34 Keeping in Balance

Purpose

To use the principle of balanced torques to find the value of an unknown mass.

Required Equipment/Supplies

meterstick
standard mass with hook
rock or unknown mass
triple-beam balance
fulcrum
fulcrum holder
string
masking tape

Discussion

Gravity pulls on every part of an object. It pulls more strongly on the more massive parts of objects and more weakly on the less massive parts. The sum of all these pulls is the weight of the object. The average position of the weight of an object is its center of gravity, or CG.

The whole weight of the object is effectively concentrated at its center of gravity. The CG of a uniform meterstick is at the 50-cm mark. In this experiment, you will balance a meterstick with a known and an unknown mass, and compute the mass of the unknown. Then you will simulate a "solitary seesaw."

Procedure

Balance the meterstick.

Step 1: Balance the meterstick horizontally with nothing hanging from it. Record the position of the CG of the meterstick.

position of meterstick CG = ______________

Using a string, attach an object of unknown mass, such as a rock, at the 90-cm mark of the meterstick, as shown in Figure A. Place a known mass on the other side to balance the meterstick. Record the mass used and its position.

mass = ____________ position = ______________

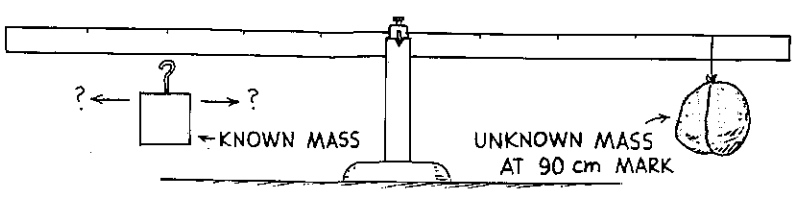


Fig. A

Compute unknown mass.

Step 2: Compute the distances from the fulcrum to each object.

distance from fulcrum to unknown mass = ___________

distance from fulcrum to known mass = ___________

These two distances are known as lever arms. The lever arm is the distance from the fulcrum to the place where the force acts.

In the following space, write an equation for balanced torques, first in words and then with the known values. Compute the unknown mass.

$mass_{computed}$ = ___________

Measure mass of unknown.

Step 3: Measure the unknown mass, using a triple-beam balance.

$mass_{measured}$ = ___________

Calculate percent error.

Step 4: Compare the measured mass to the value you computed in Step 2, and calculate the percentage difference.

$$\% \text{ error} = \frac{|mass_{computed} - mass_{measured}|}{mass_{measured}} \times 100\%$$

= ___________

Set up "solitary seesaw."

Step 5: Place the fulcrum exactly on the 85-cm mark. Balance the meterstick using a single mass hung between the 85-cm and 100-cm marks, as in Figure B. Record the mass used and its position.

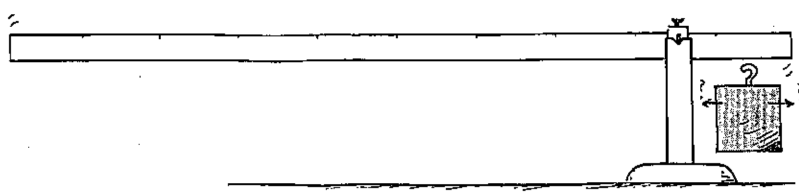


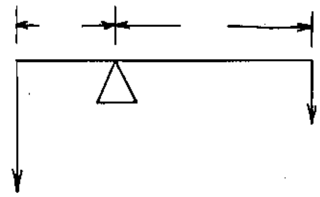
Fig. B

mass = ___________ position = ___________

Name Period Date

Step 6: Draw a lever diagram of your meterstick system in the following space. Be sure to label the fulcrum, the masses whose weights give rise to torques on each side of the fulcrum, and the lever arm for each mass.

Draw lever diagram.



1. Where is the mass of the meterstick effectively located?

____

____

Compute the mass of the meterstick. Show your work in the following space.

$\text{mass}_{\text{computed}} =$ ____________

Step 7: Remove the meterstick and measure its mass on a triple-beam balance.

Measure mass of meterstick.

$\text{mass}_{\text{measured}} =$ ____________

Step 8: Find the percent error for the computed value of the mass of the meterstick.

Calculate percent error.

$$\%\ \text{error} = \frac{|\text{mass}_{\text{computed}} - \text{mass}_{\text{measured}}|}{\text{mass}_{\text{measured}}} \times 100\%$$

$=$ __________________

Going Further

For a uniform, symmetrical object the CG is located at its geometrical center. The CG of a uniform meterstick is at the 50-cm mark. But for an asymmetrical object such as a baseball bat, the CG is nearer the heavier end. In this part of the experiment, you will learn how to find the location of the center of gravity for an asymmetrical rigid object.

Balance meterstick.

Step 9: If a rock is attached to your meterstick away from the midpoint, the new CG of the *combined* meterstick plus rock is *not* in the center. Use masking tape to attach the rock to the meterstick between the 0-cm and 50-cm mark. Move the fulcrum to the 60-cm mark, as shown in Figure C. Hang a known mass between the 60-cm and 100-cm mark to balance the meterstick. Record the mass used and its position.

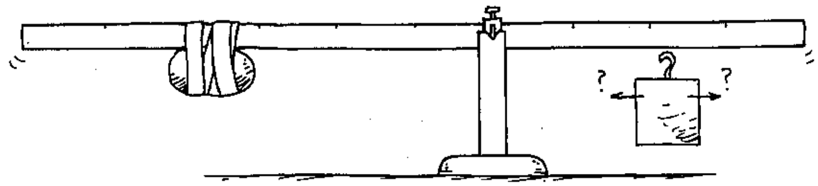


Fig. C

mass = ___________ position = ___________

Step 10: Find the mass of the meterstick/rock combination with a triple-beam balance.

mass of meterstick/rock combination = ___________

Find the CG of the meterstick/rock combination using an equation for balanced torques. In the following space, write down the equation first in words and then with known values.

distance from CG to fulcrum = ___________

computed position of CG = ___________

Step 11: Verify the location of the CG by removing the added known mass and placing the fulcrum at the predicted CG point.

2. Does the meterstick balance?

____

____

3. How far was your predicted location of the CG from its actual location?

____

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