Rose State College
T. Earman

Physics I Lab

Lab Title: Density/Measurement

Name: Tyler Earman

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Partner(s): N/A

Objective:

The objective of this laboratory was to calculate the density of unknown materials by first taking their weight and volume and calculating their density at this point. To add a challenge, not all materials had an easily measured volume and therefore techniques such as measuring displacement in a static body (like water) were necessary. Finally, the densities of the materials measured were used to identify the materials.

Procedure:

Mass

The mass of each of the nine (9) samples was determined using a digital scale, further a volume of water was also massed for usage with a displacement technique.

Volume

Volumes of the materials were ascertained through various mechanisms.

Regular materials (id est, materials which bore no discernible irregularities such as craters and ridges, and bore resemblance to simple geometric shapes) were measured using digital calipers. To increase accuracy, all three (3) dimensions X, Y, and Z were measured even on shapes which implied regular distribution of measurements throughout the material (id est, spheres and cubes) in order to compensate for production precision attenuation.

Irregular materials were determined using an accurate mechanism of water displacement. With the digital scale tared at the final weight of the beaker and containing water, the irregular material was then tied onto a string with very low mass and lower into the beaker, submerging it in water fully but preventing it from coming into contact with any of the extremities of the beaker (which would have caused an error in accuracy). The amount of water displaced above the tare introduced earlier was equivalent to the volume of the irregular material.

Data:

The following table conveys all information taken directly from the instruments during the duration of the experiment and were used to calculate the retaining data later.

Sample	Mass (g)	Length/Base (cm)	Width (cm)	Height (cm)	Diameter (cm)	Displacement (mL)
Wooden wedge	77.2	5.12	4.48	10.44		
Wooden Cylinder	68.8	4.99			4.93	
Metallic Cube	148.4	2.51	2.51	2.6		
Wooden Cube	14.6	2.35	2.4	2.47		
Metallic Cynlinder	53.7	4.98			1.25	
Metallic Sphere	80				2.66	
Glass Sphere	19.7				2.46	
Grey Irregular Object	97					12.9
Yellow Irregular Object	35.7					7.3

Analysis:

Once the above data was ascertained, the following formula was applied to the data in order to attain its final density.

$$\rho = \frac{m}{V}$$

Spherical Sample Volumes

Measurements coming from the calipers showed the diameter of the spherical objects so it was then necessary to apply the formula $r = \frac{1}{2}d$ in order to determine the radius (which is used in all applicable formulas, *r* being radius and *d* being diameter).

Once the radius is calculated, the volume can be calculated using the formula: $V = \frac{4}{3}\pi r^2$ where *V* is the volume and *r* is the radius.

The data and calculated values for the spherical samples is shown bellow

Sample	Mass (g)	Diameter (cm)	Volume (mL)	Density (g/mL)
Metallic Sphere	80	2.66	7.41	10.8
Glass Sphere	19.7	2.46	6.34	3.11

Cubical Sample Volumes

For cubical samples, the formula for calculating volume is $V = lwh$ where *V* is the volume, *l* is the length, *w* is the width, and *h* is the height.

The data and calculated values for the cubical samples is shown bellow.

Sample	Mass (g)	Length (cm)	Width (cm)	Height (cm)	Volume (mL)	Density (g/mL)
Metallic Cube	148.4	2.51	2.51	2.6	16.38	9.06
Wooden Cube	14.6	2.35	2.4	2.47	13.93	1.05

Cylindrical Sample Volumes

The formula for calculating the volume of a cylinder is: $V = \pi r^2 h$ where *V* is the volume, *r* is the radius, and *h* is the height.

The data and calculated values for the cylindrical samples is shown bellow.

Sample	Mass (g)	Height (cm)	Diameter (cm)	Volume (mL)	Density (g/mL)
Wooden Cylinder	68.8	4.99	4.93	95.25	0.72
Metallic Cylinder	53.7	4.98	1.25	6.11	8.79

Wedge Sample Volumes

The formula for calculating the volume of a wedge (triangular prism) is: $V=\frac{1}{2}bhd$ where V is the volume, b is the base, h is the height, and d is the depth.

The data and calculated values for the wedge sample is given bellow.

Sample	Mass (g)	Base (cm)	Depth (cm)	Height (cm)	Volume (mL)	Density (g/mL)
Wooden wedge	77.2	5.12	4.48	10.44	119.73	0.64

Irregular Sample Volumes

Given the assumptions:

1 gram of water is equivalent to 1 milliliter, and 1 milliliter of water equals 1 cubic centimeter

The values of the irregular shapes were ascertained using a displacement method where the scale was tared after the sample of water was placed upon it and became of stable measurement, and the sample was then submersed yet suspended by a very low mass string. The scale then output the displacement of the sample in grams, and given the assumptions above, we can assume its volume according to its water displacement.

The data and calculated values for the irregular samples is given bellow.

Sample	Mass (g)	Displacement (mL)	Volume (mL)	Density (g/mL)
Grey Irregular Object	97	12.9	12.9	7.52
Yellow Irregular Object	35.7	7.3	7.3	4.89

Sample Identification

The calculated values for the samples was then taken and compared to a list of known values in order to ascertain the material that the samples were made out of. Any differences between the experimentally derived data and the accepted values was taken into account and used to calculate the error given by the following formulas:

Percent Error: $\left|\left(\frac{u-v}{u}\right)\right| * 100\,\%$

Percent Difference: $\left|\left(\frac{u-v}{\frac{1}{2}(u+v)}\right)\right| * 100\,\%$

Where u is the true value and v is the measured value.

The following table shows all the final data and calculations and well as their error levels.

Sample	Experimental Density (g/mL)	Known Material	True Density (g/mL)	Percent Error
Wooden wedge	0.64	Wood (Pine)	0.37-0.64	N/A
Wooden Cylinder	0.72	Wood (Oak)	0.67-0.79	N/A
Metallic Cube	9.06	Copper	8.9	1.80%
Wooden Cube	1.05	Lignum Vitae	1.03-1.12	N/A
Metallic Cynlinder	8.79	Brass	8.4-8.9	N/A
Metallic Sphere	10.8	Silver	10.5	2.86%
Glass Sphere	3.11	Glass	2.4-2.8	11.07%
Grey Irregular Object	7.52	Zinc	7.13	5.47%
Yellow Irregular Object	4.89	Pyrite	5.01	2.40%

Conclusion

The property of density was found to be a measurement of the mass of a sample per unit of volume (grams per milliliter in this case). As such with a decrease in volume and the mass remaining static, the density therefore increases.

Bellow is a graph comparing the samples to their experimental densities.