Target Density Lab

Density Inquiry Lab Activities

Introduction

The concept of density is reinforced as students measure the volume and mass of an unknown liquid in a graduated cylinder, graph the results, and predict the mass of the empty cylinder from their data. See how carefully students collect data and analyze their graphs when their grades depend on the accuracy of their predictions!

Concepts

- Density
- Graphing skills
- Making predictions
- Mass and volume

Materials

For each student group

Liquid A (e.g., 50% salt solution), 100 mL

Liquid B (density less than Liquid A), 100 mL

Graduated cylinder, 100-mL

Medicine cups, 30-mL, 2

Paper towels

Pipets, Beral-type, 2

Ruler

To be shared

Balance, electronic, 0.01-g precision, 3

Computer with spreadsheet program (optional)

Computer printer (optional)

Flasks, Erlenmeyer, 500-mL, 6

Stoppers, solid, to fit flasks, 6

For teacher preparation

Clay, modeling or putty

Food coloring, 2 different colors

Safety Precautions

Hazards in this activity depend on the solutions used. Even if using salt water and distilled water, it is good practice to have students wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information for chosen solutions.

Preparation

1. Prepare enough of Liquid A and Liquid B for 100 mL for each lab group.
2. Add different colors of food coloring to each liquid for easy identification and for better visibility when reading volume measurements.
3. Dispense Liquid A into three 500-mL flasks to be shared by student groups. Stopper and label each flask "A."
4. Repeat step 3 with Liquid B.
5. Place a small amount of modeling clay or putty on the base of one graduated cylinder.
6. Place a slightly different amount of clay on each of the remaining cylinders. This prevents students from comparing predictions.
7. Place three electronic balances at a central location or main desk. *Note:* Each group will be assigned one of the three balances, and will continue to use the same balance throughout the lab.

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8. Copy enough Target Density Lab Worksheets for each student.

Disposal

Disposal will depend on the solutions used. Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste.

Tips

- This lab may be conducted after students have had some experience with the concept of density.
- To prevent excess wait time, the instructor should stay by the main desk with the balances. If a group has a question, a representative may approach the teacher.
- More balances may be used if available; however, three usually prevent any significant back-up.
- Students actually have three targets in this activity.

1) Mass of the empty cylinder

2) Mass of the cylinder with x amount of solution

3) Volume of liquid needed for a total mass (solution + liquid) of x grams

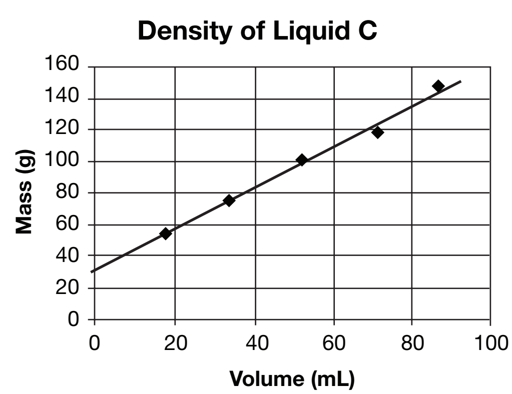
Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter

Answers to Worksheet Questions

Volume of Liquid C (mL)	Mass of Liquid C & Cylinder (g)
17.5	52.73
33.7	74.60
52.1	99.43
71.1	116.72
86.4	145.78



Post-Lab Questions

1. Circle the data point in the table above that must have been read incorrectly.
2. Using your best fit line, determine the mass of the empty graduated cylinder.

   30 g
3. What volume of liquid C must be added to the cylinder to give a total mass of 85.0 g?

   45 mL
4. What is the density of liquid C?

   1.35 g/mL
5. Liquid D is more dense than C. Draw in what its line would look like on the graph above (using the same cylinder).

   Note: Any line that has the same y-intercept as liquid C and has a steeper slope than C is acceptable.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Target Density Lab* activity, presented by Bob Becker, is available in *Density Inquiry Lab Activities* and in *Bob Becker Target Labs*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Target Density Lab* are available from Flinn Scientific, Inc.

Catalog No.	Description
V0003	Food Coloring Dyes
OB2141	FlinnScientific Electronic Balance, 0.01 g
AP5442	Polypropylene Medicine Cups, Pkg/100
GP2020	Cylinder, 100 mL
GP9145	Flask, Erlenmeyer, Ecomony Choice, 500 mL
AP1721	Beryl-type Pipets, Graduated
FB0600	Modeling Clay
AP4685	Ruler, Metric/English, Transparent

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

Target Density Lab Worksheet

In this lab, you are going to have some fun with density! You will collect data for the mass and volume of a liquid and graph the results. You will then learn how that graph can help you make accurate predictions. But be very careful with your data collecting and your graph analysis—your grade depends on it!

Procedure

Important: Use the same graduated cylinder and balance throughout the lab.

1. Pour 15-20 mL of liquid A (red) into the small cup (between the lines). Then transfer this liquid into the graduated cylinder; record the precise volume in Data Table A.
2. Weigh the cylinder and liquid on one of the balances at the front of the room. Record this mass in the data table.
3. Repeat steps 1 and 2 four more times, for a total of five volume and mass readings, each time adding more liquid to the cylinder.
4. When you have finished five trials, pour liquid A back into the flask from which it came.
5. Recopy your data onto the spreadsheet on the computer. It is set up to graph the data points for you. Then print out your graph (2 copies, one for you and one for your partner) and use a ruler to carefully draw a best fit straight line for the five points. (Ignore any obvious outliers.) Extend this line across the entire graph grid. Then use your best fit line to make the following predictions.

