Experiment 1

MEASUREMENT AND GRAPHICAL ANALYSIS

OBJECTIVE

To get acquainted with the concepts and measurement of length, mass and volume and to measure these quantities with instruments like a Vernier caliper, ruler and micrometer; using the measurements of various shaped objects to calculate their volumes and densities. Also to learn error analysis in measurements.

EQUIPMENT

Electronic Balance

Vernier Caliper

Micrometer

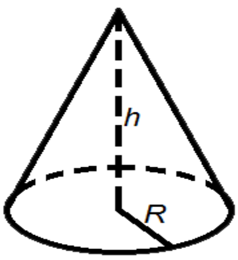
Ruler

Rigid bodies of different shapes

VOLUMES OF DIFFERENT SHAPES

Volume of a right circular cone is equal to one third of the product of the area of its base times the height.

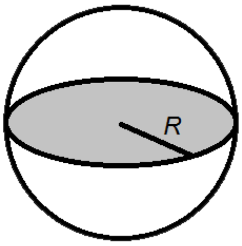
$$V = \frac{1}{3} \pi R^2 h$$



$$V = \frac{1}{3} A_b h$$

where V - volume of a cone,
A_b - area of the base,
R - radius of the base,
h - height,
$\pi = 3.141592$.

Volume formula of a sphere (solid):



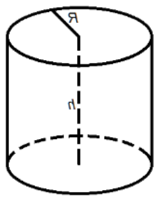
$$V = \frac{4}{3} \pi R^3$$

where V - volume of a sphere,

R - radius of a sphere,

Volume of a cylinder:

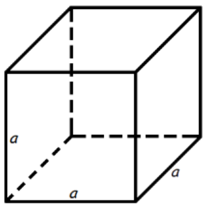
$$V = \pi r^2 h = \pi \frac{d^2}{4} h ,$$



where r is a radius of the base, h is height of a cylinder, d is diameter of the base.

Volume formula of a Cube: $V = a^3$

a - the length of an edge.



Density of an object $\rho = \frac{m}{V}$ *kg-m*$^{-3}$

PROCEDURE

1. Measure the height of the cylinder and its diameter with a ruler.
2. Repeat the same measurement with a Vernier caliper and a micrometer.
3. Measure the diameters and lengths of other objects with a Vernier or a micrometer.
4. Measure the masses of all the objects with the electronic balance.
5. Using the formulas given above determine the volumes of the objects.
6. Since all the objects are made of the same material, draw a graph of mass versus volume and from the graph determine the density

DRAWING A GRAPH

You should use as much area of the graph paper as possible when you plot your data. Your graph should not squeezed to a corner of a large empty paper. To do this you should carefully adjust the scales of your axes. Consider the minimum and maximum values of each variable and the length of your paper, hence your axes and choose your scale.
You should clearly label each axis and write depressed the scale. Then should mark the position corresponding to each data pair. After you have placed all the data points, since you know that the relationship between the two variables, (mass and volume) is linear, try to draw the straight line that best represent your data points. Using the slope of this line calculate the density.
Note that in a **y** versus **x** linear graph, the slope is $slope = \frac{\Delta y}{\Delta x}$

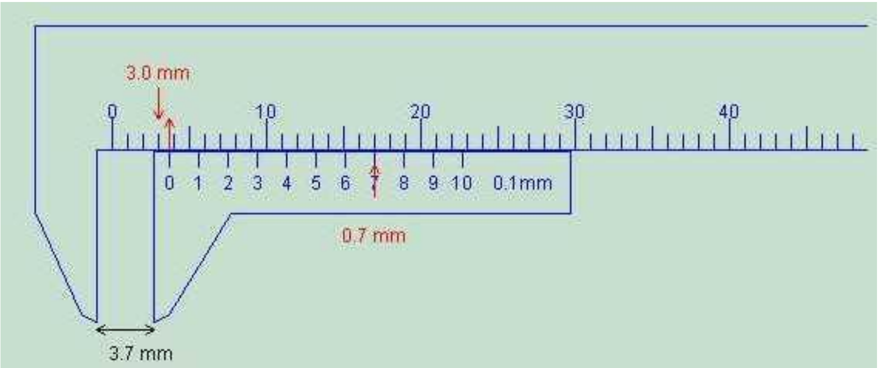
DATA

CALCULATIONS

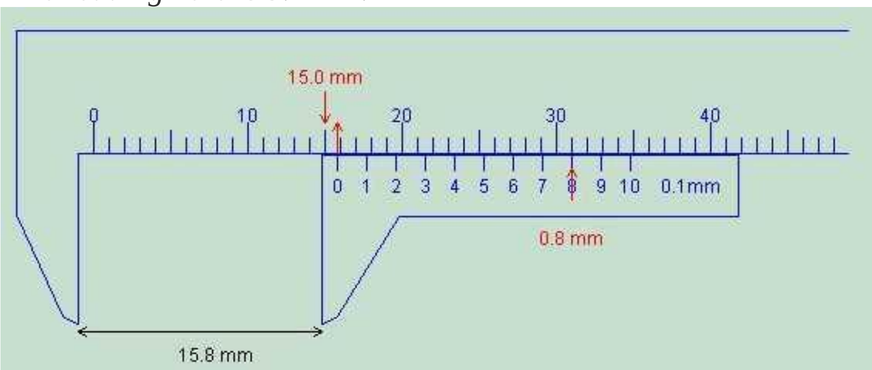
APPENDIX

Using the Vernier Calipers & Micrometer Screw Gauge

The precision of length measurements may be increased by using a device that uses a sliding vernier scale. Two such instruments that are based on a vernier scale which you will use in the laboratory to measure lengths of objects are the vernier callipers and the micrometer screw gauge. These instruments have a main scale (in millimetres) and a sliding or rotating vernier scale. In the figure below, the vernier scale (below) is divided into 10 equal divisions and thus the least count of the instrument is 0.1 mm. Both the main scale and the vernier scale readings are taken into account while making a measurement. The main scale reading is the first reading on the main scale immediately to the left of the zero of the vernier scale (3 mm), while the vernier scale reading is the mark on the vernier scale which exactly coincides with a mark on the main scale (0.7 mm). The reading is therefore 3.7 mm.

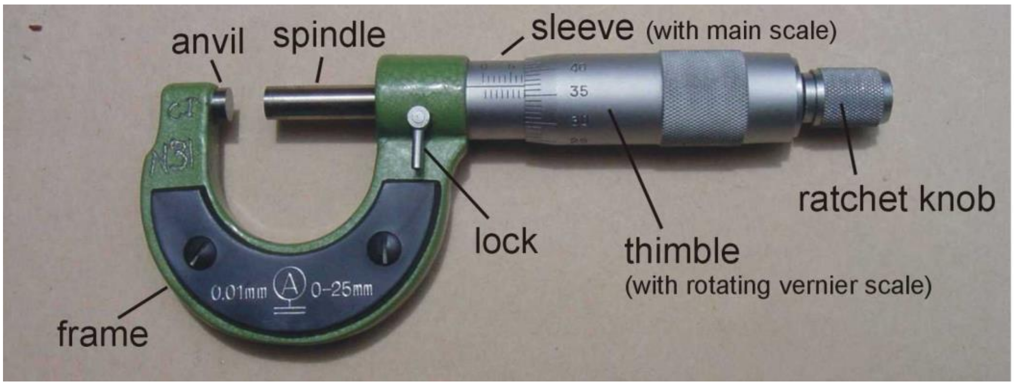


The reading here is 3.7 mm.



The micrometer screw gauge

The micrometer screw gauge is used to measure even smaller dimensions than the vernier callipers. The micrometer screw gauge also uses an auxiliary scale (measuring hundredths of a millimetre) which is marked on a rotary thimble. Basically it is a screw with an accurately constant pitch (the amount by which the thimble moves forward or backward for one complete revolution). The micrometers in our laboratory have a pitch of 0.50 mm (two full turns are required to close the jaws by 1.00 mm). The rotating thimble is subdivided into 50 equal divisions. The thimble passes through a frame that carries a millimetre scale graduated to 0.5 mm. The jaws can be adjusted by rotating the thimble using the small ratchet knob. This includes a friction clutch which prevents too much tension being applied. The thimble must be rotated through two revolutions to open the jaws by 1 mm.



The micrometer screw gauge

In order to measure an object, the object is placed between the jaws and the thimble is rotated using the ratchet until the object is secured. Note that the ratchet knob must be used to secure the object firmly between the jaws, otherwise the instrument could be damaged or give an inconsistent reading. The manufacturer recommends 3 clicks of the ratchet before taking the reading. The lock may be used to ensure that the thimble does not rotate while you take the reading.

The first significant figure is taken from the last graduation showing on the sleeve directly to the left of the revolving thimble. Note that an additional half scale division (0.5 mm) must be included if the mark below the main scale is visible between the thimble and the main scale division on the sleeve. The remaining two significant figures (hundredths of a millimetre) are taken directly from the thimble opposite the main scale.

The reading is 7.38 mm.

In figure above the last graduation visible to the left of the thimble is 7 mm and the thimble lines up with the main scale at 38 hundredths of a millimetre (0.38 mm); therefore the reading is 7.38 mm.

The reading is 7.72 mm.