its center of gravity) acts as a force that must be included in the calculations of the torques.

Because kilograms of mass (1kg = 1000g) and newtons of force are proportional (by the constant g), and meters and centimeters are proportional (by the constant 100cm = 1m), we can substitute grams for *force* and cm for *distance* to get our torques. That will simplify our calculations!

PURPOSE:

After completing this experiment, you should understand the conditions for equilibrium of parallel forces and you should know how to calculate any additional forces that are needed to establish equilibrium with parallel forces.

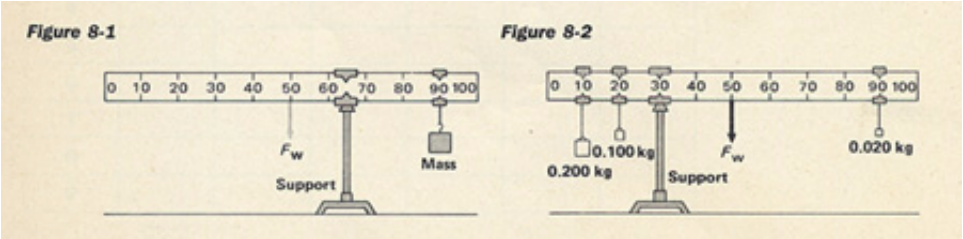
PROCEDURE

A. Weight of meterstick as a force at its center of gravity.

Place the meterstick on the platform balance and determine its mass. Record this value _____ g.

Locate the center of gravity of the meterstick by balancing it and see if it is at the 50cm mark. Note any difference ____cm.

REMEMBER that the Torque Arm is the distance from the center of rotation (the fulcrum) to each mass (not from the end of the meter stick).



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B. Equilibrium: of several parallel forces

1. Balance the meterstick at its center of gravity on a fulcrum. This should be at the 50cm mark unless you have a deformed stick. The weight of the stick is now cancelled out by the upward force of the fulcrum.

Using the NASA weightless string, place a 500g mass 8.0cm from the fulcrum. Using the formula **C = CC**, and showing your method (hup-two-three-four), calculate the distance *from the fulcrum* to to where a 100g mass must be hung to produce equilibrium.

..... **DIAGRAM**:..... **CALCULATIONS**

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Now hang a 100g mass at the calculated distance *from the fulcrum* and adjust it to balance. Record your error (the difference between the **calculated value** and the **measured value**). _____ cm.

Calculate your percentage error. **% error = your error/measured value X 100%**

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2. Balance the meterstick at its center of gravity on a fulcrum so we'll not have to consider the mass of the stick. Place a 20g mass 40cm to the left of the fulcrum, a 200g mass 10cm to the right of the fulcrum, and a 100g mass 25cm to the right of the fulcrum. Calculate where a 500g mass must be placed to produce equilibrium. *Note: if your answer comes out negative, place the force on the other side of the fulcrum.*

..... **DIAGRAM:** ..... **CALCULATIONS**

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Now hang a 500g mass at the calculated distance *from the fulcrum* and adjust it to balance. Record your error (the difference between the **calculated value** and the **measured value**). _____ cm.

Calculate your percentage error. **% error = your error/measured value X 100%**

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3. Place the fulcrum 5.0cm from the left end of the stick. Hang a 1000g mass 20cm *from the fulcrum*. Show on your diagram that the weight of the stick is at the center of mass (the 50 cm mark). This should be 45cm *from the fulcrum*. Calculate the force in grams needed to produce equilibrium when a spring balance is placed 90cm *from the fulcrum*.

..... **DIAGRAM**:..... **CALCULATIONS**

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Now with a string loop, attach the spring balance at the calculated distance *from the fulcrum* and adjust it to produce equilibrium. The force is _____g. Record your error (the difference between the **calculated value** and the **measured value**). _____ g.

Calculate your percentage error. **% error = your error/measured value X 100%**

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4. Place the fulcrum 8.0cm from the left end of the stick. ***For this problem the fulcrum will be inverted***. Hang a 200g mass 60cm *from the fulcrum*. Show on your diagram that the weight of the stick is at the center of mass (the 50 cm mark). This should be 42cm *from the fulcrum*. Calculate the *upward* force in grams needed to produce equilibrium when a spring balance is placed 30cm *from the fulcrum*.

..... **DIAGRAM**: .....**CALCULATIONS**

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Now with a string loop, attach the spring balance at the calculated distance *from the fulcrum* and adjust it to produce equilibrium. Record your error (the difference between the **calculated value** and the **measured value**). _____ g.

Calculate your percentage error. **% error = your error/measured value X 100%**

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TRANSLATIONAL EQUILIBRIUM:

Calculate how Translations Equilibrium is established in each set up above (ups = downs):

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#2.

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#3.

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#4.

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CRITIQUE: