Physics Name:

Lab – Measurement

PART I – DIRECT MEASUREMENT

Objective:
To measure the density of various samples AS ACCURATELY AS POSSIBLE (within 10% error for full credit).

Materials:

graduated cylinder
ruler, triple beam balance
density samples (Al, Cu)
large washer
vernier caliper

Procedure:

A. Water Displacement Method

1. Use a triple beam balance to measure the mass of the density sample. Remember that the scales are accurate to the nearest 0.001g. Record the uncertainty of the measurement.
2. Use a graduated cylinder to measure the volume of the sample by water displacement. Remember that the cylinders are accurate to the nearest 0.5 mL. Record the uncertainty of the measurement.
3. Calculate the density of the samples using the formula: **D = M ÷ V**. Your units will be g/mL (or g/cm_3). Propagate your error of measurement.

B. Volume of a Cylinder Method

1. Use a triple beam balance to measure the mass of the density sample, or copy down mass from part one. Record the uncertainty of the measurement.
2. Use a Vernier caliper to measure the diameter and height of the density sample in centimeters. Calculate the volume of the sample using the formula **$V = \pi r^2 h$.** Record the uncertainty of the measurement. Propagate your error.
3. Calculate the density of the samples using the formula: **D = M ÷ V**. Your units will be g/mL (or g/cm3). Propagate your error.
4. Enter data in data tables 1 & 2 and repeat the procedure for all density samples.

*** NOTE: Keep the same density samples for the whole lab so you can ***

4. Enter data in table 1 and repeat the procedure for the second density sample.
5. Find the accepted values for the density of your samples in a **reference book** and enter in data table 3. Calculate percent of error.

C. Density of an "unknown rock".

1. Follow the steps in part A to find the density of an "unknown rock". Enter data in the data table. Record uncertainty.

DATA TABLE 1 – Mass and Volume

Substance	Mass (g)	Vol –Method A (mL)	Vol – Method B (mL)	Density – Method A (g/mL)	Density – Method B (g/mL)
Copper (Cu)					
Aluminum (Al)					
Unk. Sample					

DATA TABLE 2 – Caliper Method dimensions

	diameter (cm)	radius (cm)	height (cm	Vol (cm^3)
Copper				
Aluminum				

DATA TABLE 3

Substance	Accepted Density	.Exper. Density	Percent Error
Copper			
Aluminum			

Extension:

Find the density of a large washer (ask instructor for sample). Explain how you measured its volume and mass. Compare this measure to your table above and make a hypothesis regarding what the washer is made of.

Questions:

1. Which method of measurement was more accurate? Explain.
2. Which measurements contributed most to your error?
3. Assume that the unknown sample was a "moon rock." Use your data, and the fact the diameter of the moon is 3.48×10^6 m to calculate the *mass* of the moon (assume that the moon is a sphere). How does your calculated mass compare to the real mass?

Error Analysis:

What factors may have affected the accuracy of your data? Can you say that your data is *accurate* or *precise*?

Conclusions:

What did you do? What did you find? What conclusions can you draw?

PART II – INDIRECT MEASUREMENT

Objective: To indirectly measure the height of a tall tree using right triangles and geometry. To investigate various methods of measuring *indirectly* when direct measurement is not practical.

Materials:

ruler/meter stick
protractor
calculator
Mass Balance
rice
textbook

Indirect Measurements:

I. ***Thickness of a page*** - Devise a method to measure the thickness of one page of your textbook. Explain what you did. Record your results.

II. ***Mass of a grain of rice*** - Devise a method to measure the mass of one grain of rice. Explain what you did. Record your results.

III. ***Height of a tall tree*** –

a. On a sunny day, stand directly in the shadow of a tall object. Measure your height, the length of the shadow, and the distance from your feet to the shadows end.

b. Use *similar triangles* to calculate the height of the object. Measure the length of the objects shadow. Have an observer line up the end of their shadow with that of the tall object. Measure the observer's height and shadow length. Calculate the height of the tall object.

c. Use *right triangle trig.* to measure the height of the same object. Measure the length of the shadow. Measure the angle between the ground and the top of the object. Calculate the height. Compare your findings.

DATA TABLE 1 – Right Triangle Trig Data

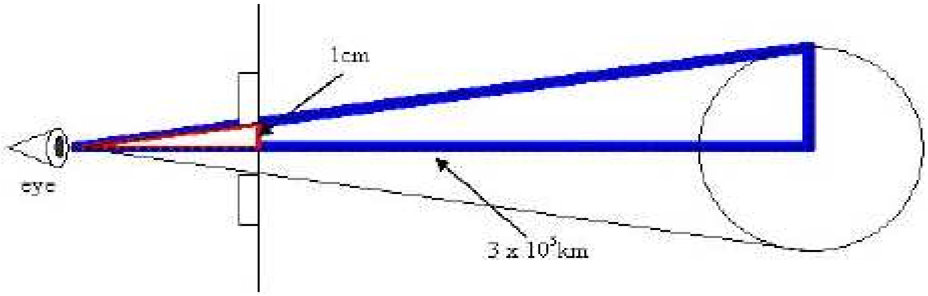
Object	Angle (º)	Shadow Length (m)	Your Height (m)	Object Height (m)

DATA TABLE 2 – Similar Triangle Data

Object	Your Height (m)	Your Shadow Length (m)	Object Shadow length (m)	Object Height (m)

Extension: Measuring the Diameter of the Moon

The key concept you will use is, again, the concept of similar triangles to indirectly measure the diameter of the moon. The activity can be done in the classroom, if the moon happens to be visible from our windows, or it can be done at home.



The equipment needed includes an index card, a pin, two strips of opaque tape (masking or electrical tape works well), and a centimeter ruler.

Oh, and one other thing, you'll need to know that the moon is about 3×10^5 km from Earth!

When the moon is full, place the two strips of tape 2cm apart on a windowpane facing the moon. After making a pinhole in the index card, observe the moon through the pinhole and two strips of tape. Back away from the window until the moon appears to just fill the space between the two strips of tape. Measure the distance from the card to the window. Using the proportionality of sides that exists for similar triangles (see figure above), calculate the diameter of the moon.

Questions:

1. Will you get more accurate measurements of the thickness of one page using an old or new textbook? Why?

2. Which method of indirect measurement is more accurate, similar triangles or right triangle trigonometry? Explain.

3. Give one example from real life where one must use *indirect* measurement to determine some unknown quantity (hint: look up!).

4. How does "time" contribute to error in this lab?

Error Analysis: What factors may have affected the accuracy of your data? Can you say that your data is *accurate* or *precise*?

Conclusions: What did you do? What did you find? What conclusions can you draw?