Microsoft Excel **in Scientific Applications II**

Introduction

This laboratory activity will enable you to develop new skills using *Microsoft Excel*. The last laboratory activity in which you used *Excel* should have provided you with skills used to analyze one-variable data. This week, you will be using *Excel* to graphically analyze two-variable data. The spreadsheet skills you learn in these early laboratory activities will likely be invaluable to your studies in chemistry, other course work, your career, and perhaps your everyday life.

Learner Outcomes

Upon completion of this laboratory activity, the student should be able to

- graph two-variable data using *Microsoft Excel*
- use *Microsoft Excel* to graphically analyze two-variable data
    - write a mathematical equation that shows the relationship between the two variables
- enter subscripts and superscripts in *Microsoft Word* and *Excel*

Background

Example 1

Enter the data below into *Sheet 1* of an *Excel* spreadsheet. Then graph the data using the Chart Wizard in *Excel*. Use an XY Scatter graph *without* connecting lines. Title and label the axes on your graph and display gridlines on both axes. Turn off the legend.

REMINDER: *Save your data* <u>*early and often*</u> *in order to avoid the accidental loss of your work. Use the following convention for naming your files: "Lastname Firstname Spreadsheet2" (include both names if you are working in pairs), saving to the H: drive and/or your own flash drive. This lab may be done totally paperless, so follow directions carefully. The spreadsheet you will be creating will be submitted electronically via your professor's instructions.*

Temp (^oC)	Temp (^oF)
0	32
20	68
40	104
60	140
80	176
100	212

Next we would like to determine the equation of the straight line a slope-intercept form:

$$y = mx + b$$

where m is the slope (rise over run) of the line, b is the y-intercept, x is horizontal data and y is vertical data. In our example, x is replaced by *Temp(℃)* since it appears on the horizontal axis and y is replaced by *Temp(℉)* since it appears on the vertical axis.

Our equation is now:

$$T_{℉} = m \cdot T_{℃} + b$$

To determine the slope (m) of the line, recall that the slope is defined as the rise divided by the run. One could determine the rise and run by selecting two points *on* a best-fit line that goes through the points and measuring their horizontal separation (run) using the *horizontal axis.* Similarly, the rise could be determined from two points using the *vertical axis*.

Alternatively, the slope and intercept can be determined using a "Trendline analysis" in *Excel*. This may be done by pointing the mouse on any one of the points on the graph and doing a right-mouse-click. You should see in this example that the equation returned is $y = 1.8x + 32$, or if we use the variables on the axes, $T_{°F} = 1.8T_{°C} + 32$, which ought to look pretty familiar! You now ought to be able to use this equation to convert between degrees Celsius and degrees Fahrenheit.

Example 2
It can be a straightforward process to obtain the equation of a straight line. But what do you do when the graph of the experimental data isn't a straight line? For example, consider the following data. Enter this data onto *Sheet 2* of your spreadsheet.

Time	Distance
(s)	(m)
0.00	0.00
1.00	4.90
2.00	19.60
3.00	44.10
4.00	78.40

Graph this data in *Excel*. Obviously, the data points do not fall on a straight line and we are unable to use the previously described slope-intercept method to determine an equation that relates time to distance. However, we can transform the data into a set of numbers that *may* yield a straight line when graphed. Insert another column to your data that calculates the square of the time:

Time	Time^2	Distance
(s)	(s^2)	(m)
0.00		0.00
1.00		4.90
2.00		19.60
3.00		44.10
4.00		78.40

Now graph *distance* vs. *time*^{2} using the Chart Wizard. Note that this produces a straight line. Perform a trendline analysis in *Excel* in the same manner as you did before, except that in the **Trendline Options**, set the y-intercept to zero. You should see in this example that the equation returned is $y = 4.90x$, or if we use the variables on the axes, *distance* = 4.90 *time*^{2}, which ought to look familiar if you've had some physics (the free-fall equation is $x = ½ gt^2$). You now ought to be able to use this equation to find the distance if given time or vice versa.

Summarizing, graphical analysis is a method used to find an equation that describes the relationship between experimental data points. The original data is manipulated (squared, cubed, 1/x, etc.) until a straight-line graph is obtained. At that point, the slope and *y*-intercept of the straight-line graph are determined and the equation for the line has been determined.

Using the Vernier Caliper

Your instructor will demonstrate the proper use of the vernier caliper. If you have any questions of how to read your measurements, ask the instructor and/or your partner or neighbor.

