EXPLORING THE RELATIONSHIP BETWEEN MASS AND VOLUME WITH THE TI-NSPIRE

Discussion:

Density is defined as the mass of a substance per unit volume of the substance. Density is often measure in g/mL or g/cm^3 for solids and liquids and in g/L for gases. The density of a substance is considered to be an identifying physical property. Each substance has its own unique density, therefore substances can be often be identified by determining their density. The density of a substance is calculated by dividing the mass by the volume using the formula:

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

Objective:

In this activity the student will use the List and Spreadsheet, Graphs and Geometry, and Calculator applications to analyze the relationship between mass and volume. The student will use the following functions:

1. enter data into lists
2. name lists
3. use formulas to populate data
4. determine regression equations
5. graph data
6. plot regression lines
7. use the calculator application

Procedure:

Part I:

A. Turn on the TI-Nspire and choose the ⌂ on the upper right. Choose New Document. If asked to save a document, choose No. Choose Lists and Spreadsheets. When the spreadsheet opens, choose the (menu) on the upper right, choose Actions and choose Resize. Press the ▶ on the NavPad twice to make the first column wider. When the column is the desired width, press (enter) and then ↰. Repeat for the next two columns.
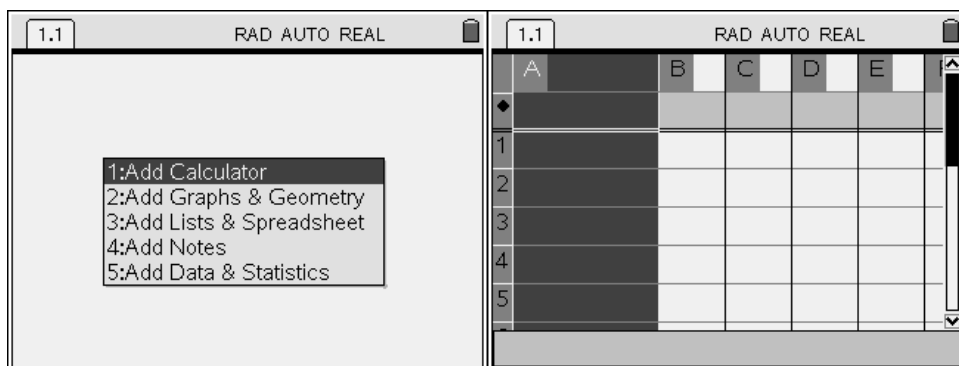
B. Move the cursor into the heading space of Column A and type in volume as the List name and press ⏎. Type in mass as the List name for Column B. Press ⏎. Type in density as the List name for Column C and press ⏎.
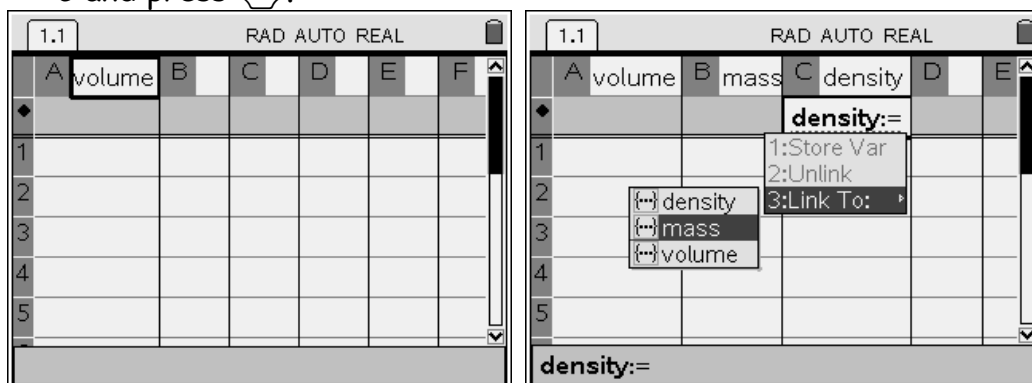
C. The mass and volumes of several pieces of a silvery metal were determined in the laboratory at 25.0 °C are given in the table below. In Column A, enter the volume readings from the table below. In Column B, enter the mass values.

Volume (mL)	Mass (g)	Density (g/mL)
10.0	27.0	
20.0	54.0	
30.0	81.0	
40.0	108.0	
50.0	135.0	

D. To complete Column C (density), it is necessary to create a formula in Column C that divides the mass in Column B by the volume in Column A (See the screen capture above). Move the cursor to the formula cell (**in gray**) in Column C and press ⊜. Then press the (stoVar) key and Link to the mass variable and press ⏎. Press the (÷). Then press the (stoVar)

key and Link to the volume variable and press ⬡(enter) . Press ⬡(enter) to populate the column. Copy the calculated density values into the table above. How do the density values compare to each other?   Why?

E. We can analyze the relationship between mass and volume to determine if it is, in fact, linear by calculating the regression data.

Linear Regression (mx+b)	
X List:	volume ▽
Y List:	mass ▽
Save RegEqn to:	f1 ▽
Frequency List:	1 ▽
Category List:	▽
	OK Cancel

1.1	RAD AUTO REAL

|	B mass	C density	D	E
◆		='mass/vol		=LinRegN
1	27.	2.7	Title	Linear ...
2	54.	2.7	RegEqn	m*x+b
3	81.	2.7	m	2.7
4	108.	2.7	b	0.
5	135.	2.7	r²	1.

