Phy 100's Lab - Measurement techniques for mass, size and density.

Name___________________________________ **Course & Sec**________

Lab Partner______________________________ **Date** ____________

1. You should have a metal block and a metal cylinder both made of the <u>same</u> material. If you are unsure if the metals are the same, ask the instructor.

2. Measure the dimensions of the metal block with the **METER STICK** to hundredths of a centimeter (0.01 cm) using visual estimates, and record each measurement in the table below (hold the block so that the black scale markings are directly in contact with it – otherwise, any separation of the markings from the block itself introduces parallax error). *Don't assume that the block is a cube, and be sure to measure three independent dimensions!* Convert each measurement to units of meters. To do this express the conversion relationship, 100 cm = 1 m as a ratio. Arrange this ratio (called a "conversion" factor, which qualitatively has a value of "1") so that when you multiply it by the quantity you wish to convert, the units that you don't want cancel out algebraically. Calculate the volume of the block by using the formula **Volume = L x W x H** for the measured dimensions and the converted dimensions. Throughout every lab assignment, always show neat, clear, and complete samples of every type of calculation.

<u>Dim.</u>	<u>Measurement</u>	
Length:	_______ cm	_______ m
Width:	_______ cm	_______ m
Height:	_______ cm	_______ m

<u>Calculate</u> volumes separately for cm and then m, and also calculate each volume unit.

Volume: __________ ___ _______________ ___

Now re-measure all of the same dimensions of the metal block using the **DIAL CALIPERS** from which you should visually estimate the values to within 0.01 mm and record in the table below. Convert each measurement to units of cm and m using the method described above. The useful conversion relationships are now 10 mm = 1 cm and 1000 mm = 1 m. Again calculate the volume of the block using the formula **Volume = L x W x H** for each set of dimensions and include the proper units for volume that result from your calculation, not memory. Which answers for volume are more precise? Why? (All question marks on all worksheets in this course require a written response!)

<u>Dim.</u>	<u>Measurement</u>		
Length:	________ mm	________ cm	_________m
Width:	________ mm	________cm	_________m
Height:	________mm	________cm	_________m
<u>Calculate</u> **Volume of Block:**	___________	___________	___________

3. On the mechanical dual pan balance, determine the mass of the block to the appropriate number of decimal places. The mass you are measuring always goes on the left-hand pan. (If the unknown mass of the block is more than the 210 g of known-mass built into the instrument, the instructor can provide you with more known-mass to pile on other pan to achieve equilibrium.) Record the measured mass in both grams and kilograms in the table below.

To convert from grams to kilograms, the useful conversion relationship is 1000 g = 1 kg. Use the conversion method described in step 2, or, as you get more proficient with conversions in the metric system, simply move the decimal point over three places to the left to convert to the larger unit of measure. Also, check your values from the balance with the spring scale and the electronic digital balance. Record the spring scale's readings as exactly as you think is reasonable. Which reading is most precise? Why? Which reading is most accurate? Why? (Attach separate sheet if needed.)

Mass of block [balance]	Mass [spring scale]	Mass [electronic]
g	g	g
kg	kg	kg

4. Now measure the dimensions of the metal cylinder using the dial calipers and record in the table below. Convert each measurement to units of cm and m (10 mm = 1 cm and 1000 mm = 1 m). Calculate the volume of the cylinder in cubic centimeters and cubic meters. Finding the volume of a cylinder is similar to finding the volume of a block, you need first to calculate its cross-sectional area and multiply that by the length. What is the shape of a simple cylinder cross-section? What is the formula for its area? **Volume Cylinder = Length x Cross Sectional Area**. Carefully show all calculations and units.

Dim.	Dial caliper Measurement		
Length:	____________ mm	________ cm	__________m
Diameter:	____________ mm	________ cm	__________m
Calculate Radius: Diameter/2		________cm	__________ m
Cross Sectional Area:		__________	__________
Volume of Cylinder		__________	__________

5. On the digital electronic balance, determine the mass of the cylinder to hundredths of a gram. In the table below, record the mass in both grams and kilograms.

Mass of cylinder [elec. balance]

____

____

6. Calculate the ratio of the mass of the block in grams to the volume of the block in cm^3. This ratio, which relates mass to volume is called DENSITY. Please show the calculation in the space below, not just the result. Include the units for density. Also express the same answer in SI units. Use the most precise values you found for mass and volume.

Density = $\frac{\text{mass}}{\text{volume}}$ =

7. Now calculate the ratio of the mass of the *cylinder* in grams to the volume of the *cylinder* in cm^3. Again, express in SI units.

Density = $\frac{\text{mass}}{\text{volume}}$ =

8. How do these 2 ratios compare? In order to compare two experimental values that you have obtained in a systematic way, one widely used method is to find the percentage difference between the two values. The instructor has provided a formula for this purpose. Please show the calculation using this formula in the space below.

9. Can you suggest a reason why the density of the block and the density of the cylinder should be compared this way? Why might their densities be either the same or different?

PART II. <u>Measuring the masses of liquids</u> This is a little less direct than measuring masses of solids. To find a liquid's volume, a graduated cylinder can be used, but to find the mass, you have to get the empty container's mass and subtract it from the total mass with the liquid in the container. Like most such devices, the graduated cylinders you will use are graduated in cubic centimeters, but marked "ml" for milliliters, which is the same thing. Even the best graduated cylinders are much less precise than a good balance or calipers. As a result, to improve the precision of your mass measurement, you need to repeat the measurement process several times and average the results.

First, find the mass of the **dry** cylinder. Then for each trial, empty the graduated cylinder, dry it with a towel (why?), and put 75 ml of tap water in it, then measure the total mass with the water. To adjust the amount of water to be as close as possible to 75.0 mL, pour from the beaker to about 74 mL, then top up the level with the eyedropper. Align the bottom of the meniscus with the scale marking on the container.

Trial #	*Total* mass (g)	— *Dry* mass (g)	= Mass of water (g)	Mass of water (kg)
1				
2				
3				
4				
Average	N/A	N/A		

1. Now calculate the density of water. Calculate the ratio of the mass of the water in grams to the volume of the water in cm^3 (1mL = 1 cm^3) using your average result. Show the calculation, not just the result.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} =$$

2. Compare the experimental value that you have just obtained for the density of water to the standard textbook value for the density of water on the sheet provided. The formula for comparing an experimental value to a trusted book value is called "percent error" and is provided separately. (Never submit a report with error or difference greater than about 10% without discussing it with the instructor!)

3. Use the textbook density sheet to identify the metal block and cylinder in the experiment and calculate the percent error for that as well. Does the identity correspond to what you'd guess the metal to be?

4. Discuss your results above. What reasons can you imagine for a non-zero % error? (Answer in blank space or on separate sheet attached.)

Densities of Various Substances

Grams per Cubic Centimeter (g/cm^3)	Material	Kilograms per Cubic Meter (kg/m^3)
	Typical Solids:	
22.570	Osmium	22,570
21.450	Platinum	21,450
19.950	Uranium	19,950
19.320	Gold	19,320
11.344	Lead	11,344
10.500	Silver	10,500
8.960	Copper	8,960
8.560	Brass	8,560
7.874	Iron	7,874
7.310	Tin	7,310
2.699	Aluminum	2,699
0.917	Ice	917
	Typical Liquids:	
13.600	Mercury	13,600
1.260	Glycerin	1,260
1.025	Seawater	1,025
1.000	Water (4^oC)	1,000
0.810	Benzene	810
0.791	Ethyl Alcohol	791