Graphing and Curve Analysis Using Microsoft Excel©2016

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The following instructions guide you through the process of using Microsoft Excel to create a simple x-y scatter plot (called a "chart" in Excel) from a set of data, and have the program calculate and draw a line that best fits your data (called a "trendline" in Excel). The last page of this document details the analysis procedure you will use on your finished graph. <u>Most of the experiments performed this semester use these graphing and analysis techniques, so it is important that you understand them</u>.

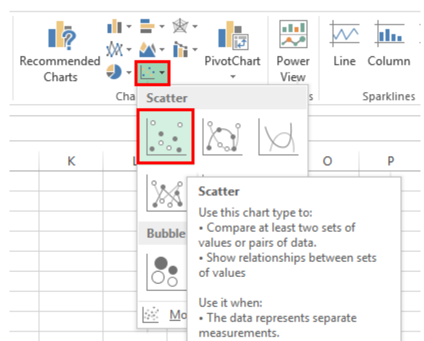
> **IMPORTANT**: The instructions to enter data into a spreadsheet and create a graph follow. For the "Graphing and Curve Analysis…" exercise, you will be working with a file containing sample data of distance and time for an object moving at a constant velocity. Click on the **File** tab (upper left corner), and choose **Open**. Click **Browse**, navigate to the *Teaching Drive (T:)*, open the "PHYS103" folder, and then select *Excel Graphing Exercise*. After opening the file, you may then skip to step #2; you will start with step #1 when entering your own experimental data. Be sure to bring a copy of these instructions to lab each week until you have mastered the process.

Creating a Graph

1. Set up columns for data in the spreadsheet, *making sure that the first column contains the values you will plot along the horizontal (x) axis*. **Include a title for each column, including the units; this will ensure that you are plotting your data correctly!** Generally, you will only need to include the data that will actually be plotted, not your raw measurements – unless you wish to check your calculations. Be sure to save your spreadsheet on your *Network Storage (P:)* drive; if your instructor wishes to check your graph during an experiment, you will have to re-enter all of your data if it has not been saved!

2. Click one **cell** (*not the column*) that contains your data; Excel will assume the data to be plotted is in the selected and adjacent columns.

3. Click the **Insert** tab. In the **Charts** group, click the **Scatter** button, then choose "Scatter" (shown highlighted at right.) A graph will appear in your worksheet.



4. The default location for your graph is that it is inserted as a new object on the worksheet, which allows you to see the data and the graph at the same time. This is useful when creating the graph as you collect your data; you can check that the data points fall along the shape of the expected function.

   Frequently, it is advantageous to have the graph appear on a separate worksheet. The graph appears full-screen, making it is easier to spot bad measurements or interesting trends when the best-fit function is applied, and the graph will look better when printed. Move the graph by first selecting it; this will switch the toolbar to the **Design** section of the **Chart Tools** tab. Next click the **Move Chart** button (on the far right) and then click the button next to **New Sheet** and then OK. The graph now appears on a new worksheet in front of the sheet that contained your data.

*Please, **do not** remove the grid lines from your graph!*

5. You will next add axis labels as follows: while looking at your graph, click the **Add Chart Element** button (on the far left), then **Axis Titles** and then **Primary Horizontal**. Repeat these steps, this time choosing **Primary Vertical**. Double-click each "Axis Title" and include an appropriate label; *you **must** include units on the axis labels!*

6. Double-click the title region and enter a title for your graph. Your title should be descriptive; "Distance cart travels vs. elapsed time" is better than "D vs. t". *You do not need to include units in the title.*

Adding the Best-Fit Function

7. Now that you have created your graph, you need to add a best-fit line, called a *trendline* in Excel. **Right-click** on any data point, and choose "Add Trendline..."; a linear fit is applied to your data (*even though this may not be the correct function for your data!*) The "Format Trendline" panel appears to the right of your graph containing six best-fit functions, also known as regressions.

   Excel will determine which of the six can be used for your data *(but it doesn't pick the correct function for you!)* In this course we might use four of these regressions: "Exponential" ($y = ae^{bx}$); "Linear" ($y = mx + b$); "Polynomial" (of 2^{nd} order: $y = ax^2 + bx + c$); or "Power" ($y = ax^b$).

