Nailing Down Density – ID: 16147

By Texas Instruments

TEACHER GUIDE

Time required
45 minutes

Topic: Physical Properties

- *Measure mass and volume.*
- *Calculate density using mass and volume.*

Activity Overview

In this activity, students will explore the relationship between mass, volume, and density. Students will determine the mass and volume of five nails as well as calculate the density of those nails. They will graph the mass and volume of each nail and then compare the slope of the graph to the calculated density of the nails.

Materials

To complete this activity, each student will require the following:

- *TI-Nspire™ technology*
- *five nails of various sizes*
- *10 mL graduated cylinder*
- *centigram balance*
- *copy of student worksheet*
- *pen or pencil*

TI-Nspire Applications

Graphs & Geometry, Lists & Spreadsheet, Notes, Calculator

Teacher Preparation

Students should be familiar with how to measure mass and volume accurately, and the relationship between mass, volume, and density. This will help students set up the equation describing density.

- *Students will need a source of water in order to make their volume measurements.*
- *The screenshots on pages 2–5 demonstrate expected student results.*
- ***To download the .tns file, go to education.ti.com/exchange and enter "16147" in the search box.***

Classroom Management

- *This activity is designed to be **student-centered**, with the teacher acting as a facilitator while students work cooperatively. The student worksheet guides students through the main steps of the activity and includes questions to guide their exploration. Students may record their answers to the questions on blank paper or answer in the .tns file using the Notes application.*
- *The ideas contained in the following pages are intended to provide a framework as to how the activity will progress. Suggestions are also provided to help ensure that the objectives for this activity are met.*
- *In some cases, these instructions are specific to those students using TI-Nspire handheld devices, but the activity can easily be done using TI-Nspire computer software.*

The following questions will guide student exploration during this activity:

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

Students will measure the mass of five nails and then determine the volume of each nail using a water submersion method. They will calculate the density of each nail using mass and volume. They will then graph the mass and volume of each nail. Finally, they will determine the slope of the regression line for the graph and compare it to the calculated density of the nails.

Problem 1 – Preliminary Questions

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

Q1. Density is defined as _____.

A. *mass per unit volume*

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

A. *g/L*

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

A. *water displacement*

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

A. *neither*

Q5. Explain your answer to the previous question.

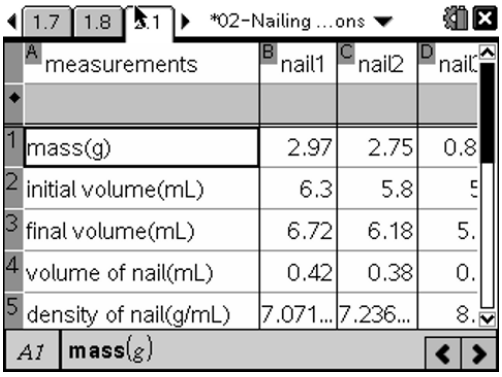
A. *Sample answer: Neither one kilogram of feathers nor one kilogram of lead is heavier; their masses are both equal to one kilogram. However, the lead has a much greater density, since the volume of one kilogram of lead would be much less than the volume of one kilogram of feathers.*

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

A. *Density is an extensive property.*

Problem 2 – Mass and Volume of Nails

Step 1: Students should obtain five different nails. They should measure the mass of each to the nearest 0.01 g and record the mass in the *Lists & Spreadsheet* application on page 2.1.



Step 2: Students will use water displacement to determine the volume of each nail. They should record the volumes on page 2.1.

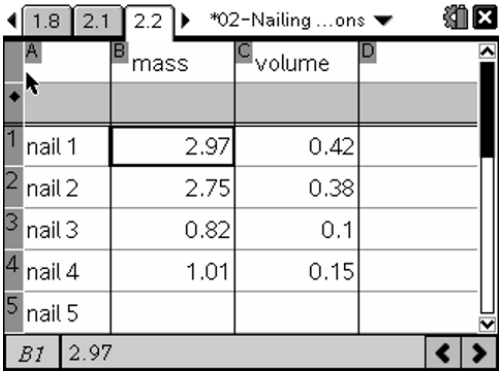
Step 3: Students will repeat for the four remaining nails.

Step 4: Students will calculate the volume of the first nail by subtracting the initial volume from the final volume using cell notation (**=b3-b2**), and repeat for the four remaining nails.

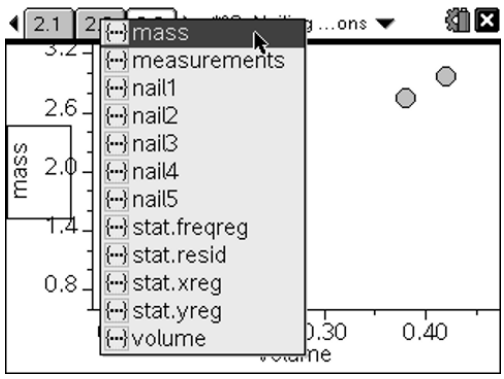
Step 5: Students will calculate the density of the first nail by dividing the mass of the nail by its volume using cell notation (**=b1/b4**), and repeat for the remaining four nails.

TI-Nspire Navigator Opportunity: *Live Presenter*
Live Presenter can be used here to display the data in the spreadsheet on page 2.1 to the entire class. Students should compare the measured and calculated values with their own. If any student data vary significantly from the live presenter's data, allow students to discuss what might account for this discrepancy. Then, have the class observe the calculated density for each nail. Pose the following question: why might the calculated densities be so similar among the nails despite the fact that each nail has a different mass and volume?

Step 6: They will then record the mass and volume of each nail in the *Lists & Spreadsheet* application on page 2.2.

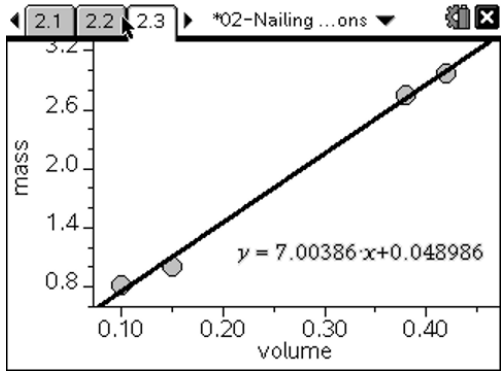


Step 7: In the *Data & Statistics* application on page 2.3, students will move the cursor to the left-hand side and click to choose mass as the variable. Then, they will move the cursor to the bottom and click to choose volume as the variable.



Step 8: Students should 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: Students should then answer questions 7–19.



Q7. What is the regression equation for your graph?

A. *y = 7.00x + 0.05*

Q8. What is the slope of the line?

A. *7*

Q9. What would the units of the slope be?

A. *g/mL*

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

A. *m = DV*

Q11. Rewrite the regression equation from page 2.11, replacing the "x" variable with *V* for volume and the "y" variable with *m* for mass.

A. *m = 7.00V + 0.05*

Q12. How does the rearranged density equation compare to the equation you wrote in question 11? Explain.

A. *The equations are the same because mass is graphed on the y-axis and volume on the x-axis and the relationship is linear.*

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

A. *The density of the nail*

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

A. *g/mL or g/cm^3*

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.**

A. *iron—7.85 g/mL*

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

A. *As the size (mass) of the nail increases, so does the volume.*

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

A. *linear*

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

A. *The density does not change because density is an intensive property. As the volume increases, the mass increases proportionately*.

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

A. *Sample answer: The density of a substance is a constant and only varies with changes in temperature. Density is an intensive property that is characteristic of a substance. Density can be used to identify a substance.*