Introduction

With the incorporation of the Vernier LabQuest 3 data acquisition system, you are now able to collect multiple data points, which would be tedious to collect by hand. The data collected by Vernier LabQuest 3 is collected as a QMBL file, or Text file, which can be imported into Excel. This data can be further manipulated within Excel. Excel can be used to perform calculations on a set of data, and to create graphs for collected data. The following instructions and exercises will ensure that everyone is comfortable with the basic functions of Excel necessary for completing the lab exercises.

There will be two portions of this exercise: Part A: You will enter, manipulate, and graph a set of given data. Part B: You will download two Excel files then manipulate and plot multiple graphs on one page. This will prepare you for tasks you will encounter during the lab this semester.

All directions are written using Excel 2016. Some commands may be the same or similar for different versions. If you can't find the menu suggested, try one of the other listed options. The right-click is a powerful option and will give access to several features hidden within various menus. For commands and keystrokes that differ for Mac operating systems, be sure to use the version of the directions for Mac instruments.

Procedure

Part A: Entering and Manipulating Data and Generating a Scatter Plot

1. Starting with Cell A1, enter the labels, "Volume $Co(NO_3)_2$ (mL)" followed by Volume H_2O (mL)" in Cell B1. To create subscripts select format cells from the FONT box in the HOME tab or right-click and select FORMAT CELLS. "Total Volume (mL)" should be added to Cell C1 and "Absorbance (AU)" in Cell D1.

   > As we manipulate data, it may be necessary to change column widths to accommodate titles. Place the cursor between columns until double-sided arrow appears. Click and drag to manually adjust. Double-click to automatically adjust column width.

2. Enter the data from Table LF.1 (below) into the spreadsheet under the appropriate column labels. As you type the values for columns A and B, the decimal place will, by default, not be shown. To change this, select the cells A2–C5, and select FORMAT CELLS, from either the FONT box in the HOME tab or by right-clicking within the selected cells. Select the NUMBER tab. Under category, choose NUMBER and change the decimal place to 1.

Table LF.1: Sample Experimental Data Collected in Lab

Trial	A	B	C	D
1	**Volume $Co(NO_3)_2$ (mL)**	**Volume H_2O(mL)**	**Total Volume (mL)**	**Absorbance (AU)**
2	1.0	4.0		0.219
3	2.0	3.0		0.424
4	3.0	2.0		0.633
5	4.0	1.0		0.823

3. Your data should match Table LF.1 above. Notice that no data has been filled in for column C. Excel can perform calculations for you, especially when the calculation is needed for a large set of data. In Cell C2, enter the following: =A2+B2. You must include an equal sign for Excel to perform a calculation.

4. Now, you could type that same calculation in all the remaining cells, but this would be tedious for a large data set. Instead, you will copy and paste the formula. Note: Multiple methods and shortcuts exist for this.

   a. Select C2 and place cursor on the lower right-hand corner of the cell. The cursor should change to a black cross-hair. Click and drag down to Cell C5. Release the mouse key, and the calculated value should appear.
   b. Highlight C2. On keyboard hold down CTRL and C at the same time. This will copy the cell contents. Highlight the destination cells, C3–C5. Now press CTRL and V at the same time. This will paste the formula into the selected cells.
   c. COPY and PASTE commands can also be accessed in the HOME menu or by right-clicking and choosing from the drop-down window.

   Regardless of the copy/paste method used, the cell referenced in the formula will change as the formula is pasted down the column. Notice how A2+B2, changed to A3+B3, etc.

5. In Cell E1, enter “Concentration (mol/L)” and in Cell F1, enter “1.53E-2”.

6. We will now use the function option again to calculate the concentration. In Cell E2, enter the following:

   =A2*$F$1/C2.

   As in Step 4, copy and paste this formula through E5. Notice the dollar signs ($) in $F$1. This creates an absolute reference. As you copy the equation, A2 will change to A3, but F1 will not change, because of the dollar sign. Your spreadsheet should match Table LF.2 below. Formulas for a column are shown in the first cell of the column. Check that your formula for Column C and Column E matches below

   Double-click on a cell or select FORMULA BAR from the VIEW menu to see formula instead of the calculated value.

