Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Date:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Time:\_\_\_\_\_\_\_\_\_\_\_\_

Partner(s):\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Course:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_   
  
Measurement of density

1) Introduction to the vernier caliper

Dimensions of the order of tenths of a millimeter (0.1 mm or 0.01 cm) can be measured using a vernier caliper. It consists of a main scale and a movable vernier scale. The main scale is calibrated in centimeters with a millimeter least count, and the vernier scale has 10 divisions that cover 9 divisions on the main scale. The left most mark on the vernier scale is the zero mark, which is often unlabeled.

A measurement is made with the vernier caliper by closing the jaws on the object to be measured and then reading the position where the zero line of the vernier falls on the main scale. The fractional part of a main scale division is obtained by noting which line on the vernier coincides with a line on the main scale. Visit this [vernier](http://members.shaw.ca/ron.blond/Vern.APPLET/index.html) web site and learn how to use a vernier caliper. <http://www.youtube.com/watch?v=4hlNi0jdoeQ>

2) Introduction to the micrometer   
    
Dimensions of the order of hundredths of a millimeter (0.01 mm or 0.001 cm) can be measured using the micrometer. It has a movable spindle that is advanced by a rotating thimble. The ratchet allows slippage of the screw mechanism when a small and constant force is exerted on the jaw. This permits the jaw to be tightened on an object with the same amount of force each time. The axial main scale is calibrated in millimeters and the thimble is calibrated in 0.01 mm.   
    
The micrometer should be checked for a zero error, for it may not read zero when the jaws are completely closed. In such cases a zero correction has to be applied to every reading. The zero error may be either positive or negative. The zero correction is always made by subtracting the zero reading from the final reading.

The micrometer is read by noting the position of the edge of the thimble on the main scale which gives the nearest whole main scale division. The position of the axial line on the circular thimble scale gives the fractional part of the main scale. Visit this [micrometer](http://members.shaw.ca/ron.blond/Micrometer.APPLET/) web site and learn how to use a micrometer. <http://www.youtube.com/watch?v=O8vMFFYNIfo>

In this experiment the mass will be measured using an electronic balance.

**A. Rectangular Solids**

Purpose: To determine the densities of various rectangular solids by measuring their dimensions and mass.

Apparatus: Electronic balance, foot ruler, vernier caliper, micrometer,   
rectangular solid metals- Al, Cu, Brass, and Fe; sheet metal, and acrylic block.

Theory:            

Data: Rectangular Solids

Create a data table as shown below in Excel spread sheet. Measure and enter the mass, length, width, and height values for the rectangular solids. Add 4 more columns and calculate the volumes and densities. Also enter the accepted densities and calculate the %Error. Use proper significant figures.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Mass | Length | Width | Height |
| Al | - | - | - | - |
| Cu | - | - | - | - |
| Fe | - | - | - | - |
| Brass | - | - | - | - |
| Sheet metal | - | - | - | - |
| Acrylic block | - | - | - | - |

If the %Errors are high, check your measurements. Insert your data table.    
  
Accepted densities (in g/cm3):

Aluminum = 2.70    Copper   = 8.90     Iron     = 7.85        Brass    = 8.40   
Steel    = 7.80        Gold       =19.30     Lead     =11.30     Nickel   = 8.75   
Platinum = 21.54    Silver      =10.5       Zinc      = 7.10        water    = 1.00   
Wood = 0.64        Acrylic    = 1.2 



**B. Cylinders**

Purpose: To determine the densities of various cylinders by measuring their dimensions and mass.

Apparatus: Metal cylinders: Cu, Fe, Steel, Brass, and Al; wood cylinder, length of Cu wire, electronic balance, foot ruler, vernier caliper, and micrometer.   
    
Theory:  
  ,       ; d = diameter, h = height.   
  
Data: Cylinders  
  
Create a data table as shown below in Excel spread sheet. Measure and enter the mass, height, and diameter values for the cylinders. Add 4 more columns and calculate the volumes and densities. Also enter the accepted densities and calculate the %Error. Use proper significant figures.

|  |  |  |  |
| --- | --- | --- | --- |
| Cylinder | Mass | Height, h | Diameter, d |
| Al |  |  |  |
| Steel |  |  |  |
| Cu |  |  |  |
| Brass |  |  |  |
| Fe |  |  |  |
| Wood |  |  |  |
| Cu wire |  |  |  |
| Penny |  |  |  |

If the %Errors are high, check your measurements. Insert your data table.     
Use this [penny composition](http://www.usmint.gov/about_the_mint/fun_facts/?action=fun_facts2) website to calculate an accepted density for your penny.

C. Density of Water

Purpose: Determine the density of water.

Apparatus: Graduated cylinder, electronic balance, and water.

Procedure: Collect 10 sets of data, plot an appropriate graph, and obtain the average density from the graph. Insert your data table and graph.

Average Density of water = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Overall Conclusion: