

## Prelab Questions.

1. a)  $\text{Density} = \frac{\text{Mass}}{\text{Volume}}$

$$= \frac{63.34 \text{ g}}{(42 - 33) \text{ cm}^3} = \frac{63.34 \text{ g}}{9.0 \text{ cm}^3}$$

$$= 7.038 \text{ g/cm}^3$$

b) The density of the bolt ( $7.038 \text{ g/cm}^3$ ) is lower than the density of the nuts ( $7.35 \text{ g/cm}^3$ ).

c) Mass per unit volume of the nuts is higher than the mass per unit volume of the bolt.

2. A graph of mass against volume of liquid added gives a straight line. The slope of the line represents the density of the material.

3. Mass of the coins decreases. decrease in density at constant volume decreases the mass. Mass is directly proportional to density at constant volume.  $\text{Mass} = \text{Density} \times \text{Volume}$ .  
 $M = D \times V$ .

4.  $\text{Volume} = \frac{\text{Mass}}{\text{Density}}$

$$V = \frac{M}{D}$$

$$V = \frac{6.25 \text{ g}}{10.5 \text{ g/ml}}$$

$$V = 0.5952 \text{ ml}$$

## The Experiment.

Rectangular blocks.  
left.

$$\text{Mass} = 0.40\text{g}.$$

$$\begin{aligned}\text{Volume} &= L \times W \times H \\ &= (1.9 \times 0.9 \times 1.1) \text{cm}^3 \\ &= 1.881 \text{cm}^3\end{aligned}$$

$$\begin{aligned}\text{Density} &= \frac{\text{Mass}}{\text{Volume}} = \frac{0.40\text{g}}{1.881 \text{cm}^3} \\ &= 0.2127 \text{g/cm}^3\end{aligned}$$

Middle.

$$\text{Mass} = 0.16\text{g}$$

$$\begin{aligned}\text{Volume} &= L \times W \times H \\ &= 1 \times 0.9 \times 0.8 \\ &= 0.72 \text{cm}^3\end{aligned}$$

$$\begin{aligned}D &= \frac{0.16}{0.72} \\ &= 0.2222 \text{g/cm}^3.\end{aligned}$$

Right.

$$\text{Mass} = 0.42\text{g}.$$

$$\begin{aligned}\text{Volume} &= 0.6 \times 1.2 \times 2.8 \\ &= 2.016 \text{cm}^3.\end{aligned}$$

$$\begin{aligned}D &= \frac{0.42}{2.016} \\ &= 0.2083 \text{g/cm}^3.\end{aligned}$$

Average density.

$$\begin{aligned}&\frac{0.2127 + 0.2222 + 0.2083}{3} \\ &= \frac{0.6432}{3} = 0.2144 \text{g/cm}^3.\end{aligned}$$

Spheres.

yellow

$$\text{Mass} = 6.80\text{g}$$

$$\begin{aligned}\text{Volume} &= \frac{4}{3}\pi r^3 \\ &= \frac{4}{3} \times 3.142 \times 1.15^3 \\ &= 6.371 \text{cm}^3.\end{aligned}$$

$$\begin{aligned}\text{Density} &= \frac{\text{Mass}}{\text{Volume}} = \frac{6.80\text{g}}{6.371 \text{cm}^3} \\ &= 1.067 \text{g/cm}^3.\end{aligned}$$

Black.

$$\text{Mass} = 10.06\text{g}.$$

$$\begin{aligned}\text{Volume} &= \frac{4}{3}\pi r^3 \\ &= \frac{4}{3} \times 3.142 \times 1.35^3 \\ &= 7.635 \text{cm}^3.\end{aligned}$$

$$\begin{aligned}D &= \frac{10.06}{7.635} \\ &= 1.318 \text{g/cm}^3.\end{aligned}$$

Green

$$\text{Mass} = 8.21\text{g}.$$

$$\begin{aligned}\text{Volume} &= \frac{4}{3} \times 3.142 \times 1.4^3 \\ &= 11.50 \text{cm}^3\end{aligned}$$

$$\begin{aligned}D &= \frac{8.21}{11.50} \\ &= 0.7139 \text{g/cm}^3.\end{aligned}$$

Average density.

$$\begin{aligned}&\frac{1.067 + 1.318 + 0.7139}{3} \\ &= \frac{3.0989}{3} = 1.033 \text{g/cm}^3\end{aligned}$$

Cylinders:

Lead (left).

$$\text{Mass} = 28.55 \text{ g}$$

$$\text{Volume} = \pi r^2 h$$

$$= 3.142 \times 0.6^2 \times 2$$

$$= 2.262 \text{ cm}^3$$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{28.55 \text{ g}}{2.262 \text{ cm}^3}$$

$$= 12.62 \text{ g/cm}^3$$

Aluminium (middle).