Table LF.2: . Completing the Calculations for the Experimental Data

Trial	A	B	C	D	E	F
1	**Volume $Co(NO_3)_2$ (mL)**	**Volume H_2O(mL)**	**Total Volume (mL)**	**Absorbance (AU)**	**Concentra-tion (mol/L)**	**1.53E-2**
2	1.0	4.0	=A2+B2	0.219	=A2*$F$1/C2	
3	2.0	3.0	5.0	0.424	6.12E-03	
4	3.0	2.0	5.0	0.633	9.18E-03	
5	4.0	1.0	5.0	0.823	1.22E-02	

7. Now that all the necessary data has been entered or calculated in Excel, you can create a scatter plot.

8. Highlight D1–E5 by clicking and dragging over the appropriate cells.

9. Click INSERT to open the appropriate ribbon at the top of the window and select SCATTER, SCATTER WITH ONLY MARKERS. A scatter plot is frequently used to visualize trends in experimental data. (Mac Users:)

10. The default for Excel is to plot the first column as x-values and the second column as y-values. In your case, you want the opposite, concentration on the x-axis and absorbance on the y-axis.

11. When your chart is selected, a menu labeled CHART TOOLS will be available.

12. Choose SELECT DATA. A new window will appear. Select SERIES 1 and click EDIT. By clicking the icon next to the SERIES X VALUES box, this will let you return to the spreadsheet to select the desired x-values by highlighting E2–E5. Clicking the icon again will expand the window. Repeat the process for the y-values, highlighting cells D2–D5. Select OK to confirm changes to the selected data. Select OK again to exit the SELECT DATA window.

13. Now you should have values between 0 and 1 on the y-axis.

14. Select the LAYOUT tab under chart tools to format your graph.

    a. Select CHART TITLE and ABOVE CHART. Type the appropriate title: "Absorbance of Cobalt Nitrate vs. Concentration.
    b. Choose the AXIS TITLE option to add appropriate labels for the primary horizontal axis by selecting TITLE BELOW AXIS [Concentration (mol/L)] and the primary vertical axis by selecting ROTATED TITLE [Absorbance (AU)].
    c. The legend can be removed, by either clicking the legend and pressing DELETE or by choosing NONE from the LAYOUT tab under LEGEND.
    d. An additional formatting step involves the numbers on the axis. Select AXES, PRIMARY HORIZONTAL AXIS, and MORE PRIMARY HORIZONTAL AXIS OPTIONS. This will allow you to change the increments and scale on the axis. For this plot, the x-axis major unit has been changed to FIXED with a value of 0.004. You can also change the display of the numbers on the axis. If the values are not in scientific notation, select NUMBER from the tab at the side. Under CATEGORY, select SCIENTIFIC. This can also be accessed by right-clicking on the axis and selecting FORMAT AXIS. For some Excel versions, you might have to choose the tab, SCALE to follow the step above.

15. Since this data has a linear relationship, you will add a trendline to the plot. Select your graphand open the CHART TOOLS ribbon, then select the LAYOUT tab.

16. Click TRENDLINE and then MORE TRENDLINE OPTIONS. Select LINEAR, and mark the two boxes for DISPLAY EQUATION ON CHART and DISPLAY R-SQUARED VALUE ON CHART. An alternate method of doing this is to right-click on the data point within the plot area and select ADD TRENDLINE.

17. Save your Scatterplot as a PNG or PDF for upload to the Post Lab Report.

> You will need to upload copies of all your graphs and data tables to the Post Lab Report for Parts A and B as PDF or PNG files so that your TA can grade them.

Part B: Downloading Excel.xlsx Files and Plotting Two Data Sets

1. Download the two files in the report online. Save the files to your computer. Right-click on the link (Excel_001) and select SAVE AS or SAVE.

2. You should have two columns (time and absorbance) data in each Excel workbook. Copy the data from Excel_002 and paste (in columns C and D) into Excel_001 so that you have all four columns within one sheet. By clicking on the column letter, the entire column will be selected.

3. You should now have the following column headings: Time/s, Absorbance, Time/s, Absorbance. Beneath this, you should have about 200 data points for one file and 1,200 data points for the other file.

4. Insert a blank column by selecting Column C and selecting INSERT CELLS from the HOME tab under INSERT. This can also be achieved by right-clicking on Column C and selecting INSERT. In the new column in Cell C1, type the following heading, ln(Absorbance)#1. In Cell F1, enter ln(Absorbance)#2.

