Lab Activity H3
How Do You Measure Up?

OUTCOMES

After completing this lab activity, the student should be able to:

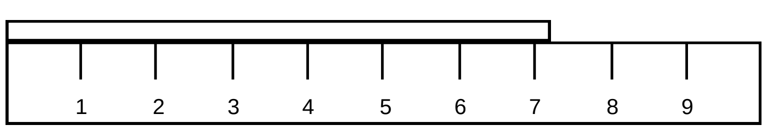
- perform basic laboratory measurements of length, mass, and volume.
- express measurements and calculated results with the proper number of significant figures.
- find the density of liquids and solids, regardless of shape or size.

DISCUSSION

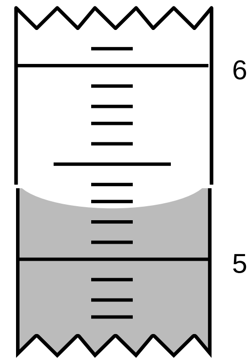
Measurements play an important role in everyday life for most people and much could certainly be discussed about their importance to the sciences. Most introductory chemistry texts do a good job of that. However, how are measurements properly made in the laboratory? How much uncertainty is in a measurement? This lab activity should lend some insight to these questions.

Measurements made in this experiment should be reported with the proper number of significant figures. Significant figures are defined as all of the digits which are certain in a measurement, plus one digit which is uncertain. On a digital display, such as one found on an electronic balance, the last digit is the uncertain digit. When an object is placed on the balance, you may notice that there is some fluctuation in the last digit. Simply report the reading most frequently displayed, including any zero digits displayed to the right of the decimal. You may assume that the uncertainty of such a measurement is ±1 in the place of the uncertain digit. So, if a balance reads 3.68 g, its uncertainty would be ± 0.01 g.

Some measurements may include an estimate of the last digit. For example, if a ruler has marks every 1 centimeter and you were measuring the length of the metal rod below, the length should be reported as 7.2 cm, or possibly 7.3 cm. The last digit is estimated and is the only uncertain digit. The uncertainty for the measurement would therefore be ± 0.1 cm. It would be inappropriate to report the length as 7.25 cm, since the last two digits are estimated and, therefore, are both uncertain. Measurements may have no more than one uncertain digit.



When water and other liquids are placed in a graduated cylinder or pipet (pipe-ETT), they form a curved surface, called a meniscus. Laboratory glassware is calibrated such that the liquid level is always read at the bottom of the meniscus. The liquid level to the right may be read as 5.25 mL, assuming we are capable of estimating to the nearest ±0.05 mL. Note that, once again, there is only one uncertain digit. As you perform calculations in this experiment, observe all rules for determining significant figures.



In this experiment, you will be calculating densities from measured masses and volumes. If you have not yet covered density in your lecture, carefully read the section on density in your textbook before coming to lab.

MATERIALS (Provided By Student)

50 pennies - dated 1983 or later
Coin - your choice
Driver's License, Bank Card, or Credit Card
Paper - 1 standard size sheet printer paper
Spoon
Sucrose (ordinary table sugar)

MATERIALS (From Kit)

Beral Pipet (dropper)
Electronic Balance
Graduated Cylinder - 10 mL
Graduated Cylinder - 100 mL
Plastic Cups - 2 needed
Ruler
Safety Goggles/Safety Glasses
Test Tube - Small

PROCEDURE

Length

1. Measure the distance from the top to bottom of a standard size sheet of printer or copy paper in inches. Then measure it in centimeters. As the measurements are made, think of the amount of uncertainty in each measurement – is it possible to measure to the nearest ±0.1 cm? ±0.01 cm? ±0.01 in? $\pm^{1}/_{16}$ in? Then record the answers with the correct number of significant figures.

2. Use the measurements obtained in the step above to calculate the number of centimeters per inch (cm/in) and the number of inches per centimeter (in/cm). Report the measurements and calculated results with the proper number of significant figures. Show all calculations.

3. Measure the width of a driver's license, credit card, or bank card. Record the measurement in inches and centimeters. Use these measurements to calculate the number of centimeters per inch and the number of inches per centimeter.