$$\text{Mass} = 29.01 \text{ g}$$

$$\text{Volume} = \pi r^2 h$$

$$= 3.142 \times 0.6^2 \times 8.2$$

$$= 9.275 \text{ cm}^3$$

$$\text{Density} = \frac{29.01 \text{ g}}{9.275 \text{ cm}^3}$$

$$= 3.128 \text{ g/cm}^3$$

Copper (right).

$$\text{Mass} = 28.49 \text{ g}$$

$$\text{Volume} = 3.142 \times 0.6^2 \times 2.6$$

$$= 2.941 \text{ cm}^3$$

$$D = \frac{28.49 \text{ g}}{2.941 \text{ cm}^3}$$

$$= 9.687 \text{ g/cm}^3$$

Average density:

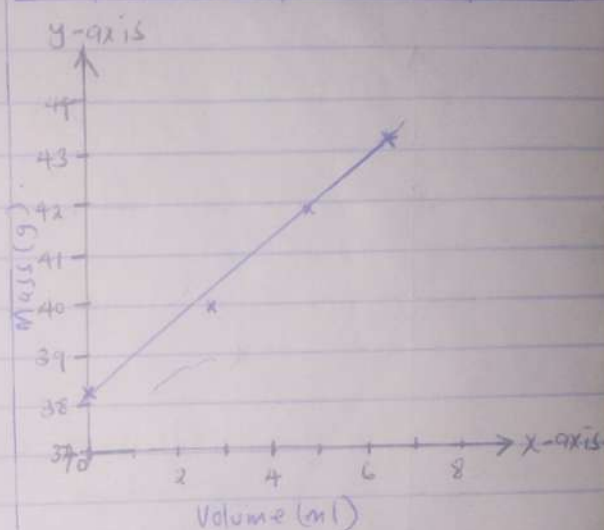
$$\frac{12.62 + 3.128 + 9.687}{3}$$

$$= \frac{25.435}{3} = 8.478 \text{ g/cm}^3$$

Liquid.

Red

|                   | Volume (ml) | Mass (g) |
|-------------------|-------------|----------|
| Just the graduate | 0.00        | 38.37    |
| 1 portion added   | 2.40        | 40.32    |
| 2nd portion added | 4.40        | 41.85    |
| 3rd portion added | 6.40        | 43.49    |



$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{38.37 - 43.49}{0.00 - 6.40}$$

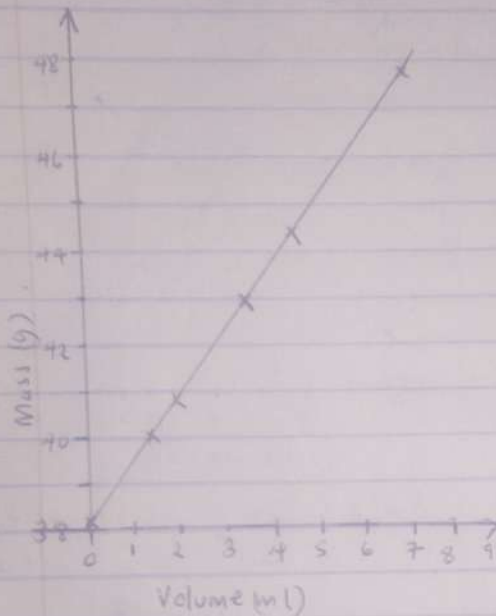
$$= \frac{-5.12}{-6.4}$$

$$= 0.8$$

$$\therefore \text{Density} = 0.8 \text{ g/ml}$$

Colorless.

|                               | Volume (ml) | Mass (g) |
|-------------------------------|-------------|----------|
| Graduate cylinder             | 0.00        | 38.52    |
| 1 <sup>st</sup> portion added | 2.40        | 40.94    |
| 2 <sup>nd</sup> portion added | 4.00        | 42.45    |
| 3 <sup>rd</sup> portion added | 5.00        | 43.58    |
| 4 <sup>th</sup> portion added | 6.50        | 45.25    |
| 5 <sup>th</sup> portion added | 8.50        | 47.34    |



$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{47.34 - 38.52}{8.50 - 0.00}$$

