

NAME_____

SECTION_____

PARTNER(S)_____

DATE_____

MEASUREMENTS, CONVERSIONS, AND MANIPULATIONS

PRE-LAB QUERIES

1. What is the meaning of "measurement"? What are you finding out when you measure something?
2. How could you measure the dimensions of the sheet of paper this activity is printed on? Be specific!

PROCEDURE

Let's explore some simple measurements and measuring devices. When you record any measurement be sure to include the units! If you are doing 80 on the beltway, are you in trouble? If it's 80 kilometers per hour the answer is no; however, if it's 80 miles per hour there could be flashing red lights!

PART I -- LINEAR MEASUREMENTS

Obtain a standard meter stick and a one foot ruler. **Use them** to answer the questions below. **No textbooks allowed!**

1. How many feet are in a meter (m)?
2. How many centimeters (cm) in a foot? Explain how you got your answer.

3. Observe the markings on the meter stick. You will notice that one side is calibrated in English units of inches. The reverse side has metric markings. Draw a **segment** of the meter stick below with the various markings. Show and label all the different **metric** markings on the diagram.



meter stick

What do you notice about the number of smaller markings between two larger marks on the meter stick?

4. Below are a series of units that are fractions of a meter and appear on the meter stick. You will notice that the sizes are indicated by means of a prefix in front of the base unit (meter). Complete the following table using these units. Be sure that a mm, cm, and dm are labeled on the meter stick diagram above.

$$1 \text{ millimeter (mm)} = 0.001 \text{ m}$$

$$1 \text{ centimeter (cm)} = 0.01 \text{ m}$$

$$1 \text{ decimeter (dm)} = 0.1 \text{ m}$$

1 m =	cm
1 cm =	mm
1 m =	mm
1 m =	dm
1 dm =	cm
1 dm =	mm

5. In any measurement you are allowed all the digits you are certain about (that is, you can be sure of from the markings) plus one digit that is an estimate. The last digit you write in any measurement is a reasonable guess and you must be certain of the next to last digit

Obtain a set of meter sticks that contain: one with no markings; one each with markings corresponding to 0.1 m (every dm), 0.01 m (every cm), and 0.001 m (every mm).

Measure the length of this lab manual using each stick in succession starting with the one that has no markings. Record the best value possible with each meter stick. Circle the number in each measurement that is your estimate.

Measurement	Calibration on Stick	Reading in Units on the Stick	Conversion to Meters
1	1 m		
2	1 dm		
3	1 cm		
4	1 mm		

Which measurement gives you the greatest certainty in length? Explain why.

IN THE FOLLOWING QUESTIONS WHERE YOU ARE ASKED FOR A CALCULATED ANSWER, SHOW YOUR CALCULATIONS.

6. Determine the dimensions of a large paper clip in millimeters. Use the metric scale on the ruler. Convert the dimensions to centimeters and meters.

Dimension	Millimeters	Centimeters	Meters
length of clip			
width of clip			
diameter of wire			

Calculate how many paper clips would be required to reach a distance of 2 feet. Explain in words how you figured this out!

ans. _____

7. Verify the number of clips needed by experiment. Illustrate (draw) your method.

ans. _____

8. Here are some English system units and metric equivalents.

$$1 \text{ inch} = 2.54 \text{ cm}$$

$$1 \text{ foot} = 12 \text{ inches} = 30.5 \text{ cm}$$

$$1 \text{ yard} = 3 \text{ ft} = 0.914 \text{ m}$$

$$1 \text{ mile} = 1760 \text{ yard} = 1.61 \text{ kilometers}$$

Are the English units related to each other by one common repeating multiple (such as 10 in the metric system)? Explain.

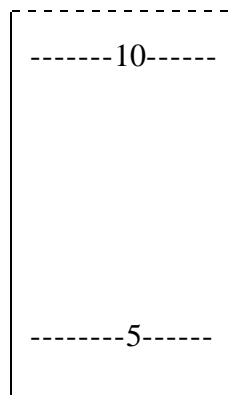
PART II -- VOLUME

What does "volume" mean?