Your Report

Follow your instructor's directions to submit this report. You may be asked to use your ARCC-assigned email account to email the file as an attachment to your professor, or you may be asked to submit it via the D2L dropbox. Remember to name the file as specified earlier in this lab (*Lastname Firstname Spreadsheet2*). In the subject line of your email message, type "Chem 1061 Lab: Spreadsheet Lab 2". If you cannot access your e-mail from the school, you may e-mail the file from home.

- On *each sheet* of the file you create, place your name, your partner's name, course number, and lab section into the header, with the professor's name, the date, and computer station number in the footer.
- The file should have 2 sheets and should have ***only* the straight-line graph, trendline analysis, and data table for Assignments 1 and 2 that follow.** *If you would like to make a printout of your spreadsheets for your own use, remember to use Print Preview in order to save paper.*
- Answers to all of the questions that are a part of each assignment. You may place your answers near the bottom of the sheet for each assignment. Give more than just an answer. Either type out the complete question and your answer or type out a complete answer (*Example—a complete sample answer to question 4 in Assignment 1 below: When time = 200 s, then* $[NO_2] = 4.05 \times 10^{-3}$ *mol/L*).

Assignment 1

1. Open a new spreadsheet and enter the data below for the decomposition of NO_2 at 330°C onto *Sheet 1*. Graph this data in *Excel*. Do the data points fall on a straight line? Insert additional columns to your data that calculate $[NO_2]^2$, log $[NO_2]$, and $1/[NO_2]$ (see below).

Time (s)	$[NO_2]$ (mol/L)	$[NO_2]^2$ (mol^2/L^2)	log $[NO_2]$	$1/[NO_2]$ (L/mol)
0	1.00E-02			
60	6.83E-03			
120	5.18E-03			
180	4.18E-03			
240	3.50E-03			
300	3.01E-03			
360	2.64E-03			

2. Plot $[NO_2]^2$ (on the *y*-axis) vs. time(on the *x*-axis), log $[NO_2]$ (on the *y*-axis) vs. time(on the *x*-axis), and $1/[NO_2]$ (on the *y*-axis) vs. time(on the *x*-axis) to determine which gives a straight line. *Save only the graph that yields a straight line.* Title the graph and label the axes.

3. What is the equation of the straight-line?

4. Use your equation of the straight line to find [NO_2] when time = 200 s.

Assignment 2

1. Obtain the necessary equipment: a collection of different steel ball bearings and one vernier caliper (one caliper per pair).

2. Measure the diameter and mass of each ball bearing and record this data onto *Sheet 2* of an *Excel* spreadsheet. Remember to label the data columns appropriately. Have a neighbor check one of your measurements just to be sure you are reading the caliper correctly.

3. Create additional columns in your spreadsheet to calculate and display the $diameter^2$, $diameter^3$, 1/diameter, 1 /$diameter^2$, 1/$diameter^3$, log (diameter), and $10^{diameter}$ for each ball bearing (see below). *Remember to give your units!*

diameter	$diameter^2$	$diameter^3$	1/diameter	1/$diameter^2$	1/$diameter^3$	log (diameter)	$10^{diameter}$	mass

4. Using *Excel*, graph mass (on the *y*-axis) vs. diameter, $diameter^2$, $diameter^3$, 1/diameter, 1 /$diameter^2$, 1/$diameter^3$, log (diameter), and $10^{diameter}$ (on the *x*-axis). *Save only the graph that yields a straight line.*

5. From the Trendline Analysis that gives you a straight line, determine the slope, *y*-intercept (if necessary…hint: what is the mass of a steel ball that has a diameter of 0 mm?), and the equation of the line.

6. How many significant figures should be reported for the slope and *y*-intercept (if necessary) in the trendline analysis? Adjust the number of decimal places in the equation to yield the correct number of significant figures. Replace the labels of *x* and *y* with *your* variables.

7. Obtain an unknown ball bearing from the instructor, measure its mass, and return it immediately to the instructor. *Do not measure the diameter with the calipers.* Use your straight-line formula to determine the diameter of the unknown ball bearing.

8. Add separate columns that enable you to calculate the volume and density of each ball bearing. Compute the average density of the ball bearings in one of the cells. Remember to include all units.

9. If you multiply the slope of your line by $6/\pi$, you should obtain the density of the ball bearings. Why?