Physics 196 - Fall 2017
Lab 1 - Measurements

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Objective: Be able to carry out simple measurements of length, mass, and,volume. Also be able to perform calculations using these measured quantities, along with error and uncertainty calculations. Be able to perform statistical calculations on a number of measurements.

Equipment: table, cylinder of metal, graduated cylinder, ruler, vernier calipers

To Turn In: Your data (neatly organized), your calculations, and the answers to the questions. You may do the calculations on a spreadsheet, but it is not required. I will share a Google spreadsheet with the class so you can share your data for Part 1 with each other.

Note: To be able to do this lab you will need to read, and understand, the document entitled "Measurements and the Theory of Errors".

Procedure:

Part 1

Have each member of your lab group measure the length and width of the front lab table in cubits. A cubit is the length of an arm from the elbow to the tip of the middle finger. Record each measurement. Also record the measurements of the rest of the students in lab. Repeat the measurements with a meterstick, one measurement for each lab partner. Again record the values from each lab group. Calculate the average and standard deviation for the length and the width of the table in cubits and meters. Next calculate the area of the table and the standard deviation of the area in both square cubits and square meters.

Part 2

You will be given a cylindrical piece of metal. First you are to measure the diameter of the cylinder at five different locations along the length of the cylinder, using the vernier calipers (I will show you how to use them). Record your measurements, and take the average and standard deviation. Next measure the height of the cylinder at five different places across the diameter. Again, take an average and standard deviation.

It is known that the volume of a cylinder is given by

$$V = \pi r^2 h$$

where π is the irrational number 3.14159..., r is the radius, and h is the height. You should calculate the volume of your cylinder using your average values for $r(= diam./2)$ and h. Express your answer in cubic mm and cubic cm. Find the percent uncertainty and standard deviation.

Next you are to measure the volume of your cylinder by displacement. You are to fill a graduated cylinder with enough water to cover the metal bob. Record the volume of water you have by reading the level of the water on the graduated cylinder. Note the units of the cylinder. Most are marked in cubic cm.

Next **gently** lower the bob into the water. Record the final volume of the water and the bob. Take the difference between the two to be the volume of the bob.

Empty the cylinder and dry off the bob. Repeat the procedure four more times. Find the average and standard deviation.

Now you are to find the percent error of the first measurements (measuring the diameter and height) using your result from displacement measurement as the standard or known value. Remember to compare the same units!!

Part 3

For this part, you must first remember the diameter, d, of the metal bob. (Use the average value.) Next take a flat piece of ribbon or strip of paper and wrap around the diameter of the metal cylinder. Mark the strip where it just begins to overlap thus measuring the length around the bob, or the circumference. Record the circumference in the same units as the diameter. Repeat the procedure at least two more times. As usual, take an average and find the standard deviation. As you should know from algebra or trigonometry, the circumference of a circle is given by

$$C = \pi d$$

Thus, the irrational number π is given as

$$\pi = C/d$$

Calculate π from your measured values. Remember to keep your units straight! Using 3.14 as your standard, calculate the percent error of your measurement.

Data Sheet for Measurements

Name_____ Group Name_____
Date_____

Part 1

Group Data

name	length, *cubit*	width, *cubit*	length, m	width, m
average				
σ				
δ				

Data for the rest of the class

name	length, *cubit*	width, *cubit*	length, m	width, m
average (for entire class)				
σ (for entire class)				
δ				

Area of table in $(cubit)^2$_____ $\pm$ _____
Area of table in m^2_____ $\pm$ _____

Part 2

Caliper Data

trial #	height, h	diameter, d	radius, $r = d/2$	$V = \pi r^2 h$
				——-
				——-
				——-
				——-
average				
σ				
δ				

Graduated Cylinder Data

trial #	V_0	V_f	ΔV
average	——-	——-	
σ	——-	——-	
δ	——-	——-	

Volume of bob using the calipers_____ ± _____
Volume of bob using the graduated cylinder _____ ± _____
Percent error in bob volume_____ ± _____

Part 3

π Measurement Data

trial #	circumference
average	
σ	
δ	

Measured value for π_____ ± _____
Percent error in π_____ ± _____

QUESTIONS

1. In part 1, which measurements had the larger fractonal uncertainties, the ones involving cubits or the ones involving meters?

2. Which is a better unit of measurement, cubits or meters? Why?

3. Can you determine a conversion factor relating cubits to meters? Why or why not?

4. In Part 2, you used the volume from the graduated cylinder as the standard. In doing this, you must assume that this is the more accurate of the two measurements. Is this a good assumption, and why?

5. In Part 3, suppose you carry the significant digits out one more place in the standard. Will this change your percent error? Why or why not?