

## Activity

### Graphical Analysis with Logger Pro

#### Purpose

Vernier's Logger Pro<sup>®</sup> is a graphical analysis software that will allow you to collect, graph and manipulate data. This lab will give you some practice using the program, especially since you will use it many times in your chemistry courses.

#### Part 1: Linear Regression, Dependent and Independent Variables

Linear regression analyzes how well two variables are related to each other by fitting a linear equation to the data.

Sample data below show how the mass changes with volume of an unknown metal.

**Table 1.** Volume and mass measurements of an unknown metal

Volume (ml)	Mass (g)
2.00	5.100
3.10	8.900
4.00	10.900
5.30	13.800

Here, the volume is displayed as the independent variable (assigned x-values) since the volume was manipulated approximately every 1 mL. The mass is the dependent variable (assigned y-values) since mass was recorded in response to the change in volumes.

#### Part 2: The Equation of a Line

If there is a linear relationship between volume and mass, a graph will show that the data points look like they connect in a straight line (or nearly so).

You can draw a straight line through the data, not by connecting the points, but by approximating a line that passes as near to as many of the points as possible. This is called a "best-fit" line. The line doesn't necessarily pass through any of the plotted points but it allows you to visualize the "scatter" in the data.

The equation of any straight line is:

$$y = mx + b \quad (1)$$

Where  $y$  is the y-axis,  $x$  is the x-axis,  $m$  is the slope and  $b$  is the y-intercept (where the line crosses the y-axis).

According to Table 1, you will graph grams as  $y$  and milliliters as  $x$ , so that equation 1 above becomes

$$g = m * mL \quad (2)$$

Rearranging (2) gives us the meaning of the slope:

$$m = g/mL \quad (3)$$


(slope,  $m$ , equals density given in g/mL)

In this case, the slope has a physical meaning. We can use the value of the slope as the density of the metal (Eqn 3) which will allow us to identify it later.

Instead of drawing in the line by "eye", Logger Pro will find the best-fit line using a least-squares method (from statistics). You will also obtain the equation of the best-fit line as well as a correlation coefficient ( $R^2$ ) which gives you a value of 1 if the data perfectly fits a straight line.

**Part 3: Graphing in Logger Pro**

THE FOLLOWING PROCEDURE IS FOR LOGGER PRO.

1. Open Logger Pro. An empty table and empty graph will be displayed.
2. Enter the data given in Table 1.
3. We don't want the points connected. Click on the graph to select it, then choose the **Options** menu then **Graph Options**. Deselect "connect points" and select "point protectors". While you're here, give the graph a title: *Determining the density of an unknown metal*. Click done.
4. It is important to use significant figures (as shown in Table 1) and to label our axes with units. Right-click on the x-column and select **Column Options** and **Data Set | X**. Use the **Column Definition tab** to type in a name, short name, and units for the X-column. Then select the **Options tab** and under "displayed precision" select decimal places. Select the number of decimal places that should be displayed for your x-values (2 in this case). Click done. Repeat for y-values. When finished, check the table for significant figures. Check the graph for axes labels and correct units.
5. To perform the linear regression analysis, choose the Analyze menu then Linear Fit, or click the short-cut button . A best-fit line will appear with the equation of the best-fit line.
6. Print a copy of the graph for EACH person in your group. Before you do, choose File>Page Setup>Orientation:Landscape. Click OK. Then click File>Print. Check Print Footer and type in your name. Click OK.

**Part 4: More graphing**

Below is another set of data for you to try graphing. Follow the directions in Part 3 to graph these data. Then obtain an equation that relates Celsius to Fahrenheit. Don't forget to print enough copies for everyone in your group.

**Table 2.** Temperature readings in units of Celsius and the corresponding measurement in Fahrenheit.

Temperature (°C)	Temperature (°F)
0.0	37.0
10.1	47.0
20.0	71.5
30.2	88.4
40.0	101.2
50.1	125.0

## Activity 2 Graphical Analysis with Logger Pro

**Activity 2 Turn-in Sheets**Graphical Analysis with Logger Pro**Follow-up Questions****Using your density graph (from Part 3):**

1) Using your graph and without doing any calculations, show on the front of your graph how you can estimate the volume for a 4.50-g mass of this unknown metal. (Do this by drawing a line from 4.50-g on the y-axis to the best-fit line, then from that point on the line to the x-axis.)

What is your estimated value for volume? \_\_\_\_\_ mL

2) What is the equation of the line you obtained? Write it out in the form  $y=mx+b$ .

How good is the correlation (Give a value from -1 to 1, shown on your graph)?

3) Using the equation displayed on your graph, calculate the volume for a 4.50-g mass of the unknown metal. Show your work below.

4) Use the table below to identify the metal based on the information obtained from your graph. Explain how you chose the metal's identity.

Substance	Density (g/mL)
Magnesium	1.74
Aluminum	2.70
Titanium	4.50
Iron	7.86
Copper	8.93
Gold	19.32

5) How does your metal's density compare to that in the table above? Scientists usually calculate a % error to compare their values with standard values.

$$\% \text{ error} = \left| \frac{\text{experimental} - \text{accepted}}{\text{accepted}} \right| \times 100\%$$

To calculate % error for this lab, use your slope as the experimental value and the density from the chart as the accepted value. Show your work.

## Activity 2 Graphical Analysis with Logger Pro

**Using your temperature graph (from Part 4):**

6) Looking at the data in Table 2, which appears to be the independent variable, °C or °F? Explain. On which axis should the independent variable be graphed?

7) What is the equation of the line you obtained? How good is the correlation?

8) The accepted conversion for Fahrenheit to Celsius is given by the following equation:

$$^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32) \quad (4)$$

Rearrange the equation to solve for °F, then compare this with the equation you obtained from the graph. Compare the slope from Equation 4 above to the slope you obtained on your graph. Calculate a percent error.

9) Absolute zero is at -273°C. Use the equation you obtained from your graph to find this value in degrees Fahrenheit.

10) BONUS: There is a temperature that is the same in Celsius as in Fahrenheit. Can you figure it out using Equation 4? Show your work.

**Make sure your name is on the front of your graph before you turn it in. Sign and date your graphs.**

Student Signature \_\_\_\_\_ Date: \_\_\_\_\_

Lab Partner's Name \_\_\_\_\_ Instructor's initials \_\_\_\_\_