Nailing Down Density

Name _____

Class _____

In this activity, you will explore the following:

- *How do mass and volume relate to density?*
- *Is there a relationship between mass and density?*

You will determine the mass and volume of five nails. You will then calculate the density of each nail, and graph the mass and volume of each nail. You will determine the slope of the regression line for the graph and compare it to the calculated density.

Density is defined as the mass per unit volume of a substance. The formula for density is:

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

where *D* is density, *m* is mass, and *V* is volume. The units of density are commonly g/mL or g/cm^3 for solids and liquids. For gases, the density is often expressed in g/L since gases are much less dense than solids or liquids. Density is an intensive property that is **not** dependent on the amount of the substance that is measured.

Mass is measured using a balance. Volume can be calculated if the object is a regularly shaped object. For irregularly shaped solids, water displacement is used to determine the volume. The volume of water is measured before and after the irregular solid is added to the graduated cylinder. The difference in volume is the volume of the object. Knowing the mass and the volume, the density can be calculated using the density formula.

Problem 1 – Preliminary Questions

Step 1: Open the file **02-Nailing_Down_Density.tns**. Students should answer the questions on pages 1–6.

Q1. Density is defined as _____.

o volume per unit mass

o mass per unit volume

o the heaviness of an object

Q2. The density of gases is often expressed in _____.

o g/mL

o g/cm^3

o g/L

o L/g

Q3. The volume of an irregular object is most easily determined by _____.

o using the formula $V = LWH$

o using the formula $V = (4/3)\pi r^3$

o using the formula $V = \pi r^2 h$

o water displacement

Q4. Which is heavier: one kilogram of feathers or one kilogram of lead?

o lead

o feathers

o neither

Q5. Explain your answer to the previous question.

Q6. Which of the following is NOT true of the density of a substance?

o Density is an intensive property.

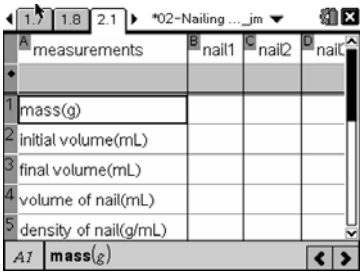
o Density is an extensive property.

o Density is a characteristic or identifying property.

o Density is temperature dependent.

Problem 2 – Mass and Volume of Nails

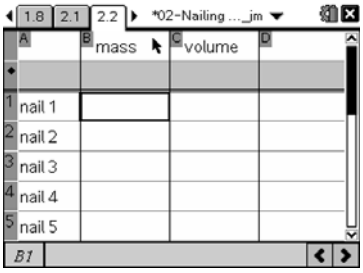
Step 1: Obtain five different nails. Measure the mass of each to the nearest 0.01 g, and record the masses in the *List & Spreadsheet* application on page 2.1.



Step 2: Half-fill a 10 mL graduated cylinder with water. Read the initial volume to the nearest 0.1 mL. Record the volume on page 2.1 for Nail 1. Then, tilt the graduated cylinder and place the nail into the graduated cylinder so that it slides gently headfirst into the water. Make sure that the nail is completely submerged. If it is not, dump the nail out and put a little more water in the graduated cylinder. Measure the final volume of the water and record it in the spreadsheet.

Step 3: Repeat Step 3 for the four remaining nails.

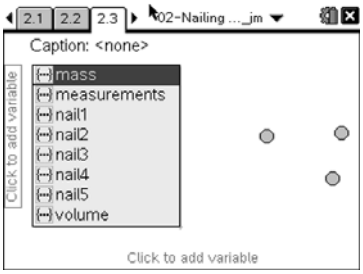
Step 4: Calculate the volume of the first nail by subtracting the initial volume from the final volume using cell notation (**=b3-b2**). Repeat for the four remaining nails.



Step 5: Calculate the density of the first nail by dividing the mass of the nail by its volume using cell notation (**=b1/b4**). Repeat for the remaining four nails.

Step 6: Record the mass and volume of each of the five nails in the spreadsheet on page 2.2.

Step 7: On page 2.3, move the cursor to the left-hand side of the graph and click to choose “mass” as the variable. Next, move the cursor to the bottom and click to choose “volume” as the variable.



Step 8: Determine the best-fit line for the nail's volume and mass relationship using the **Regression** tool (**Menu > Analyze > Regression > Show Linear (mx + b)**.

Step 9: Answer questions 7–19.

Q7. What is the regression equation for your graph?

Q8. What is the slope of the line?

Q9. What would the units of the slope be?

Q10. The formula for density is $D = m/V$, where D is density, m is mass, and V is volume. Rearrange the formula for density by isolating mass instead of density.

Q11. Rewrite the regression equation from the *Data & Statistics* page by replacing the "x" variable with V for volume and the "y" variable with m for mass.

Q12. How does the rearranged $D = m/V$ equation compare to the equation you wrote in the previous question? Explain.

Q13. What does the slope of the graph on the *Data & Statistics* page represent?

Q14. What unit(s) would be assigned to the slope of this graph?

Q15. Use the Internet to go to http://www.engineeringtoolbox.com/metal-alloys-densities-d_50.html to identify the element whose properties would match the density that was calculated for the nail. Remember that 1 $kg/m^3 = 0.001\ g/cm^3$ and that $1\ cm^3 = 1\ mL$.

Q16. Refer to the data that were collected; what effect does changing the size (mass) of the nail have on the volume of the nail?

Q17. What mathematical relationship exists between the mass and volume of the nail?

Q18. From your data, how does changing the volume affect the density of the nail? Explain.

Q19. Summarize what you have learned about density from this experiment.