Name: _____ Name: _____

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Static Equilibrium
Using a Meter Stick to Determine an Unknown Mass

Note on grading: Your lab score in large part will be based on how accurately your group performs the lab's activities. Cheating during any part of the lab activity will result in a grade of zero. *Only the TA may weigh the unknown mass and the meterstick to determine the actual mass of each.*

DO NOT Write or Draw on the Meterstick

Purpose:

Applying the principle $\sum\tau = 0$ for a rigid body in static equilibrium, the students will use a meterstick and some known masses to predict the mass of an unknown object and determine the mass of the meterstick without weighing either the unknown mass or the meterstick.

Part I – Estimating the Mass of the Unknown using a Single Data Point

Students may not use a scale or balance for Part I, Part II, or Part III to weigh the unknown or meterstick.

Hints:

1. Although the meter stick has mass, you will not be allowed to weigh the meter stick to determine its mass.
2. Typically, the meterstick's center of mass is not located at 50cm.
3. Since the mass of the meter stick is unknown, the pivot point must be chosen wisely.
4. Maximizing the length of the lever arms will result in less error.
5. Use the Vernier caliper to measure the diameter of the unknown mass. Use this information to more precisely determine where the center of mass of the unknown mass is located on the meterstick.
6. Place the piece of provided angle to be used as a pivot point on a book to help prevent it from sliding on the bench top.
7. Approximately half of the meterstick will need to extend over the edge of the bench. Place the pivot point approximately 10cm from the edge of the bench. The side of the meterstick that extends over the edge of the bench will be used to hang the known masses.
8. The mass hanger has a mass of 5 grams.
9. Use the provided loop of string to hang the known mass.

Briefly explain how the mass of the meterstick can be made irrelevant based on the selection of the pivot point. (5 points)

Using the meterstick and 20 grams of known mass, estimate the mass of your unknown object. (5 points)

Equation in variable form to determine the Unknown's Mass	Estimate of the Unknown's Mass (g)

Part II – Determining the Mass of the Unknown using Multiple Data Points

Students may not use a scale or balance for Part I, Part II, or Part III to weigh the unknown or meterstick.

The torque produced by the known masses will be varied to collect a minimum of 8 data points. The torque produced by the known masses will be considered the independent variable. Create a scatter plot of "Lever Arm to Unknown" vs "Torque Produced by Known Masses".

Hints

1. Use a minimum of 10g for the known mass.
2. To vary the torque produced by the known mass, the known mass and the lever arm of the hanging known mass may be varied.
3. The lever arm of the unknown mass should not be allowed to remain constant.
4. The mass of the unknown can be found with a fair amount of precision with carefully taken measurements. The largest source of error is not keeping the meterstick's center of mass on the pivot point. A percent difference of 0.5% or less is obtainable.

Predict the mass of the unknown mass using the scatter plot. The predicted mass of the Unknown recorded below must be related to the scatter plot's fit equation.

Before beginning Part III, request the TA to weigh the unknown, and determine your percent difference.

Attach the Scatter Plot and Data Table: The scatter plot requires appropriate labels. (20 points)

Predicted Mass of Unknown in grams (a)	Actual Mass of Unknown in grams (b)	Percent Difference $= \frac{\lvert a-b \rvert}{b} x100\%$	Score from Table Below

Percent Difference	<=1.7%	<=2.0%	<=2.2%	<=2.5%	<=3.2%	<=3.7%	>3.7%
Points	25 (100%)	24 (96%)	22 (88%)	21 (84%)	19 (76%)	18 (72%)	15 (60%)

Part III - Determining the Mass of the Meterstick

Students may not use a scale or balance for Part I, Part II, or Part III to weigh the unknown or meterstick.

Collect a minimum of 8 data points to create an appropriate scatter plot to determine the mass of the meterstick.

Considering the experience that was gained with Part I and Part II, more precise results are expected for Part III. Therefore, the point allocation associated with the percent difference has been tightened.

Hints

1. The pivot point will have to be varied.
2. Do not use the unknown from Parts I and II as a mass.
3. Appropriately apply any of the Hints from Parts I or II.

Attach the Scatter Plot and Data Table: The scatter plot requires appropriate labels. (20 points)

The predicted mass of the Meterstick recorded below must be related to the scatter plot's fit equation.

Predicted Mass of Meterstick in grams (a)	Actual Mass of Meterstick in grams (b)	Percent Difference $= \frac{\lvert a-b \rvert}{b} x100\%$	Score from Table Below

Percent Difference	<=1.2%	<=1.4%	<=1.6%	<=2.0%	<=2.4%	<=2.7%	>2.7%
Points	25 (100%)	24 (96%)	22 (88%)	21 (84%)	19 (76%)	18 (72%)	15 (60%)