**Lab - Density is an Intrinsic Property**

***BVSD Standard Physical Science 1.6****: Scientists use the tools of math to solve problems, analyze data, and evaluate the validity of results.*

***COMMON CORE:*** *LA.9-10.CCSS.ELA-Literacy.RST.9-10.3 · Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.LA.9-10.CCSS.ELA-Literacy.RST.9-10.7 · Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. LA.9-10.CCSS.ELA-Literacy.RST.9-10.4 · Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.*

**I Overview:**

Density (mass/volume) is an intrinsic property of matter. This means that the density of a material **does not** **change with the amount of the material you have**. In this lab we will prove the intrinsic nature of density with two different materials – water and modeling clay. You will collect data for volume and mass for several samples of each material and calculate the density for each sample. Then you will graph the data and calculate an average density for the material by determining the slope of the line on the graph of Mass vs Volume.

**II. Prelab Questions:** Answer these on a separate sheet of paper PRIOR to coming to lab on block day!

1. a) Define intrinsic properties.

1. b) Answer the following keeping that definition in mind. If I use a small piece of clay, the mass and the volume will be small. If I use a large piece of clay, the mass and volume will be large. What result should I expect if I compare the densities of clay for both a small and large piece of clay?

2. You will be making a graph as part of the postlab for this experiment. If you plot the mass on the y-axis and the volume on the x-axis, what property of matter will correspond to the slope of your graph?

3. Determine the density using the following data:

|  |  |
| --- | --- |
| Volume water in graduated cylinder before adding solid substance X | 15.25 mL |
| Mass solid substance X | 13.85 g |
| Volume water in graduated cylinder after adding solid substance X | 24.10 mL |

**III Procedure:**

**Part 1 – Density of water – make sure to follow sig figs!**

1. Find the mass of the empty graduated cylinder and record on the data table in each row for that column.

2. Put 10 mL of water in the graduated cylinder and find the mass of the water plus cylinder. Record in the data table.

3. Add enough water to fill to 20mL and determine the mass with 20 mL of water.

4. Repeat the process for the following volumes of water: 30 mL, 40 mL, 55 mL, 60 mL, 75 mL, 90 mL, and 100mL.

5. Calculate the mass of the water for each trial and record in the data table.

6. Calculate the density for each trial and record in the data table.

We will be plotting your individual data using a spreadsheet program called Excel and analyzing the data from it.

**Data Table – Part 1 – water**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Volume of Water (mL)** | **Mass empty Grad Cyl (g)** | **Mass Grad Cyl and water** | **Sum of water mass ALONE** | **Density** |
| 10.0 |  |  |  |  |
| 20.0 |  |  |  |  |
| 30.0 |  |  |  |  |
| 40.0 |  |  |  |  |
| 55.0 |  |  |  |  |
| 60.0 |  |  |  |  |
| 75.0 |  |  |  |  |
| 90.0 |  |  |  |  |
| 100.0 |  |  |  |  |

**Part 2 – Density of modeling clay**

1. Get a piece of modeling clay from your teacher.

2. Divide the modeling clay into five different size pieces. Try to aim for pieces at least as large as a blueberry.

3. Find the mass of the first piece and record in the data table

4. Find an appropriate graduated cylinder.

5. Fill the graduated cylinder about half full with water and record the initial volume.

6. Put the piece of clay in the graduated cylinder and make sure to get as many of the bubbles out as you can. Record the volume after the clay has been added. This is called volume by displacement.

7. Remove the piece of clay.

8. Repeat steps 3-7 for the next four pieces of clay.

9. Calculate the density for each trial and record in the data table.

We will be using Excel to analyze this data as well.