A. Predict how much the empty graduated cylinder weighs

6. Record your prediction in Part A below (include the units). *Hint:* On your best fit line, this should be the mass that corresponds with a volume of 0 mL. This is called the *y*-intercept (the point where the line meets the *y*-axis, see Figure 1). Be as precise and accurate as you can. Your grade is based on how close your prediction is to the actual mass (See Scoring Table below).
7. Once you have written down your prediction in the space below, dry out your graduated cylinder and hand it (and this sheet) to your instructor. He/she will weigh it (on the same balance you have been using), and then record the actual mass and your score.

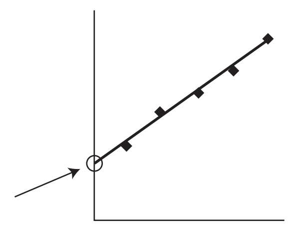


Figure 1.

B. Predict how much the cylinder will weigh with 50.0 mL of liquid A in it

8. Record your prediction in Part B below (include the units). *Hint:* This too can be determined from your best fit line, just see what mass corresponds with a volume of 50.0 mL.
9. Once you have written down your prediction in the space below, pour precisely 50.0 mL of liquid A into the cylinder and hand it (along with this sheet) to your instructor, He/she will weigh it, and then record the actual mass and your score.

C. Predict what volume of liquid A must be added to the cylinder to give a total mass of 95.00 g

10. Record your prediction in Part C below (include the units). *Hint:* This can also be determined from your best fit line, just see what volume corresponds with a mass of 95.00 g.
11. Add precisely this much liquid A to the cylinder then hand it to your instructor. He/she will weigh it and then record the actual mass and your score.
12. Rinse out and dry out your cylinder.
13. Repeat steps 1–4 using liquid B (blue) instead. Record the volume and mass in Data Table B. *Note:* Only repeat steps 1–4.
14. Plot these points (by hand) on the same graph you use for liquid A. Draw a separate best fit line for these data points.

D. Determine the density of liquids A and B

15. To determine the density of liquid A, you must understand what the "slope" of a line is. Slope is defined as how much a line goes up divided by how far it goes over. This is sometimes called "rise over run," and for a graph it is defined as the change in *y*-value divided by the change in *x*-value. Since our graph has mass plotted on the *y*-axis and volume plotted on the *x*-axis, the slope will be the change in mass divided by the change in volume. Mass divided by volume is density, so once

you have found the slope, you've found the density! And finding the slope of a line is actually very easy. Let's start with the best fit line for liquid A.

a) Pick any two points on the line for liquid A. Don't use your data points; just use any points on the best-fit line. Try to use points that are pretty far apart and that are easy to read.

b) Record the volume and mass for the higher point in Data Table C, V_{higher} m_{higher}.

c) Record the volume and mass for the lower point, V_{lower} m_{lower}.

d) Subtract the volumes ($V_{higher} - V_{lower}$) to get the change in volume, ΔV.

e) Subtract the masses ($m_{higher} - m_{lower}$) to get the change in mass (Δm) and record this value.

f) Divide: This is the slope of the line, and it is also the density of liquid A, Δm/ΔV. Record the density of liquid A.

16. Repeat steps 15a–f, using the best fit line for liquid B. Record results in Data Table D.
17. Now ask the instructor to show you how to have the best fit line and its y-intercept and slope show up on the graph on the computer spreadsheet. How do your values compare to the ones this computer gives?

Scoring Table

Within	Score
0.5 g	5.0 points
1.0 g	4.5 points
2.0 g	4.0 points
3.0 g	3.5 points
5.0 g	3.0 points
10 g	2.0 points
You tried	1.0 point

Part A
Data Table A, Liquid A

Trial	Volume (mL)	Mass (g)
1		
2		
3		
4		
5		

Prediction of mass of empty graduated cylinder ___________

Actual mass of empty graduated cylinder _________ Your score _________

Part B

Prediction of mass of graduated cylinder and 50.0 mL of liquid A __________

Actual mass of graduated cylinder and 50.0 mL of liquid A _________ Your score _________

Part C

Predicted volume of liquid A added for a total mass of 95.00 g _______

Actual mass of cylinder and liquid A __________ Your score _________

Data Table B, Liquid B

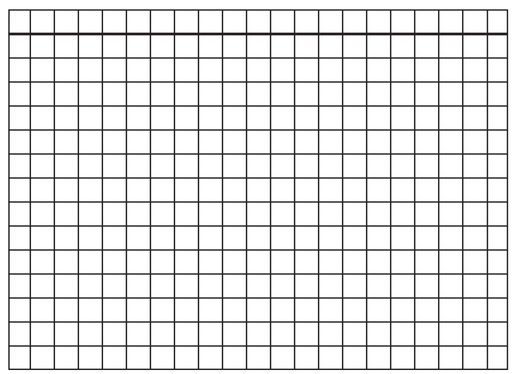
Trial	Volume (mL)	Mass (g)
1		
2		
3		
4		
5		

Part D
Data Table C

	V_{higher} (mL)	m_{higher} (g)	V_{lower} (mL)	m_{lower} (g)	ΔV (mL)	Δm (g)	Density $\Delta m/\Delta V$
Liquid A							
Liquid B							

Plot the following data on the graph below, (you will need to increment and label the axes), and then draw a best-fit line. Give a title to your graph. Use the graph to answer the *Post-Lab Questions*.

Volume of Liquid C (mL)	Mass of Liquid C & Cylinder (g)
17.5	52.73
33.7	74.60
52.1	99.43
71.1	116.72
86.4	145.78



Post-Lab Questions

1. Circle the data point in the table above that must have been read incorrectly.

2. Using your best fit line, determine the mass of the empty graduated cylinder.

3. What volume of liquid C must be added to the cylinder to give a total mass of 85.0 g?

4. What is the density of liquid C?

5. Liquid D is more dense than C. Draw in what its line would look like on the graph above (using the same cylinder).