
Experiment G: Introduction to Graphical Representation of Data & the Use of Excel[®]

Scientists answer posed questions by performing experiments which provide information about a given problem. After collecting sufficient data, scientists attempt to correlate their findings and derive fundamental relationships that may exist between the acquired data. Graphical representations of data illustrate such relationships among data more readily. A graph is a diagram that represents the variation of one factor in relation to one or more other factors. These variables can be represented on a coordinate axes. The vertical axis is the y-axis (or ordinate), and the horizontal axis is the x-axis (or abscissa). When plotting a certain variable on a particular axis, experiments are normally designed so that you vary one property (represented by the *independent variable*) and then measure the corresponding effect on the other property (represented by the *dependent variable*).

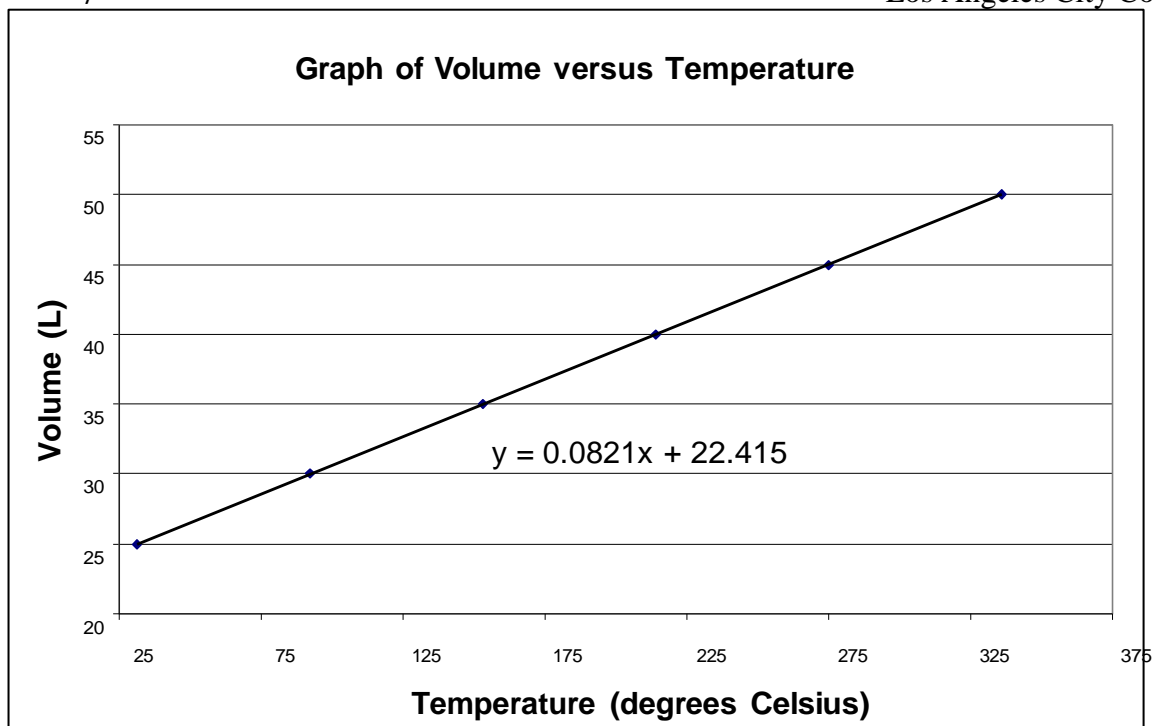
All graphs should conform to the following guidelines:

1. They should have a descriptive title.
2. The independent variable is conventionally placed on the horizontal axis; the dependent variable is plotted on the vertical axis.
3. Label both the vertical and horizontal axes with units clearly marked.
4. The scale chosen for the data should reflect the precision of the measurements. For example, if temperature is known to be ± 0.1 °C, you should be able to plot the value this closely. Moreover, the data points should be distributed so that the points extend throughout the entire page (as opposed to a small portion of the paper).
5. There should be a visible point on the graph for each experimental value.