**Data Table – Part 2 – Clay**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sample** | **Mass of Clay** | **Initial Volume in Grad. Cyl.** | **Finial Volume in Grad. Cyl.** | **Volume of Clay alone** | **Density of Clay** |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |
| 5 |  |  |  |  |  |

**IV. Data Analysis**

1. Open your spreadsheet program and put the following data into cell A1 “Mass of water alone”; B1 “Volume of water” and C1 “Density of water”. Adjust the widths of the column as necessary or use Wrap Text so the titles of each column are available. Repeat the same process in cell E1 “Mass of Clay”; F1 “Volume of Clay alone” and G1 “Density of Clay”

2. Enter the data you have for the mass and volume of water and the mass and volume of clay. Do not enter the data for the density of water or clay.

3. We are going to use Excel to calculate the density of both water and clay. To do this, you need to tell Excel what you want to calculate. The instructions follow, but watch as your teacher shows it on the overhead.

 a) In cell C2 type “**=A2/B2**”. (You MUST type the ‘=’ sign!!!)This tells Excel to divide your A2 mass by your B2 volume.

 b) Click on cell C2 – you should see a small square in the bottom right corner. Grab that square and drag it down to cell C10. This will populate each of the cells C3-C10 with the same calculation.

 c) Repeat the process in cell G2 “=E1/F1”. Then drag the square down to cell G6.

4. Now we are going to make graphs of your data and analyze them as a whole. To make a graph in Excel, follow the instructions from your teacher, but the steps follow.

 a) Highlight the cells A2 through A10 and B2 through B10. Click on Insert – Scatter Plot (with just dots)

 b) Your graph should appear with the mass plotted on the y-axis and the volume plotted on the x-axis for the water data.

 c) Repeat the process with the clay and create a new graph. Highlight cells E2 through E6 and F2 through F6. Insert Scatter Plot.

5. You will need to label your axes and give your chart a title. To do this for each graph, follow the steps below.

 a) Click on the chart you would like to label and near the top menu you should see “Chart Tools”. Click on Layout and you will see options to make a Chart Title (pick the above chart version); Axis Labels (Horizontal – pick below chart; Vertical – pick rotated title). Label the chart and axes for both graphs you have made.

6. One last thing that Excel can do for you. It is capable of find the best fit line through your data and giving you the equation for that line in y=mx+b format. To do this,

 a) Click on any of the data points in your chart.

 b) While they are highlighted, right click and pick “Add Trendline”

 c) A window will pop up with options regarding the trendline. Pick a linear equation and then at the bottom, click display equation on chart and display R2 value. Excel will then plot the best fit line through the data (the trendline) and give you the equation for it (where the slope is the best fit density).

 d) Repeat the process for the other chart.

**IV. Postlab Questions** – Answer the following questions using readable writing in your lab report and attach the data tables and graphs from Excel to your Word doc.

1. Calculate an average value of the density of the water and of the clay based on your data alone. Show your work using Equation Editor (Insert Equation – use fraction).

2. Using the slope of the line provided by Excel, how close was your average value of the density for both the clay and the water to the value provided by Excel. Use numbers in your comparisons.

 3. Looking back at your calculations of density for the clay, did the size of your chunk of clay affect the value of the density greatly? Should the size of the clay affect the value of the density? Explain why or why not.

4. When determining the line of best fit, the line should go through the origin (0, 0). (It may not because Excel is not as knowledgeable as you are.) If the line of best fit should go through the origin, what does that imply about the values for mass, volume and density of your two substances at the origin?

5. The accepted value for the density of modeling clay is 1.50 g/mL. Using the equation below, determine your percent error. Was your data accurate or precise (or both or neither)?

$$\% error= \frac{(accepted value-your average value)}{accepted value} x 100$$

6. Hypothesize as to two possible errors that would have led to a density of clay other than 1.50 g/mL. Again, please do not waste my time and yours talking about a miscalculation or reading the measurements incorrectly. Discuss two errors that could have led to an increased or decreased mass or an increased or decreased volume based on the procedure you used.

7. Attach your data tables and graphs. Your graph should have:

 a) labeled axes with units AND TITLE

 b) two lines of best fit – one for water and one for clay.

 c) equations for lines of best fit (trendlines) and r2 values.