5. In Cell C2, enter the following formula: =LN(B2).

6. Copy this formula into all the cells in Column C. The same copy and paste methods described in Part A will also apply here.

7. Repeat for Cell F2 by entering: = LN(E2) Copy this formula into all cells in Column F. You should have all 200 data points on your worksheet.

8. Now you can generate a scatter plot for this information. You are going to learn how to plot more than one set of data on a graph.

9. Select the data in Column A and Column C. To select columns that are not adjacent, select one column, hold CTRL, and select the remaining columns, one at a time.

10. Select the INSERT ribbon at top of the window. Under CHART, select SCATTER, SCATTER WITH ONLY MARKERS. Time should be on your x-axis and absorbance should be on your y-axis. Look at the numbers

on the axis to determine what values were plotted on each axis.

11. Now, you want to add a second set of data. Right-click on the plot area and choose SELECT DATA (or choose SELECT DATA from the DESIGN tab of CHART TOOLS).

    a. Under LEGEND ENTRIES (SERIES), select ADD.
    b. Give your series a new name, ln(Absorbance)2. For the "Series X Values" click the icon next to the box to select values from your spreadsheet. When finished your Series X values should contain *D*2:*D*1202. For the Series Y values, repeat but select the values in column F for absorbance. Your Series Y values should contain $F$2:$F$1202. The text proceeding the cell letters and numbers refers to how your spreadsheet is named, the tab in the bottom right corner. Do not change the text proceeding with the cell reference.
    c. Select OK to accept changes. Select OK on the next screen to save changes. You should now have two lines on your plot.

12. Format your graph. When your chart is selected, a menu labeled CHART TOOLS will be available.

13. Select the LAYOUT tab to format your graph.

    a. Select CHART TITLE, ABOVE CHART. Type "ln (Absorbance) vs. Time."
    b. Choose the AXIS TITLE option to add appropriate labels for the horizontal axis [Time (seconds)] and the vertical axis [ln(Absorbance)].
    c. Since you have multiple data sets on this plot, the legend will be useful, so do not delete it.

14. By default, the x-axis is set to cross the y-axis at zero. You can move the axis to the bottom of the graph by the following steps.

    a. On the y-axis, right-click and select FORMAT AXIS from the window. (This can also be accessed through CHART TOOLS > LAYOUT > AXES > PRIMARY VERTICAL AXIS > MORE PRIMARY VERTICAL AXIS OPTIONS.)
    b. Under the option, HORIZONTAL AXIS CROSSES, select AXIS VALUE and enter the lowest value (–5, for this graph)
    c. Now your x-axis is at the bottom of your plot area.

15. Now you have two sets of data on the same chart, which will make it easy to compare multiple sets of data.

16. Add a linear trendline for both sets of data. Be sure to select DISPLAY EQUATION ON CHART and DISPLAY

R-SQUARED ON CHART.

17. Upload your graph, containing two data series, trendlines, and equations (with R-squared values) to post-lab report as a PNG or PDF for upload to the Post Lab Report.

> You will need to upload copies of all your graphs and data tables to the Post Lab Report for Parts A and B as PDF or PNG files so that your TA can grade them.

Part C: Additional Formatting Tips

There are many regions on a chart that can be individually formatted. Each region has its formatting options associated with it.

- The title text, the axis labels, and the numbers should be appropriately sized for the size of the printed chart. These areas can be individually selected and formatted.
- Try to maximize the area that the data takes up on the chart. To do this, change the range of the axis so that the data fills the chart area. There is no need to show the 0 on an axis where the first data point is at 200. Doing this makes it difficult to view and interpret the data. Select the axis, FORMAT AXIS, and AXIS OPTIONS to make this change.
- A white background is often the easiest to read. Select the plot area (make sure no data points are selected). Right-click and select FORMAT PLOT AREA. Select the background color.
- Excessive gridlines make it difficult to see data points, especially when plotting multiple series on a single graph.
- Use simple fonts such as Arial, Times New Roman, or Calibri. Avoid the use of decorative fonts. Right-click AXIS TITLE, and select FONT to choose text style and size.

You will need to upload copies of all your graphs and data tables to the Post Lab Report for Parts A and B as PDF or PNG files so that your TA can grade them.