Let us first examine a direct function involving a linear graph. Consider the following measurements made of an oxygen sample under standard pressure:

Volume (L)	Temperature (°C)
25.00	31.49
30.00	92.38
35.00	153.28
40.00	214.18
45.00	275.08
50.00	335.97

Using graph paper or any graphing program such as Microsoft Office Excel[®], one can first construct a plot of the data, where volume is determined to lie on the y-axis, and temperature is plotted on the x-axis. Once the data is plotted, a best-fitting line is constructed, and an equation of the line in slope-intercept form $y = mx + b$ is formulated, where m = slope and b = y-intercept. That is,

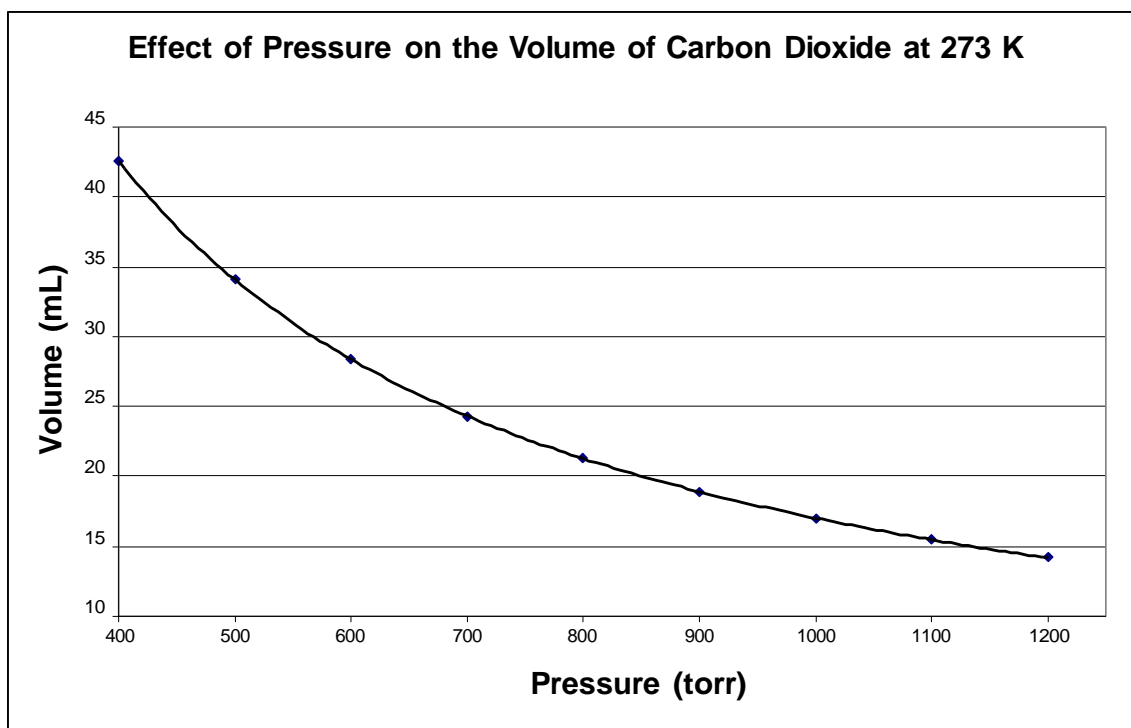


Now examine an indirect function involving a hyperbola. Consider the following measurements made of a carbon dioxide gas sample at 273 K:

Volume (mL)	Pressure (torr)
42.6	400
34.1	500
28.4	600
24.3	700
21.3	800
18.9	900
17.0	1000
15.5	1100
14.2	1200

Once again, using graph paper or any graphing program such as Microsoft Office Excel[®], one can construct a plot of the data, where volume is determined to lie on the y-axis, and pressure is plotted on the x-axis.

As depicted in the graph below, some chemical relationships are not linear; that is, there are no simple linear equations to represent such relationships. Instead, a plot of data for this kind of relationship gives a curved (non-linear) fit. Such a graph is useful in showing an overall chemical relationship, although the slope and the y-intercept are NOT relevant to its interpretation.



In this exercise, you will use acquired measurements to graphically analyze experimental data for the purpose of determining the density of an unknown liquid. By doing so, you will also how learn to use Microsoft Office Excel[®] to create computerized linear and non-linear graph. Any *students without a personal computer and/or Microsoft Office Excel[®] are invited to use the college's library computers designated for student use or create the data using the graphing program of their choice.*

Mock Laboratory Procedure – for this week, the data is provided for you! Read the following procedure to become familiar with how the experimental data was collected.

Fill one of the 100 mL beakers a little more than half-full of the unknown liquid assigned to you. Pipette 10.00 mL of the liquid from the half-full beaker into the empty one. Pipettes are calibrated to deliver the volume of a liquid specified by the markings on the pipette. Make sure that the bottom of the concave meniscus of the liquid exactly coincides with the line marked on the upper stem of the pipette. Do NOT blow the liquid out of the pipette; let it drain naturally. If there is still a drop of liquid on the tip of the pipette, touch it gently to the side of the container to which the liquid is being transferred. Cover the beaker with the provided watch glass to avoid evaporation of the unknown liquid.

