

**Introduction:**

Recall from LAD 1 the density of a substance is its mass per unit volume. It is a derived (calculated) unit and is difficult to measure directly. The mass and volume must be measured, and the resulting density can be calculated. The mass and volumes collected in this lab will be graphed and NOT calculated. Graphs can be useful as a visual representation of the data to help identify relationships and correlations.

**PreLAD: This should be done before coming to class.**

Prepare a data table to gather the four sets of data. Keep in mind that you will need three volume columns. (One for water, one for water + object, and one for the actual volume of the object.) Use excel if you like, but you may use lined paper this time if you prefer – but you must use a ruler to make columns. Don't forget your LAD # and title and name at the top.

**Procedure overview: - Goggles are not necessary for this lab**

Be sure that the object is dry when determining its mass. Use five objects (of the same material) of different masses to get more varied results for graphing purposes and so you can answer question 5. The volume of irregularly shaped objects can easily be determined by the water displacement method, since the volume of the object is equal to the volume of liquid it displaces. Put the object directly into a graduated cylinder with a pre-measured amount of water, and measure the volume increase. Be sure to use as accurate a graduated cylinder as possible based on the size of the object being measured. DO NOT DROP the objects through the bottom of the cylinder; tip the cylinder sideways and slide the object in. DO NOT FORCE the object into a cylinder, use a larger one if the object is too tight.

**Part A:**

1. Determine the mass and corresponding volume for 5 objects of ONE (all the same) TYPE of metal material (you will choose either aluminum or iron).
  - Remember that you will need to measure the volume of water before the object is in, and then measure the volume of water with the object in it. A simple subtraction will allow you to calculate the volume of the water displaced which is of course equal to the volume of the object.
  - Be sure you have a space on your data table for all three of the volume values.
2. Repeat the process for a second TYPE of material (you will choose either glass rods or rubber tubes).

**Part B:**

3. Collect mass and volume data from the whiteboard board for two more materials different from the materials tested in Part A. (This way you will end up with four sets of data but we can finish more quickly since you only need to measure two sets.)

**Disposal:**

All the solids should be dried and returned to their respective places on the center lab bench.

**Processing the Data:**

- Do NOT calculate density. Follow the directions in the graphing section to produce two graphs. Follow the guidelines on page 2.

**Graphing: STOP – Before you construct your graph, read and heed the reference document: What Makes a Good Graph? Learn to use Excel, or some other spreadsheet graphing program. For help with Excel, go to the LAD 5.3 Graphing in Excel help sheet.**

- A. Produce TWO separate x vs y graphs. Print them FULL page size.
- B. Plot mass (y axis) vs volume (x axis) for each set of data, putting the two metal data on one graph and the two nonmetal materials on the other graph. Plot a third set of data on each graph that will represent water. (Remember that the density of water is approximately = 1 g/ml). Even though you did not measure it, be sure and include (0,0) as a data point for all of you data sets.
- C. Draw the "best straight line" (the average or regression line, Excel calls it a "trend line") for each set of data - Do NOT connect the dots. Use the (0,0) line as a data point for each type of material.
- D. Determine the slope of all the average (trendline) lines. (Excel will do this for you.)

**Post LAD Questions:**

1. For these graphs, what does the slope represent? How is density related to the steepness of the lines?
2. Why is it sensible (useful) to graph mass vs volume and not volume vs mass?
3. Why can the (0,0) point be used as a data point for each type of material?
4. Why does the procedure suggest using objects of different masses, and not objects all with similar mass?
5. Does either the shape or size of an object affect its density? Why, or why not, and how does the lab data support the answer?
6. How is density related to whether solid objects float or sink in particular liquids?
7. Having seen ice cubes, glass square, ipe, oak, pine, foam, and cork all placed in water. Sort all of these materials in order from most dense to least dense. Sketch a picture of what they would look like in a large beaker of water.
8. Give two reasons that the water displacement method might not be suitable for all solid materials?
9. Look up the theoretical density values for each substance tested and compare to the slope of each line.
  - a. Calculate % error.
10. Comment on the accuracy and precision of the two sets of data that you personally tested. Does the error appear to be systematic or random?
11. Write an error analysis: (do this for at least two possible sources of error)
  - a. State the source of the error,
  - b. state which data and how that data would be affected ( higher or lower ),
  - c. then state how any intermediate and final calculated value(s) would be affected ( higher or lower ).