8. Select the function that best fits your data. <u>Note that when performing an actual experiment you will generally know the function that you expect to fit your data</u>. *You will be guessing at the best fit when doing the "Graphing and Curve Analysis…" exercise*. If you pick the wrong regression and have closed the "Format Trendline" window, right-click on the trendline and choose **Format Trendline** again.

   Important note: If you pick a function which cannot be applied to the selected data set, Excel will remove the trendline, and the dialog box will switch from "Format Trendline" to "Format Chart Area"! Close this window, and add the trendline again.

9. Next, you will <u>**ALWAYS**</u> put a check in the box next to **Display Equation on Chart**. This will display the appropriate equation for the line chosen. Excel calculates the values of the appropriate coefficients *a, b, c,* and *m*. You should note that more significant figures might be presented than are dictated by the accuracy of your measurements. It is from these coefficient values that you will be performing your analysis.

   - Note that the default font size for the equation box is very small, which your lab instructor will find difficult to read. Increase the font size by selecting the equation box, clicking the **Home** tab and changing the font size to **14**. Move the equation so that it does not obscure the line or any data points. Thank you.

10. With your graph now created, corrections or additions to the data can be made if needed. Simply change a number, or delete a bad data point and the graph will update automatically.

Printing the Graph

Since all the groups in your lab section will collect similar data for a particular experiment, it is important to add your names to the graph to distinguish it from the others in the printer. An elegant way of adding your names, the date and the experiment title to your graph is to put them in the header of the page that prints.

13. Recall that the graph prints nicer when you move it to its own worksheet, so be sure you are on the tab containing your graph. Click the **File** tab, then **Print**. It is not necessary to print your data, since your lab report contains a data table. If you need to make a change, click the **Back Arrow** button (top left of the screen), and make your modifications.

14. You can add your name – and your lab partners' – to the header as follows: in the **Print** window, click the **Page Setup...** link (below the "Settings", center-left on the window), and then the **Header/Footer** tab. Next click the **Custom Header...** button, and type your names in the "Left Section" box. You can put the experiment title in the "Center Section" box.

15. Insert the current date in the "Right Section" box by clicking the "Date" button (the little calendar – see sample at right). This will add ***&[Date]*** to the right section of the header, and will print the current date on the graph.

16. Click **OK** twice to return to the print window. If the graph is to your liking, check that you are printing to the correct lab (*the printer name contains the room number*), set the number of copies and click the **Print** button. In general, you will print one copy for each member of your group, unless otherwise instructed, so that each person can include a copy with their own lab report.

Analyzing the Graph

Now you will analyze your graph to determine the results of your experiment. These results will come from the values calculated in your best-fit function. How will you determine which results give you the quantities that you are seeking?

The first step of our analysis with graphed data will always be to look at the best-fit function, and see how it compares to the expected theory for the experiment. Today you should have chosen the Linear fit for this data (if you have previously read these instructions, you should know that already!) The form of a linear function is $y = (slope)\, x + y\text{-}intercept = m\,x + b$.

Next, you should look at your graph to determine what x and y represent. Today you plotted time, t on the horizontal (x) axis and distance, D on the vertical (y) axis. Now we can substitute t for x, and D for y so that our equation becomes:

$$y = m\,x + b$$
$$D = m\,t + b$$

We see that we have two unknown constants: the slope, m and the y-intercept, b. Next, we need to look at the relationship between distance and time. The definition of velocity gives us $v = D/t$; we can algebraically rearrange the velocity definition so that it follows the pattern of a linear function, as shown below:

$$D = v\,t$$
$$y = m\,x + b$$

This shows us that the slope of the line equals the velocity. What is the y-intercept (the value of y when $x = 0$) in this case? What are the units of b?

17. What velocity do you get from your linear graph of distance vs. time? Write the value (*and the appropriate units!*) on your printed graph.

<u>This is how we will analyze graphed data in all future experiments</u>, whether the data is linear or non-linear (as you will see next week.) Note that in today's example, the expected intercept, b is zero, but the graph shows that it actually has a small value. In future experiments, this may be an indication of an error, or the result of some initial conditions of your measurements, or perhaps something interesting that occurred while performing your experiment.