Next, weigh the beaker and cover with the 10.00 mL of liquid in it. Your measurements should be accurate to the nearest 0.001 g. Transfer another 10.00 mL portion of the liquid to the beaker and reweigh the covered beaker and liquid. Repeat this process until you have FIVE collective readings of volume and mass.

Excel[®] Procedure

Note that various versions of Excel[®] may function a bit differently from the directions outlined below. Please adjust accordingly. One set of instructions are provided for users with Microsoft Office Excel[®] 2007. If you encounter difficulties, consult your instructor for assistance. As newer versions of Excel come into existence the following directions can still be used as general guidelines.

If you are using Microsoft Office Excel[®] 2007, begin by typing the data onto your Excel[®] spreadsheet in (x, y) form. To plot the data, highlight the x/y coordinates, select **Insert** from the display menu followed by **Scatter**, choose **X Y (Scatter)**, and click **OK**. To label the graph and coordinate axes, use the **Layout** function from the toolbar and select the appropriate **Labels**.

Once your data is plotted, you can draw a best-fitting line for the data utilizing the trend line function. Place the mouse cursor on one of the data points and proceed to right-click. All the data points corresponding to a particular data set should now be highlighted. Right-click again, and various menu options will pop up; select **Add Trend line...** utilizing the left-click. If your graph involves a linear function, select **Linear**. If your graph involves a non-linear function, select **Power** for this particular lab. Under the options menu, you can display an equation on your graph by selecting **Display Equation on chart**. Finally, click on **OK** (or **Close**) and print your graph.

In the Excel program: create, organize, and record all data then analyze. Attach the excel file in an email to your instructor as the report for this exercise.

Experimental Data Set 1:

Data and Calculations

Liquid Unknown # sample data provided below!

<u>Measurement #</u>	<u>Volume (mL)</u>	<u>Mass (g) of beaker + cover + liquid</u>
1	10.00 mL	104.941 g
2	20.00 mL	112.703 g
3	30.00 mL	120.575 g
4	40.00 mL	128.436 g
5	50.00 mL	136.298 g

Post-lab Questions to Experimental Set 1:

1. Calculate the density of your unknown liquid. Report your average: _____
2. Using Excel[®] plot and construct a graph appropriate for the above set of data, there are several different ways to graph this data. Next, add a trendline, write the slope-intercept equation for your liquid unknown below. What is the density of your unknown? Make sure to include the appropriate units. How does this density value compare to your result from question #1 above?
3. Use your slope-intercept equation from Excel to determine:
 - A. the mass (in grams) of 27.0 mL of your liquid. _____
 - B. what volume (in mL) would 17.0 g of your liquid occupy. _____

Experimental Data Set 2:

Consider the following data showing the effect of temperature on the vapor pressure of water at 1 atmospheric pressure:

Temperature (K)	Vapor Pressure (torr)
273	4.6
283	9.2
293	17.5
303	31.8
313	55.3
323	92.5
333	149.4
343	233.7
353	355.1
363	525.8
373	760.0

- Graph the data on Excel[®], plotting pressure on the x-axis and temperature on the y-axis. Identify the independent and dependent variables.
- The vapor pressure of a liquid is known to be an exponential function of the temperature. Therefore, the insertion of a *power trendline* allows you to see how well this particular set of experimental data agrees with the predicted behavior. Create a *power trendline* connecting your data points. Make sure to print out a copy of this graph for inclusion with this report.
- Next, create an Excel[®] graph of the **log P vs. 1/T** (*note: log = logarithm, the exponent to which a base must be raised to produce a given number; this function is found on most scientific calculators*). In this format which property is the independent variable? How does this graph compare to your previously constructed Excel[®] graph from section A? Is this data linear? Briefly explain any similarities/differences in your two graphs. Make sure to print out a copy of this graph for inclusion with this report.

Experimental Data Set 3:

The data for concentration and density of glucose solutions at 20 °C is found to be:

Concentration (% by mass)	Density (kg/L)
1.00	1.0038
2.50	1.0095
3.00	1.0115
4.00	1.0154
5.50	1.0212
7.00	1.0272
9.00	1.0352

The researcher can adjust the concentration. Therefore, the % by mass is the independent variable, and the density is the dependent variable.

A. Construct an Excel[®] graph of this data. Use the trend line function to formulate the slope-intercept equation. Write this equation in terms of D and %. Make sure to print out a copy of this graph for inclusion with this report.

B. Use the equation of the line to determine the density of a 4.80% glucose solution.

C. Use the equation of the line to calculate the % by mass of a glucose solution whose density is 1.0652 kg/L.