Mass

4. Place a coin on the balance and measure its mass. Then place a plastic cup on the balance and measure its mass. Place the coin in the cup and measure their combined mass. Subtract the mass of the empty cup from the combined mass.

5. Use the following conversion factors to express the mass of the coin in ounces and in pounds: 16 oz = 1 lb (exact), 28.35 g = 1 oz. Show your work.

Volume

6. Fill a small test tube to the brim with water. Pour the water into a 10 mL graduated cylinder. Measure and report the volume with the correct number of digits (include one uncertain digit). Fill the test tube again and pour the contents into a 100 mL graduated cylinder. Measure and report this volume with the correct number of digits (include one uncertain digit). How much uncertainty is in each measurement? Are the measured volumes the same? Explain.

EYE PROTECTION MUST BE WORN FOR THE REMAINDER OF THIS EXPERIMENT!

Density

7. Place a clean, dry plastic cup onto the balance. Record its mass. Remove the cup from the balance to avoid accidentally spilling on it. Use the graduated cylinder to measure and pour 100 mL of water into the cup. Place the cup back onto the balance. Use a dropper to add or remove water from the cup, so that it now contains exactly 100.0 g water. Remember to take into consideration the mass of the cup.

Example: If the cup has a mass of 6.8 g, then exactly 100.0 g of water added to the cup would bring the combined mass of the cup and water to 106.8 g.

8. Place the other clean, dry plastic cup onto the balance. Then measure and add the exact mass* of sucrose assigned by the professor to the cup. Remember to take into consideration the mass of the cup. Pour the sucrose into the water and stir until all of the sugar has dissolved. Since your grade will, in part, depend on the accuracy of your measurements, avoid spilling any of the sugar or water while pouring or stirring. **REQUIRED PHOTO: Includes the <u>date</u> clearly shown on a calendar, newspaper, cell phone, or written on a sheet of paper, along with sugar, cup, and laminated card from your kit.**

* This quantity should be found on the card found in your lab kit. Each student will be assigned a different amount.

9. **Trial 1.** Place the clean, dry 100-mL graduated cylinder onto the balance. Record its mass. Remove the cylinder from the balance and pour 25.0 mL of the prepared sugar water into the cylinder. Place the cylinder back on the balance and record the new mass. Use this mass and the mass of the empty cylinder to find the mass of the sugar water. Also record the exact volume of sugar water in the cylinder with the correct number of significant figures. Calculate the density of the sugar water, using the proper units and significant figures.

10. **Trial 2.** Remove the cylinder from the balance and pour an additional 50.0 mL of sugar water into the cylinder. Place the cylinder back on the balance and record the new mass. Calculate only the mass of the sugar water that was ***added in this second trial only***. Use this mass and the exact volume of sugar water added in this second trial to calculate the density.

11. Empty and rinse the 100 mL graduated cylinder until thoroughly clean. Fill the cylinder about one-half full with water. Estimate the volume of water in the cylinder to the nearest ±0.1 mL. Place the number of pennies* (dated 1983 or later) assigned by the professor onto the balance and record the mass.

12. Carefully slide the pennies down the side of the graduated cylinder, a few at a time, until all of the pennies have been added. Each penny should be fully submerged. Record the volume for the water level in the cylinder. Use your data to calculate the density of the pennies. Show your calculations. **REQUIRED PHOTO: Includes your <u>face</u> and/or clearly shows a <u>Picture I.D.</u> (with name), with the pennies inside the graduated cylinder, and the laminated card from your kit.**

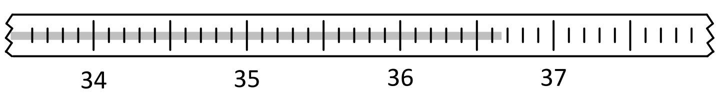
    * This quantity should be found on the card found in your lab kit. Each student will be assigned a different amount.

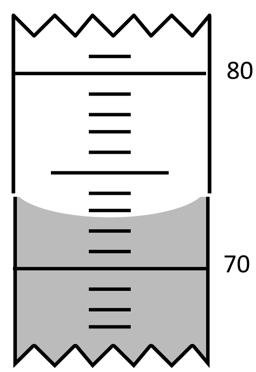
Name____ Lab Section_______________

PRELAB QUESTIONS

1. The mass of a large diamond was measured on an analytical balance, as shown on the display below. Circle the uncertain digit (or use the drawing tools in your word processor to point to the uncertain digit or type the letter X above the uncertain digit). What is the uncertainty of this measurement? How should the mass of the diamond be reported?