F. To perform a regression, select Stat Calculations from the Statistics menu. Since the relationship between mass and volume should be linear, we choose to perform a Linear Regression (y = mx + b). For the X-list, press the NavPad ▾ and choose mass by pressing ⬡(enter). (tab) down to the Y-list and use the NavPad ▾ key to choose volume by pressing ⬡(enter). (tab) further to 1st Result Column, choose the letter D, and press ⬡(enter) to populate Columns D and E with the Linear Regression Data. Record the Regression data with appropriate **units** below:

m=_____

b=_____

r=_____

G. The correlation coefficient (r) for the data is an absolute value of 1, so the data appears to be linear. To graph the data with the regression function, it is necessary to insert the Graphs and Geometry application. Press the (ctrl) key and the letter (i) to insert a new Graphs and Geometry page.

H. Draw a scatter plot of mass vs volume, choose Menu, Graph Type, Scatter Plot. Press ⬡(enter) to choose the x variable which is mass and press ⬡(enter). Press Tab, then press ⬡(enter) to choose the Y-variable (select volume). Adust the window by pressing Menu, Window, Zoom-9. The scatterplot will be displayed. Make a sketch of the graph with axes labeled and proper units included in the space below.
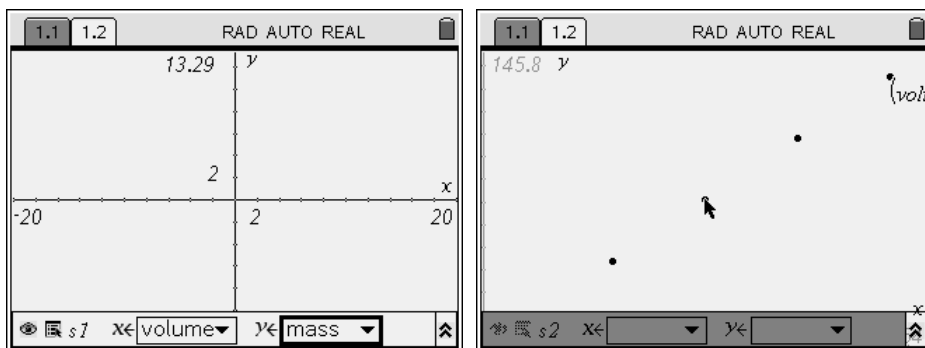
I. To plot the regression equation, press Menu, Graph Type, and function. Press the ▲ on the NavPad to access f1(x), and press (enter) to draws its graph. The regression line passes through each of the points, further indicating the linearity of the relationship.

J. In order to determine if changing either the mass or the volume changes the density value, choose (menu), Trace, and Graph Trace. Move to three points along the regression line. Choose points at approximately one third, one half, and two thirds along the regression line. Write down the data pairs for each point in the data table below:

Data Pair	Volume (mL)	Mass (g)	Density (g/mL)
1			
2			
3			

K. To calculate density values for other pairs of data, it is necessary to use the Calculator application. Press the (ctrl) key and the letter (i) to insert a new Calculator page.

L. On the Calculator page, calculate the density of each of the pairs above. Write the density value calculated in the data table above.

Part II

A. The data below is for a liquid determined **at 25.0 °C**. Repeat the process of calculating density for the following data:

Volume (mL)	Mass (g)	Density (g/mL)
10.0	9.97	

20.0	19.94	
30.0	24.91	
40.0	39.88	
50.0	49.85	

B. What do you expect to happen to the data in the linked columns when this new data is entered? Why does this change occur?

C. Fill in the data table above with the appropriate data from the Lists and Spreadsheets application.

D. Make a sketch of the graph with axes labeled and proper units included. Record the regression statistics with **appropriate units** below:

      m=_____

      b=_____

      r=_____

E. In order to determine if changing either the mass or the volume changes the density value, choose b, Trace, and Graph Trace. Move to three points along the regression line. Choose points at approximately one third, one half, and two thirds along the regression line. Write down the data pairs for each point in the data table below:

Data Pair	Volume (mL)	Mass (g)	Density (g/mL)
1			
2			
3			

F. To calculate density values for other pairs of data, it is necessary to use the Calculator application. Press the (ctrl) key and the letter ⓘ to insert a new Calculator page.

G. On the Calculator page, calculate the density of each of the pairs above. Write the density value calculated in the data table above.

Questions:

1. What was true of the y-intercept (b) in Part I? Explain
2. What was true of the y-intercept (b) in Part II? Explain.
3. What were true of the density values calculated from the traced data pairs in Part I?
4. What were true of the density values calculated from the traced data pairs in Part II?
5. Does the density of a given substance change if the mass of the substance changes? Explain.

6. Does the density of a given substance change if the volume of the substance changes? Explain.
7. In your own words, explain why density allows scientists to identify substances.
8. After consulting density values from a reference book or the Internet, what is the identity of the silvery metal in Part I?
9. What is the identity of the liquid in Part II?

Self-Evaluation:
You will be expected to master the skills taught in this exercise in order to complete homework problems. Final evaluation will be the use of those skills to solve similar problems on the Measurements and Calculations Unit Test. Evaluate your mastery of these skills for Part II of this exercise.

Skill	Complete activity without referring to instructions (3 points)	Complete activity with reference to instructions (2 points)	Complete activity with teacher assistance (1 point)
Enter data into lists			
Name lists			
Use formulas to populate data			
Determine regression equations			
Graph data			
Plot regression equations			
Use the calculator application			