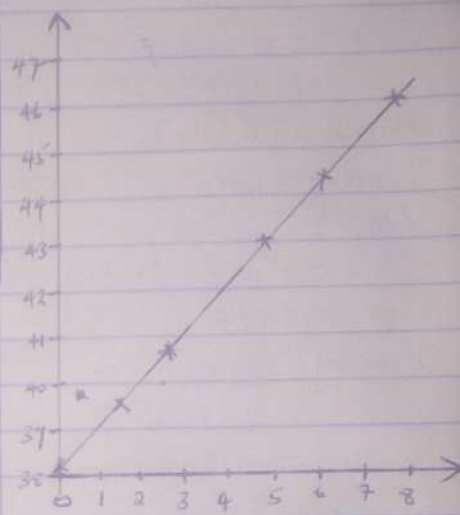
$$= \frac{8.82}{8.50}$$

$$= 1.038$$

$\therefore \text{Density} = 1.038 \text{ g/ml}$

blue.

|                               | Volume (ml) | Mass (g) |
|-------------------------------|-------------|----------|
| Graduate cylinder             | 0.00        | 38.37    |
| 1 <sup>st</sup> portion added | 0.40        | 39.65    |
| 2 <sup>nd</sup> portion added | 2.50        | 40.86    |
| 3 <sup>rd</sup> portion added | 4.70        | 43.04    |
| 4 <sup>th</sup> portion added | 6.30        | 44.49    |
| 5 <sup>th</sup> portion added | 7.70        | 46.12    |



$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{46.12 - 38.37}{7.70 - 0.00}$$

$$= \frac{7.75}{7.70}$$

$$= 0.9143$$

$\therefore \text{Density} = 0.9143 \text{ g/ml}$

Average.

$$0.8 + 1.038 + 0.9143$$

$$\frac{2.7523}{3} = 0.9174 \text{ g/ml}$$

Penny.

1980

$$1^{\text{st}} \text{ stack Mass} = 29.63 \text{ g}$$

$$2^{\text{nd}} \text{ stack Mass} = (60.56 - 29.63) \\ = 30.93 \text{ g.}$$

$$3^{\text{rd}} \text{ stack Mass} = (91.39 - 60.56) \\ = 30.83 \text{ g.}$$

$$1^{\text{st}} \text{ stack volume} = 4 \text{ cm}^3$$

$$2^{\text{nd}} \text{ stack Volume} = 4 \text{ cm}^3$$

$$3^{\text{rd}} \text{ stack Volume} = 4 \text{ cm}^3.$$

$$\text{Density of stack 2} = \frac{\text{Mass}}{\text{Volume}} \\ = \frac{30.93 \text{ g}}{4 \text{ cm}^3} \\ = 7.733 \text{ g/ml}$$

$$\text{Density of stack 3} = \frac{30.83}{4} \\ = 7.708 \text{ g/ml.}$$

$$\text{Density of stack 1} = \frac{29.63}{4} \\ = 7.408 \text{ g/ml.}$$

Average.

$$\frac{7.733 + 7.708 + 7.408}{3}$$

$$= \frac{22.849}{3}$$

$$= 7.616 \text{ g/ml.}$$

## Postlab Questions.

- | Material           | Density (g/ml) |
|--------------------|----------------|
| Rectangular blocks | 0.2144         |
| Spheres            | 1.033          |
| Cylinders          | 8.478          |
| Liquids            | 0.9174         |
| Penny              | 7.616          |

- $$\% \text{ error} = \left( \frac{\text{Accepted} - \text{experimental}}{\text{Accepted}} \right) \times 100\%$$

Experimental value of lead

$$= 12.62 \text{ g/ml}$$

Accepted value of lead

$$= 11.34 \text{ g/ml}$$

$$\% \text{ error of lead} = \frac{|11.34 - 12.62|}{11.34} \times 100$$

$$= \frac{|-1.28|}{11.34} \times 100$$

$$= |11.29\%|$$

$$\therefore \% \text{ error of lead} = 11.29\%$$

- $$\text{Average Mass} = \frac{29.63 + 30.93 + 30.83}{30}$$

$$= \frac{91.39}{30} = 3.046 \text{ g}$$

$$\text{Average volume} = \frac{1 + 1 + 1}{3} = \frac{3}{30}$$

$$= 0.1 \text{ cm}^3$$

$$\text{Average density} = \frac{3.046}{0.1}$$

$$= 7.615 \text{ g/ml}$$

4. To determine if a piece of jewelry is pure gold, determine its density.

- Measure the mass of the jewelry.

- Put the jewelry inside water in a measuring cylinder containing water.

- Determine the volume of water displaced by the jewelry. The volume of water displaced is the volume of the jewelry.

- Hence calculate the density of the jewelry.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Pure gold has a density of  $19.3 \text{ g/ml}$ .

5. Discontinuity occurs between 1981 and 1982. This is because the densities recorded are much higher.