2. What is the temperature shown in the thermometer, read to the nearest ±0.01°C? What is the volume shown in the graduated cylinder, read to the nearest ±0.1 mL?





Temperature = ___________________________

Volume = ___________________________

3. An automobile tank is filled to capacity with 12.5 gal of gasoline. What is the volume of the tank in liters? Show your work, using the provided conversions.
(29.6 mL = 1 fl oz, 128 fl oz = 1 gal, 1000 mL = 1 L)

4. What is the equation used for calculating density? How does the density of one gallon of water compare to two gallons of water? Explain.

5. A block of wood measures 15.64 cm × 9.21 cm × 4.60 cm and has a mass of 371.06 g. What is the volume of the wood block? What is the density of the wood block?

6. As precision increases, does uncertainty increase or decrease? Why?

7. Which safety precautions, if any, must be observed during this lab activity?

PHOTOS - Please compress photos and save your file **before** uploading to the dropbox. Photos should come close to filling the boxes below and all required items should be **clearly visible**.

Required Photo 1:
Required Photo 2:

Name____ Lab Section_____________

DATA AND QUESTIONS

Length

Make sure each of your measurements and calculations show the correct number of significant figures. Include the uncertainties for the four measurements below.

	Paper	License or Bank Card
inches	±	±
centimeters	±	±
cm/in		
in/cm		

How do your calculated cm/in values above compare to the actual conversion factor (2.54 cm/in)? Explain any variations.

Mass

(1) Mass of coin	
(2) Combined mass	
(3) Mass of cup	
(4) = (2) - (3)	

What answer should be obtained by subtracting? Did your answer vary from what you expected? Explain any variation.

Express the mass of the coin in ounces and in pounds. Show your work.

Volume

Volume with 10 mL graduated cylinder	±	Volume with 100 mL graduated cylinder	±

Are the measured volumes the same? Which graduated cylinder is more precise? Explain.

Density of Sugar Water

Mass of Sucrose Assigned = ______________

Mass of empty plastic cup 1		Mass of empty plastic cup 2	
Mass of water added	100.0 g	Mass of sucrose added	
Mass of water and cup		Mass of sucrose and cup	

	Trial 1	**Trial 2**
Mass of graduated cylinder BEFORE addition of sugar water		
Mass of graduated cylinder AFTER addition of sugar water		
Mass of sugar water added		
Volume of sugar water added		
Density of sugar water		

How do the values of the densities for sugar water compare between the two trials? What did you expect to find? Explain any difference.

Density of Pennies

Number of Pennies Assigned	
Mass of the Pennies	
Volume Reading AFTER Adding Pennies	
Volume of Water BEFORE Adding Pennies	
Volume of the Pennies	
Density of the Pennies	

Lab Report Submission Checklist

Complete the appropriate checklist and **submit this page** along with your lab activity.

Lab Activity Submitted Via the D2L Dropbox

	Prelab assignment is complete.	
	Remainder of lab activity is complete (data, questions, photos. etc.).	
	Required photos of the procedure included.	
	At least one photo shows face or photo I.D. At least one photo clearly shows the date.	
	Document filename in format of **Lastname Firstname HX**.	
	File size is no larger than 10 MB.	
	Only one document submitted for this lab activity.	
	Lab submitted on time.	
		If late, this is your first extension.

Lab Activity Submitted Via the US Postal Service or In Person

	Prelab assignment is complete.	
	Remainder of lab activity is complete (data, questions, photos. etc.).	
	Required photos (at least one showing face or photo I.D.; at least one shows the date) of the procedure **or** a tangible artifact or product from the lab activity is included.	
	If return is desired, a self-addressed stamped envelope **with sufficient postage** is included*.	
	Lab submitted on time (postmarked by due date if sent via USPS).	
		If late, this is your first extension.

*You may find a postage calculator at http://postcalc.usps.gov. Use the balance in your kit to find the weight.