

- Record the mass and volume of each object. The volume (V) of a rectangle can be found by measuring then multiplying the length (l) times the width (w) times the height (h). ($V_{\text{rectangle}} = lwh$), The volume of a cube can be found by ($V_{\text{cube}} = S^3 = S \times S \times S$). By measuring the diameter (d) and the height (h) then using the formula $V = \pi h(d^2/4)$ or $V = \pi r^2 h$ where r is the radius the volume of a cylinder can be found. Note the diameter $d = 2r$. To find the volume of a triangular prism $V_{\text{Triangular prism}} = \frac{1}{2} bhw$ where (b) is the base.
- To find the volume by displacement, fill a graduated cylinder halfway with water and note the volume of water. Place the object into the graduated cylinder so that it is completely submerged. Next read the volume of the graduated cylinder. **Note: $1 \text{ cm}^3 = 1 \text{ cc} = 1 \text{ ml}$**

Object Description	Mass (g)	Volume (cm^3) by measurement	Volume (ml) using displacement
Copper Cylinder	0.448	0.05	0.05
Copper Cube	71.68	8.00	8.00
Copper Rectangle	106.60	11.90	11.99
Copper Triangular Prism	8.90	1.00	0.99
Aluminum Cylinder	0.643	0.24	0.23
Aluminum Cube	2.67	1.01	1.01
Aluminum Rectangle	64.02	24.00	24.03
Aluminum Triangular Prism	2.7	1.00	1.00
Lead Cylinder	0.568	0.05	0.05
Lead Cube	91.05	8.00	7.97
Lead Rectangle	336.3	30.04	30.02
Lead Triangular Prism	11.28	1.00	1.02
Teflon Cylinder	0.05	0.02	0.02
Teflon Cube	59.4	27.00	26.93
Teflon Rectangle	13.7	6.00	5.99
Teflon Triangular Prism	52.85	24.01	24.00

- 2B.** Is the measured volume and the displaced volume the same or different for the objects. Explain why or why not!

the displaced volume is slightly low because some of it is left in the container due to adhesion.



2C. Is the mass or the volume the same for any of the objects? Explain why!

The masses and volumes are slightly different due to errors resulting from measurement instruments

2D. Record the number you obtain when you divide the mass by its volume.

Object	Mass/ Volume (g/cc)
Copper Cylinder	8.89
Copper Cube	8.96
Copper Rectangle	8.957
Copper Triangular Prism	8.90
Aluminum Cylinder	2.679
Aluminum Cube	2.64
Aluminum Rectangle	2.667
Aluminum Triangular Prism	2.7
Lead Cylinder	11.36
Lead Cube	11.38
Lead Rectangle	11.195
Lead Triangular Prism	11.28
Teflon Cylinder	2.5
Teflon Cube	2.2
Teflon Rectangle	2.28
Teflon Triangular Prism	2.201

2E. Is the mass/volume number the same for any of the objects? Explain why!

The mass and volume vary by a few figures less than 1 due to errors occurring during measurement, rounding off and truncation.

- 3A. Find the mass of an empty 10 mL graduated cylinder. 50.34 g
 3B. Get 10.00 ml of water in a graduated cylinder and then find the total mass. 60.34 g
 3C. Pour out 5.00 cm³ of water. What is the mass of the total mass now? 55.30 g
 3D. Find the mass of an empty 100 mL graduated cylinder. 138.25 g
 3E. Get 50.0 cc of water in a graduated cylinder and then find the total mass. 188.29 g
 3F. Pour out 5.0 cm³ of water. What is the mass of the total mass now? 183.26 g
 3G. Pour out 15.0 ml of water. What is the mass of the total mass now? 168.20 g
 3H. Pour out 30.0cm³ of water. What is the mass of the total mass now? 138.17 g

3B – 3H, complete the following table for just the water.

Line	Mass of Graduated Cylinder + H ₂ O (g)	Mass of Water (g)	Water Volume (ml)	Water Mass/Volume (g/ml)
3B	60.34	10	10	1.00
3C	55.30	5	5	1.00
3D	138.25	0	0	-----
3E	188.29	50	50	1.00
3F	183.26	45	45	1.00
3G	168.20	30	30	1.00
3H	138.17	0	0	-----

3I. Write down a rule that you can use to predict whether the number you obtain by dividing the mass by the volume for a piece of an object will be the same as that for a larger piece of the object.

$$d = m/v$$

3J. If you were to cut an object into equal 1 cm³ volumes, give an example of an object for which all of the 1cc pieces have the same mass.

Pure copper

3K. Give an example of an object for which the 1cc pieces do not share the mass equally.

Bronze

3L. What does an object have to be like in order for the 1cc pieces to share the mass equally?

Must be a pure substance



4. The result obtained when two numbers are divided is called the ratio. 15/3 is called the ratio of 15 to 3. Above we have found that mass and volume are proportional for a given homogeneous substance. Therefore, the ratio of mass to volume is the same for all samples of the substance. Density (ρ) is the name given to this ratio. $\rho = m/v$.

Mass, volume and density are properties of matter. However, mass and volume tell us something about a specific object. In contrast, the density contains information about a class of objects. Under the same conditions, all objects made of the same material have the same density. This is not true for mass and volume.

- 4a. Calculate the average density from the mass to volume ratios above for copper, aluminum, lead and Teflon then record in the table below. Copper = 8.96 Aluminum Lead Teflon

- 4b. Using the accepted values calculate the percent error using the formula

$$\% \text{ Error} = \frac{|\text{Actual} - \text{Experimental}|}{\text{Actual}} \times 100 \text{ and record in the table below.}$$

Material	Average Density (g/ml)	Actual Density (g/ml)	% Error
Copper	8.96	8.94	0.22%
Aluminum	2.67	2.70	1.11%
Lead	11.304	11.34	0.317%
Teflon	2.295	2.20	0.00043%

$$\rho = m/v$$

$$m = \rho v$$

$$v = m/\rho$$

Where: ρ = density m = mass v = volume



5. Suppose we have a stone with a mass of 15.0 g and a volume of 5.00 ml. (1st find density this will be the same for any piece of this rock)

$$d = m/v = 15/3 = 3.0\text{g/cm}^3$$

- 5A. What is the mass of 1.00 ml of this stone?

$$\text{mass} = \text{volume} * \text{density} = 1 * 3 = 3\text{g}$$

- 5B. Suppose we have a larger piece of the same kind of stone with a volume of 17.0 cc. What would its mass be?

$$\text{mass} = \text{volume} * \text{density} = 3 * 17 = 51\text{g}$$

- 5C. What is the volume of 90.0 g of the same kind of stone?

$$\begin{aligned}\text{volume} &= \text{mass}/\text{density} \\ &= 90/3 = 30\text{cm}^3\end{aligned}$$

6. A certain piece of metal has a mass of 125 g and a volume of 25.0 cm³.

$$\begin{aligned}\text{density} &= \text{mass}/\text{volume} \\ &= 125/25 = 5\text{g/cm}^3\end{aligned}$$

- 6A. What is the mass of 1.00 cm³ of this metal?

$$\text{mass} = \text{volume} * \text{density} = 1 * 5 = 5\text{g}$$

- 6B. What is the volume of 80.0 g of this metal?

$$\begin{aligned}\text{volume} &= \text{mass}/\text{density} \\ &= 80/5 = 16\text{cm}^3\end{aligned}$$

- 6C. What is the mass of 40.0 cc of this metal?

$$\begin{aligned}\text{Mass} &= \text{volume} * \\ &\text{density} \\ &= 40 * 5 \\ &= 200\text{g}\end{aligned}$$