In geometry, you may have calculated the "volume" of solid geometric figures. For example, if you had a cube exactly 10 cm on each side, you found the volume by $s \times s \times s$ or s^3 . What is the volume of this 10 cm cube? _____ This cube would hold 1 liter of water!

Obtain a graduated cylinder and an eye dropper. The graduated cylinder is marked in units of milliliters (mL). A liter (L) equals 1000 mL, while a quart is 0.95 L or 950 mL.

9. Look carefully at the markings on a 25 mL graduated cylinder. Draw a picture and label the marks representing the space between 5 of the milliliter markings. Referring back to your experience with the meter stick, **how many decimal places will this measuring device provide?** (Remember you are allowed one estimated place beyond what you are sure of from the markings.)



10. Carefully count 50 drops of water into the dry 25 mL graduated cylinder. What is the volume of the 50 drops?

ans. _____

Calculate the volume of one drop.

ans. _____

11. Pour the water in the cylinder above into another dry graduated cylinder. Do you get the same volume? Explain why or why not.

Graduated cylinders are designed to contain the volume marked and not to accurately deliver or transfer liquid to another container as you may have seen when you transferred water from one cylinder to another.

12. Obtain an empty plastic soda bottle of unknown volume and a large graduated cylinder. Determine how many drops are required to entirely **fill** the soda bottle. Explain how you are going to do this, then do it, and obtain an answer.

ans. _____

PART III -- MASS

Now let's explore mass by using a balance, which measures the mass in units of grams (g). Mass is the amount of matter in an object. Mass, unlike weight, is independent of gravity.

13. Mass **each** of five (5) **small** paper clips separately, **one at a time**. Record the masses in the table below and calculate the average mass of a single paper clip. The balance does the estimating of the last digit for you. Set the balance so that you obtain at **least 2 decimal places**.

Paper Clip	Mass
#1	
#2	
#3	
#4	
#5	
average	

14. Obtain a small flat plastic container called a massing boat and determine the mass.

Count out 25 paper clips into the massing boat. Determine the **total mass**.

Calculate the mass of the 25 paper clips. _____

Calculate the average mass of one paper clip from the mass of 25 paper clips. _____

How well does your average mass from the five paper clips compare to the average from the group of 25 paper clips?

15. Based on the average mass of paper clips calculated above, if you were given a kilogram of paper clips, how many paper clips would you have?

$$1 \text{ kilogram (kg)} = 1000 \text{ g}$$

Let's explore a combination of two of the measurements.

16. Place 15.0 mL of water into a 25.0 mL graduated cylinder. Obtain the mass of the cylinder and water. Record your data in the table that follows.

Add small paper clips, one at a time, and watch the water level in the cylinder. What happens? Why do you think it happens?

Continue adding until you have 10 paper clips in the water. Mass the cylinder, water, and paper clips and record the mass. Record the exact volume in the cylinder at this point. Be sure all the paper clips are completely submerged in the water. Calculate the volume due to the 10 paper clips and record in the table.

Add 10 more paper clips to the cylinder. Measure the mass of cylinder, water, and all the paper clips and record. Record the exact volume in the cylinder and record in the table. Calculate the volume and mass due to the 20 paper clips. Determine the mass/volume ratio for 10 and 20 paper clips.

	Total Mass	Total Volume	Volume due to paper clips	Mass of paper clips	mass/volume for paper clips
cylinder + water		15.0 mL			
cylinder + water + 10 paper clips					
cylinder + water + 20 paper clips					

17. The ratio of mass divided by volume is called **density**. What are the units of density?

Does density depend on the amount of paper clips (number or mass)? Explain.

The volume of the paper clips was measured by water displacement. **Density** is an intensive property of the paper clips, meaning that it is a characteristic that does not depend on mass. Both volume and mass are extensive properties, because they depend on the amount of material.

18. Name another property of the paper clips that does not depend on the mass.

POST-LAB QUESTIONS

Be sure to show all calculations.

1. List any sources of error in your measurements.
2. Describe precisely how you can determine the volume of a paper clip by a method other than water displacement.
3. How many paper clips (size used in lab) would you need to form a line of paper clips between the College and the US Air Arena, a distance of 1.4 miles?

