

Title: Simple Measurements: Density

Object: To learn how to make good measurements by determining the density of several objects by making length and mass measurements.

Introduction: The density of an object is defined to be its mass divided by its volume:

$$d = \frac{m}{V} \quad (1)$$

An object's mass can be measured directly using an equal-arm balance. The volume, however, must be calculated from a combination of various length measurements using a meter stick, vernier calipers, and a micrometer caliper.

For a rectangular block, the volume is calculated from the product of the length, the width, and the height:

$$V = L \times W \times H \quad (2)$$

For a disk or a rod the volume is equal to the area of the end (π multiplied by the square of the radius) multiplied by the thickness or length:

$$V = \pi r^2 L \quad (3)$$

Apparatus and Procedure:

1. Equal-arm balance: The object to be measured (weighed or "massed") is placed on the left-hand tray and known masses are placed on the right-hand tray until a balance is achieved. A slider is provided for fine adjustments. Draw a sketch of the equal-arm balance.

2. Vernier caliper: The width or thickness of a small object can be measured by closing it between the jaws of the caliper. The result is read by noting the position of the zero line of the vernier scale. One additional significant digit can be obtained by observing which line of the vernier scale coincides with a line on the main scale. Draw a sketch of the vernier caliper.

3. Micrometer caliper: This instrument is a “C” shaped frame with a screw adjustment. The object to be measured is placed between the anvil and the screw, which is advanced until the object is gently but firmly gripped. Using the micrometer caliper, more accurate measurements can be made on smaller objects than with the vernier caliper. Draw a sketch of the micrometer caliper.

Results: Record the various measurements and calculate the density for each of the objects listed below. Remember to record and maintain the proper number of significant figures.

1. Wooden block: Using a meter stick measure and record the length, width, and height of the block. Using the correct formula from the theory, compute the density of the wooden block.

Block # _____ Mass = _____
 Length = _____ Width = _____ Height = _____ Volume = _____
 Experimental Density = _____
 Accepted Density = _____
 Percent Difference = _____

2. Masonite disk: Using a meter stick and a vernier caliper measure the radius and thickness of a masonite disk. Using the correct formula from the theory, compute the density of masonite.

Disk # _____ Mass = _____
 Diameter = _____ Thickness = _____ Volume = _____
 Experimental Density = _____
 Accepted Density = _____
 Percent Difference = _____

3. Aluminum rod: Using a meter stick and a vernier caliper measure the length and diameter of an aluminum rod. Using the correct formula, compute the density of aluminum.

Rod # _____ Mass = _____
Length = _____ Diameter = _____ Volume = _____
Experimental Density = _____
Accepted Density = _____
Percent Difference = _____

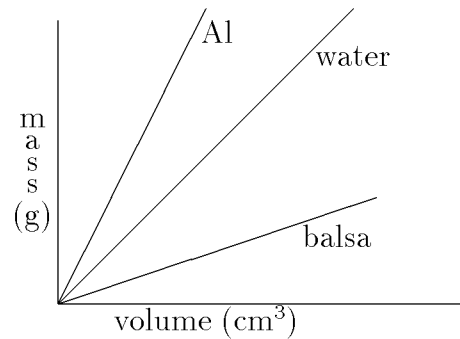
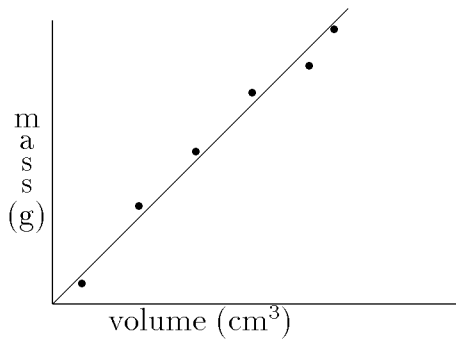
4. Copper wire: Measure the length and radius of a copper wire using a meter stick and a micrometer caliper. Compute the density of copper.

Length = _____ Diameter = _____ Mass = _____
Volume = _____
Experimental Density = _____
Accepted Density = _____
Percent Difference = _____

Discussion:

1. If you had a block of copper with the same dimensions as your wooden block, what would be its mass?
2. If you had a disk made of aluminum with the same mass and thickness as your masonite disk, what would be its radius?
3. Given that water has a density of 1.0 g/cm^3 , which of the above objects would float on water?
 - (a) the wooden block
 - (b) the masonite disk
 - (c) the aluminum rod
 - (d) the copper wire

4. If you were able to measure the mass and volume of a number of different-sized samples of the same substance you could plot them on a graph of mass (vertical axis) versus volume (horizontal axis). Each data point would represent one of the samples. You could then draw a best-fit straight line with a ruler through (0,0) and your data points. The slope of that straight line would be the density of the substance. For example, some data for water might be like that below. The slope of this straight line could be computed by picking two (widely-separated) points *on* the line (not data points, since they have uncertainty in them) and use $m = \frac{y_2 - y_1}{x_2 - x_1}$ to compute the slope of the line. The slope in the example on the left should be close to 1.0 g/cm³, the density of water. Similar lines for other substances would have different slopes; the more dense the substance, the steeper the line.



5. There are also ways to measure the densities of things other than solids, such as liquids and gasses. To find the volume of a liquid, you can simply pour it in a graduated cylinder and read the volume on the markings on the side (the mass of the liquid can be obtained by putting the cylinder on the equal-arm balance when full and when empty and subtracting). In fact, this method of finding volume can be modified to work for solids as well: read the volume of a liquid in a graduated cylinder, then drop the solid into the liquid; the level of the liquid will rise and the difference is the volume of the submerged solid.
6. However, if the density of the solid is less than the density of the liquid, the object will float instead of sink.

Conclusions: