

## Using MS Excel to Create Graphs: Some MS Excel Basics

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In this handout, we will consider some basics including generating data and creating, customizing, and manipulating graphs that we use in creating interactive workbooks using MS Excel.

**Customizing the MS Excel Window:** You may find it helpful to customize your MS Excel environment by adding toolbars and toolbar buttons that you will use frequently. To do this, you may use the Customize option on the Toolbars menu of the View menu, the Customize option on the Tools menu, or use one of the down-arrows at the end of a displayed toolbar, selecting Add or Remove Buttons and then Customize at the bottom of the drop down menu. Figure 1 displays an example of the drop down menu for the Control Toolbox Toolbar that is generated by left-clicking the arrow at the end of this toolbar. Depending on the version of MS Excel that you are using, the individual toolbar buttons may be displayed in a slightly different manner but each version of MS Excel will include the Reset Toolbar and Customize options on this drop down menu in some manner.

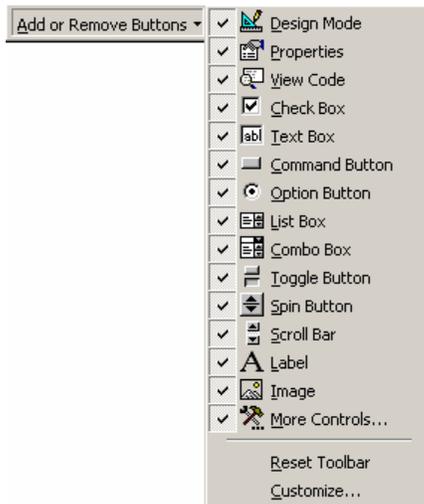


Figure 1: The Add or Remove Buttons drop down menu from the Control Toolbox Toolbar.

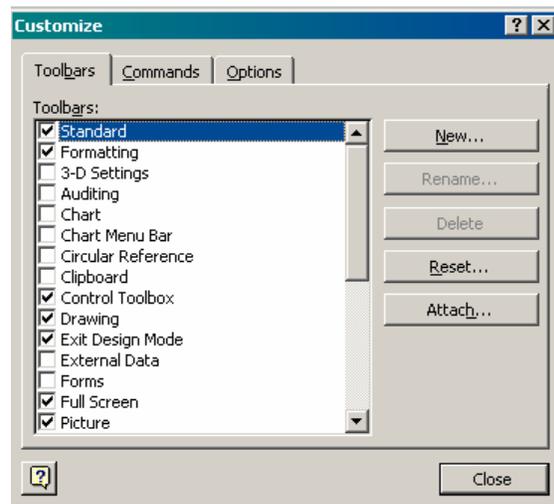


Figure 2: Customize Dialog Box.

Using the Customize dialog box, you can select the toolbars that you want to display. As you can see in Figure 2 above, some of the toolbars that I frequently use include the Standard, Formatting, Control Toolbox (of course), Drawing, Exit Design Mode (convenient to have an extra exit for design mode other than the one on the toolbar), Full Screen, and Picture. You can also create your own toolbars displaying

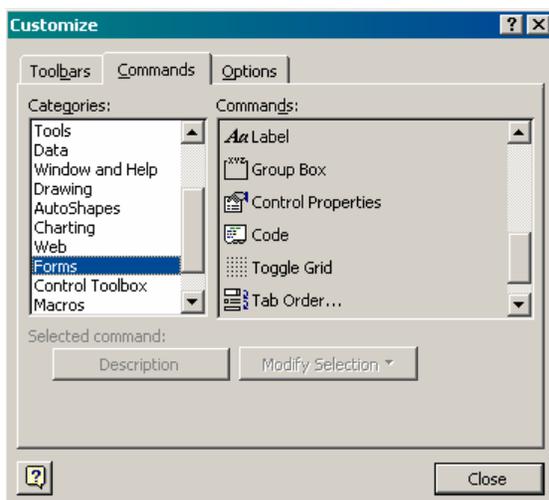


Figure 3: The Commands Tab.

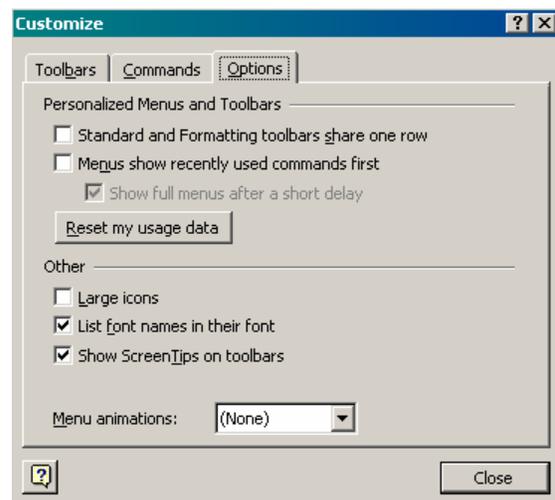


Figure 4: The Options Tab.

toolbar buttons that you frequently use. Using the Command tab, you can add buttons to *any* toolbar, including toolbars that you create. To add toolbar buttons, simply select the category, left-click, hold, and drag the toolbar button to the desired location among the displayed toolbars, and release – the new toolbar button will be displayed in the selected location. One toolbar button that you will find helpful to add is Toggle Grid.

Toggle Grid, , allows you to *easily* turn off the grid lines. The Toggle Grid button is displayed in the Command window corresponding to the Forms Category, Figure 3. Another way in which to turn off the grid lines is to uncheck the Gridlines box displayed on the View tab in the Options dialog box that is displayed by selecting the Options entry on the Tools menu, Figure 5; if you plan to use the elements on the Forms Toolbar then you will have easy access to the Toggle Grid button.

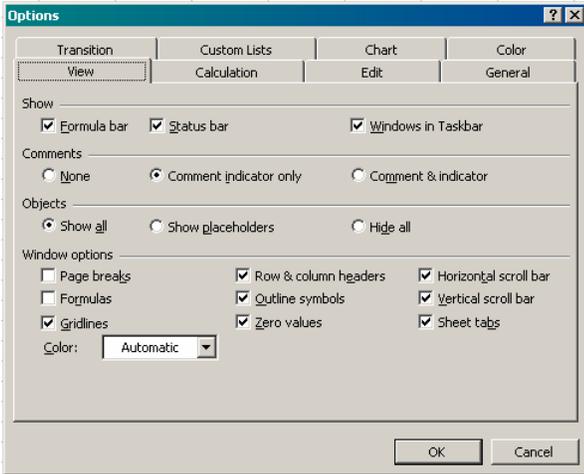


Figure 5: View tab in the Options Dialog Box.

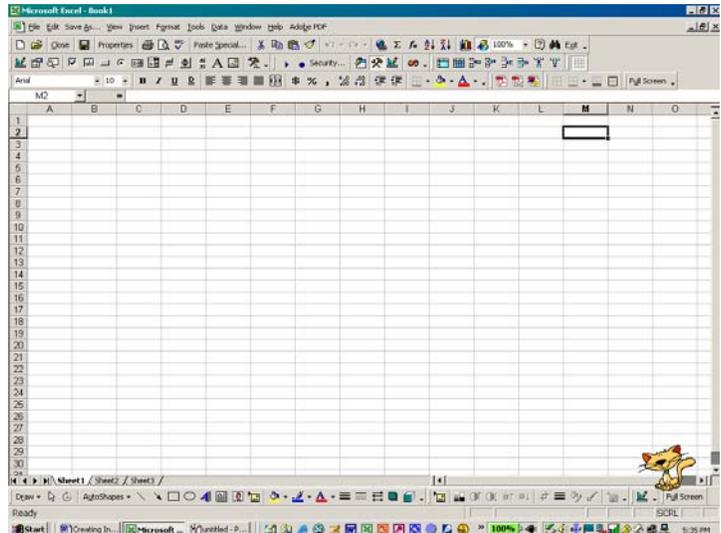


Figure 6: My Laptop's MS Excel Window.

Unchecking the Standard and Formatting toolbars share one row box on the Options tab of the Customize dialog box, Figure 4, will allow you to see all the basic toolbar buttons rather than having to search for them at the end of the top row of toolbar buttons.

It is important to mention that displaying toolbars will reduce the amount of the worksheet that you can view in the MS Excel window, Figure 6. However, if you use particular design elements frequently, having access to the toolbars and the toolbar buttons will be very helpful. Since the adding and removing toolbars is very easy, it is not a problem either way.

**Generating Data:** The auto fill feature in MS Excel is very helpful in generating data for graphs. While many folks like to start the sequence of inputs/outputs and then let MS Excel fill in the rest, I have found it very helpful to control the auto fill – this minimizes possible errors. There are two methods that I use a great deal: the first involves formulas and a start-value, and the second involves formulas, a start-value, and cells containing parameters.

|   | A      | B | C |
|---|--------|---|---|
| 1 | -5     |   |   |
| 2 | =a1+.1 |   |   |
| 3 |        |   |   |
| 4 |        |   |   |

Figure 7: The inputs, differing by 0.1, are all dependent on the start-value in cell A1.

|   | A    | B           | C | D |
|---|------|-------------|---|---|
| 1 | -5   | =a1^3-16*a1 |   |   |
| 2 | -4.9 |             |   |   |
| 3 |      |             |   |   |
| 4 |      |             |   |   |

Figure 8: In turn, the outputs are dependent on the start-value in cell A1.

Using formulas and a start-value allows you to control *and* adjust the data as desired since both the inputs and the outputs are dependent upon the start-value. In Figure 7, the start-value of  $-5$  is entered in the first cell of input column A, cell A1. Using the formula,  $=a1+0.1$ , we can create inputs that differ by  $0.1$  and can be adjusted simply by changing the start-value. In Figure 8, the first output formula is entered,  $=a1^3+16*a1$ . Of course, this output is dependent upon the start-value in cell A1. Using the auto fill to generate the output in cell B2, we can then select and drag the formulas in cells A2 and B2, Figure 9, to generate the desired data, Figure 10; to generate the inputs from  $-5$  to  $5$ , inclusive, we drag to row 101.

|    | A    | B       | C |
|----|------|---------|---|
| 1  | -5   | -45     |   |
| 2  | -4.9 | -39.249 |   |
| 3  |      |         |   |
| 4  |      |         |   |
| 5  |      |         |   |
| 6  |      |         |   |
| 7  |      |         |   |
| 8  |      |         |   |
| 9  |      |         |   |
| 10 |      |         |   |
| 11 |      |         |   |
| 12 |      |         |   |
| 13 |      |         |   |
| 14 |      |         |   |
| 15 |      |         |   |
| 16 |      |         |   |
| 17 |      |         |   |

Figure 9: Dragging the formulas in cells A2 and B2.

|    | A    | B        | C |
|----|------|----------|---|
| 1  | -5   | -45      |   |
| 2  | -4.9 | -39.249  |   |
| 3  | -4.8 | -33.792  |   |
| 4  | -4.7 | -28.623  |   |
| 5  | -4.6 | -23.736  |   |
| 6  | -4.5 | -19.125  |   |
| 7  | -4.4 | -14.784  |   |
| 8  | -4.3 | -10.707  |   |
| 9  | -4.2 | -6.888   |   |
| 10 | -4.1 | -3.321   |   |
| 11 | -4   | -1.1E-13 |   |
| 12 | -3.9 | 3.081    |   |
| 13 | -3.8 | 5.928    |   |
| 14 | -3.7 | 8.547    |   |
| 15 | -3.6 | 10.944   |   |
| 16 | -3.5 | 13.125   |   |
| 17 |      |          |   |

Figure 10: The data generated using the auto fill.

After generating the data, you can easily change the inputs and the output simply by changing the start-value. In Figure 11, the start-value is  $-5$  but changing the start-value to  $7$  changes both the inputs in column A and the outputs in column B, Figure 12.

|    | A    | B        | C |
|----|------|----------|---|
| 1  | -5   | -45      |   |
| 2  | -4.9 | -39.249  |   |
| 3  | -4.8 | -33.792  |   |
| 4  | -4.7 | -28.623  |   |
| 5  | -4.6 | -23.736  |   |
| 6  | -4.5 | -19.125  |   |
| 7  | -4.4 | -14.784  |   |
| 8  | -4.3 | -10.707  |   |
| 9  | -4.2 | -6.888   |   |
| 10 | -4.1 | -3.321   |   |
| 11 | -4   | -1.1E-13 |   |
| 12 | -3.9 | 3.081    |   |
| 13 | -3.8 | 5.928    |   |
| 14 | -3.7 | 8.547    |   |
| 15 | -3.6 | 10.944   |   |

Figure 11: Start-value of  $-5$  in cell A1.

|    | A   | B       | C |
|----|-----|---------|---|
| 1  | 7   | 231     |   |
| 2  | 7.1 | 244.311 |   |
| 3  | 7.2 | 258.048 |   |
| 4  | 7.3 | 272.217 |   |
| 5  | 7.4 | 286.824 |   |
| 6  | 7.5 | 301.875 |   |
| 7  | 7.6 | 317.376 |   |
| 8  | 7.7 | 333.333 |   |
| 9  | 7.8 | 349.752 |   |
| 10 | 7.9 | 366.639 |   |
| 11 | 8   | 384     |   |
| 12 | 8.1 | 401.841 |   |
| 13 | 8.2 | 420.168 |   |
| 14 | 8.3 | 438.987 |   |
| 15 | 8.4 | 458.304 |   |

Figure 12: The data when the start-value is changed to  $7$ .

Using a start value will allow you to easily adjust the data as desired without having to reenter the data. Since the values in columns A and B are determined by formulas that depend on the value in cell A1, changing this value, for example from  $-5$  in Figure 11 to  $7$  in Figure 12, changes all values in these columns.

Of course, to make adjusting the data even easier, you could enter the values of the parameters that you would like to control in selected cells; if you want to be able to use these values later, you will find it helpful to label them on the worksheet. So, for example, instead of using a fixed increment of 0.1 as we have above, we could put the incremental value for the data in a cell and then reference this cell value in place of the 0.1 that we used above.

Let us put our start-value, -5, in cell D1, and the coefficients of our cubic function,  $y = x^3 - 16x$ , in cells E1, F1, G1, and H1, respectively, Figure 13. It is important to remember to use \$'s around the cell letter to fix the cells otherwise the auto fill will affect the row number for the parameters in the formulas. If you want to control the change in input, previously set as 0.1, you can store that in a cell as well; here, we will put our input-change in Cell J1.

|   |    |   |   |     |   |   |
|---|----|---|---|-----|---|---|
| C | D  | E | F | G   | H | I |
|   | -5 | 1 | 0 | -16 | 0 |   |

Figure 13: The start-value and the coefficients of the function entered in cells D1, E1, F1, G1, and H1, respectively.

|   |         |
|---|---------|
|   | SUM     |
|   | A       |
| 1 | =\$d\$1 |
| 2 |         |

Figure 14: The start-value is entered in cell A1 using a formula, =\$d\$1.

We enter the formula for cell A1, =\$d\$1, Figure 14, to set the start value, and then enter the formula, =a1+\$j\$1, Figure 15, in cell A2. When we use the auto fill, the formula in cell A2 will generate the inputs.

|   |            |   |   |  |  |
|---|------------|---|---|--|--|
|   | SUM        |   |   |  |  |
|   | A          | B | C |  |  |
| 1 | -5         |   |   |  |  |
| 2 | =a1+\$j\$1 |   |   |  |  |
| 3 |            |   |   |  |  |

Figure 15: The input formula that uses the start-value and the input-change, =a1+\$j\$1, is entered in cell A2.

|   |      |   |   |   |   |   |  |
|---|------|---|---|---|---|---|--|
|   | SUM  |   |   |   |   |   |  |
|   | A    | B   | C | D | E | F |  |
| 1 | -5   | =\$E\$1*A1^3+\$F\$1*A1^2+\$G\$1*A1+\$H\$1 |   |   |   | 0 |  |
| 2 | -4.9 |   |   |   |   |   |  |
| 3 |      |   |   |   |   |   |  |

Figure 16: The output formula, =\$e\$1\*a1^3 + \$f\$1\*a1^2 + \$g\$1\*a1 + \$h\$1, is entered in cell B1.

We enter the output formula, =\$e\$1\*a1^3+\$f\$1\*a1^2+\$g\$1\*a1+\$h\$1, in cell B1, Figure 16, and use the auto fill to generate the output for cell B2. Examining the entry in cell B2, Figure 17, we see that the auto fill did not change the row numbers for which we used \$'s – these, as desired, remained fixed.

|      |         |   |    |   |   |
|------|---------|---|----|---|---|
|      | B       | C | D  | E | F |
| -5   | -45     |   | -5 | 1 | 0 |
| -4.9 | -39.249 |   |    |   |   |

Figure 17: The auto fill is used to generate the entry in cell B2.

|      |         |   |    |   |   |   |
|------|---------|---|----|---|---|---|
|      | B       | C | D  | E | F | G |
| -5   | -45     |   | -5 | 1 | 0 |   |
| -4.9 | -39.249 |   |    |   |   |   |
| -4.8 | -33.792 |   |    |   |   |   |

Figure 18: The auto fill produces the "same" entry in cell B3.

Then, as before, we can use the auto fill to generate the number of desired input-output pairs; here, as before, we will generate 101 points. Having generated the data, we can change the data by changing any of these parameter values.

**Creating a Graph:** Now that we have two sets of data, one for which we can control the start-value and the other for which we can control the start-value, input change, and output function parameters, we are ready to generate some graphs.

Let us graph our first data set. We select the data that we want to graph, the data between rows 1 and 101, inclusive, in columns A and B. We open the Chart Wizard using either the Chart entry on the Insert menu or the Chart Wizard toolbar button, . The first step of four (4) is to select the graph type. Since we would like to create a curve that connects our data points without markers, we select the XY (Scatter) and "Scatter with data points connected by smoothed Lines without markers", Figure 19. The second step allows you to check the data series. We use the Data Range tab, Figure 20, to check that the location of the data, in columns A and B

between rows 1 and 101, inclusive. We can use the Series tab, Figure 21, to change the data series as we could on the Data Range tab, to name the data set, and to add and to remove series from our graph simply by specifying the location of the data. Here, let us name this data series “First Set”, Figure 22.

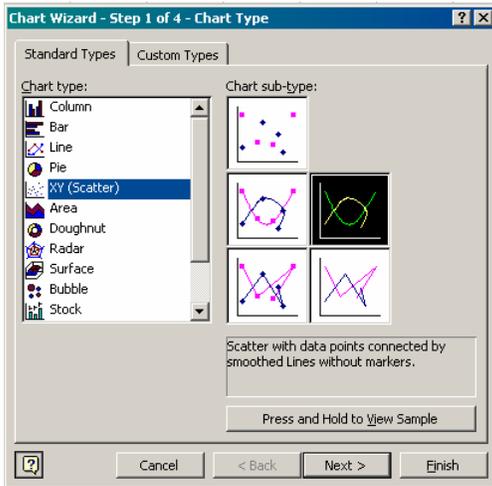


Figure 19: Step 1 – Select the chart type.

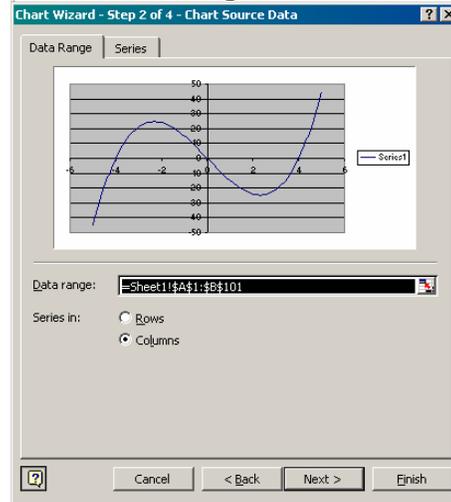


Figure 20: Step 2 Data Range tab – the Data range and the location of the series, Rows or Columns.

After entering the name for our data series in the Name box, the name will appear in the Series box as well as in the graph legend, Figure 22.

In general, I find that naming the data series makes dealing with the data more complicated. I chose to name the series here so that you will have an opportunity to see how to name and then rename a series. For our renaming of the series, it is important to note that the original name of the series was “Series1”.

When I create a graph containing only one data set, I never use a legend. The legend tends to take up space, and in the case of a graph containing only one data series, the legend serves no purpose; a graph title, that can be entered using the Titles tab in Step 4, is more useful for providing information about the data and the graph.

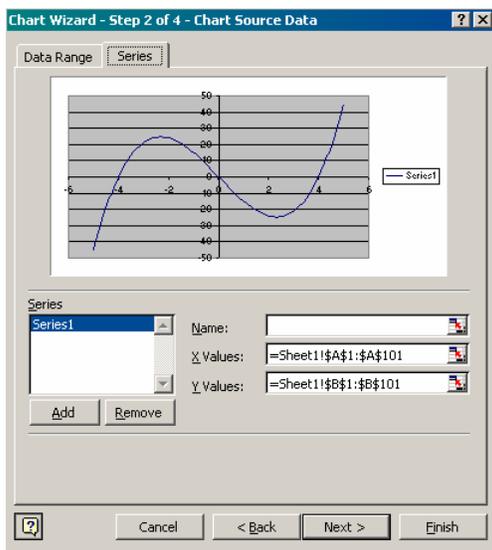


Figure 21: Step 2 Series tab – useful for changing the inputs and output, naming the data set, and adding and removing data series.

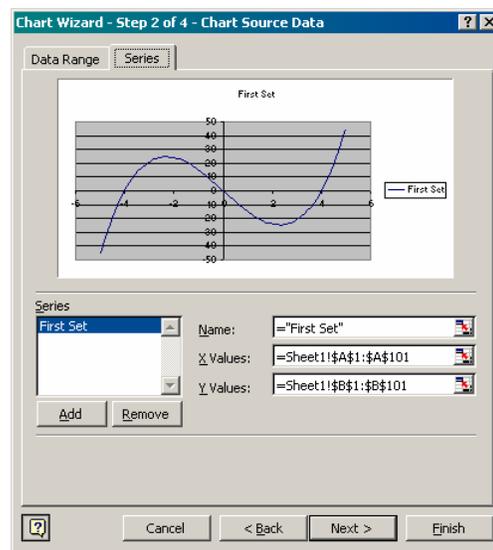


Figure 22: Step 2 Series tab – after our data set has been named “First Set”.

For graphs containing more than one data series, using a legend and naming the data series is very helpful for data and graph manipulation as well as to those reading the graph.

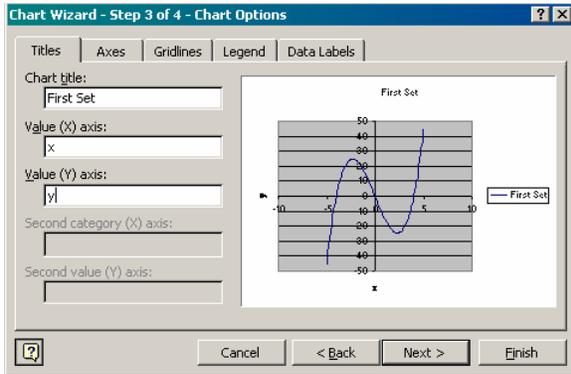


Figure 23: The Titles tab in Step 3.

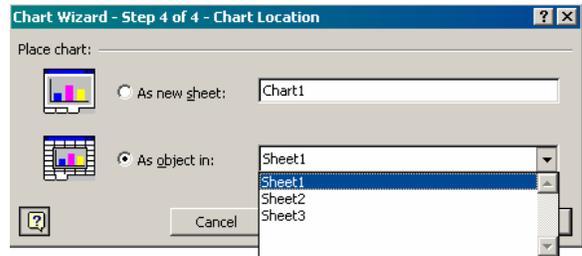


Figure 24: Step 4 – select the location of the graph.

In Step 3, if you choose to remove the horizontal gridline, you may do so using the Gridlines tab. The Legend can be removed using the Legend tab, and titles and axis labels can be added using the Titles tab, Figure 23. Here, the title is added so that I can show you how to modify and remove the title.

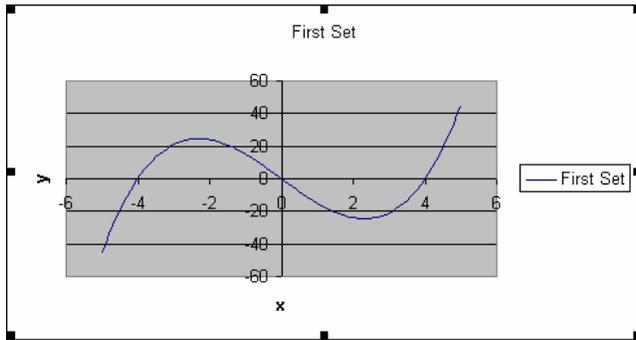


Figure 25: The newly generated graph.

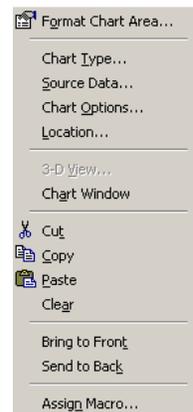


Figure 26: The pop-up menu that is displayed when you right-click the white region of the graph.

In Step 4, Figure 24, we determine the placement of the graph, on the current sheet or one of the other sheets within the workbook, here, sheets 1, 2, and 3, or a new sheet that you can name; the default is “As object in” the current sheet, and the default new name is “Chart” numbered from 1.

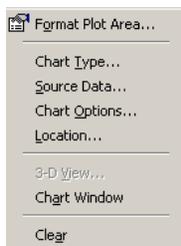


Figure 27: The pop-up menu that is displayed when you right-click the grey region of the graph.



Figure 28: The pop-up menu that is displayed when you right-click a gridline.

After clicking Finish in Step 4, the new graph, Figure 25, is generated and placed near the data on the selected sheet. If you like the graph as is, then it is ready for use. Of course, if you do not, then you will need to modify the graph, changing the attributes as desired.

**Modifying a Graph:** Since I do not like the gray background, the gridlines, the input or the output scales, the placement and orientation of the axis labels, or the title, we will modify the graph.

Right-clicking the white region of the graph generates a pop-up menu, Figure 26, that allows us change the attributes of the graph area (Format Chart Area), to change the graph type, to access the Source Data, and to change the graph options. Selecting Chart Options allows you to change the elements of Step 3, Titles, Axes, Gridlines, Legend, and Data Labels. So, of course, this would provide one way in which to eliminate the gridlines, the legend, and the title.

Right-clicking the grey region of the graph generates a pop-up menu, Figure 27, that allows us to change the plot area (Format Plot Area), the graph type, the Source Data, and the graph options. So, when we need to access the sources data or change the graph options or graph type, we can simply right click on the chart or plot area.

The *easiest* way in which to delete the gridlines is to right-click a gridline and then select the Clear option on the pop-up menu, Figure 28. If you choose to keep the gridlines, this same pop-up menu will allow you to access the Format Gridlines dialog box in which you can change the weight, pattern, and color of the gridlines as well as change the scale on the associated axis. Needless to say, I used the Clear option to remove the gridlines.

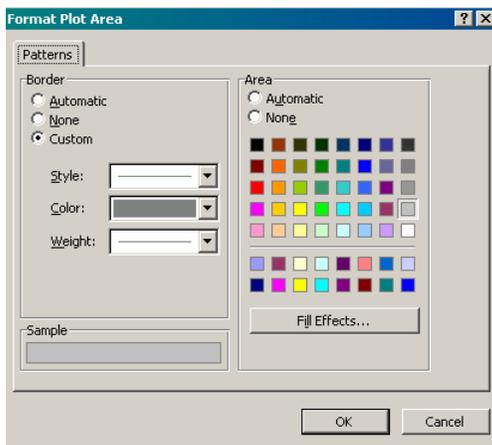


Figure 29: The Format Plot Area Dialog Box.

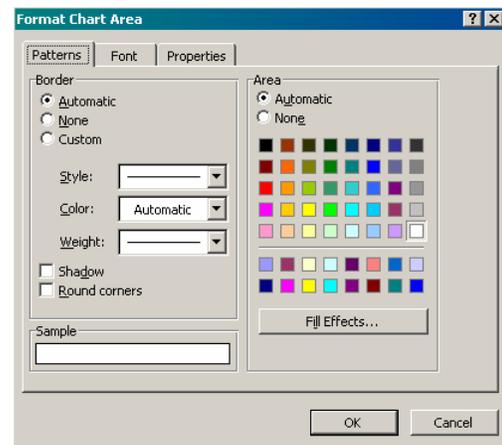


Figure 30: The Format Chart Area Dialog Box.

Right-clicking the grey region and selecting Format Plot Area on the pop-up menu, opens the Format Plot Area Dialog Box, Figure 29, in which we can change the border pattern and color and the color and pattern of the Area. Here, we will remove the border and make the Area white. It is very important that you are careful when you select None for the Area – selecting None makes the plot area transparent. If you choose to use this option, I would suggest that you use it after you have made all of your other graph changes; selecting the parts of the graph become difficult when the Plot Area and the Chart Area are transparent.

To change the border on the Chart Area, right-click the Chart Area, the outer region of the graph, and select Format Chart Area on pop-up menu. Notice that having changed the Plot Area color to white, changing the Chart Area after that becomes more difficult, especially if you have resized the Plot Area. So, I suggest that you change the Chart Area before you change the plot area; resizing the plot area in between would be beneficial as well especially if you plan to make the Chart Area and the Plot Area the same color.

Using the Format Chart Area dialog box, Figure 30, you can change the color, style/pattern, and the weight of the border as well as change the color of the Chart Area. In addition, you can change the font, color, style, and size that will be used for the title and the legend. Here, we only eliminate the border.

So, if you choose not to make any changes to the title, the legend or the axis labels, then in order,

- modify to the Chart Area,
- resize the Plot Area (left-click the Plot Area to select it; move the cursor to one of the handles, the black rectangles at the corners or middles of the sides, until the cursor becomes a black double-arrow, and then left-click, hold, and drag the plot area to the desired size), and then
- modify the Plot Area, to make things as simple as possible.



Figure 31: The pop-up menus for the Chart Title, the Axis Title, and the Legend.

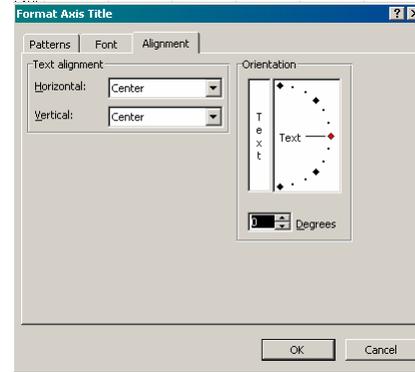


Figure 32: The Alignment tab in the Format Axis Title Dialog Box.

If you decide to delete chart title, axis labels or the legend, you can do so by left-clicking to select the chart title, axis label or legend and then use Cut on the Edit menu, the Delete key, or right-clicking and selecting Clear on the associated pop-up menu, Figure 31. To change the location of the chart title, the axis titles, or the legend, simply left-click the chart title, the axis title, or the legend and drag it to the desired location. The format option on these pop-up menus can be used to change the alignment, patterns and font for the associated item. In addition to right-clicking and selecting the associated Format option on the pop-up menu, the format dialog boxes can also be opened by double-clicking the chart title, the axis title, or the legend..

Using the Alignment tab of the Format Axis Title Dialog Box, Figure 32, we fix the orientation of the y-axis label; this label is always written vertically along the left-hand side of the plot area.

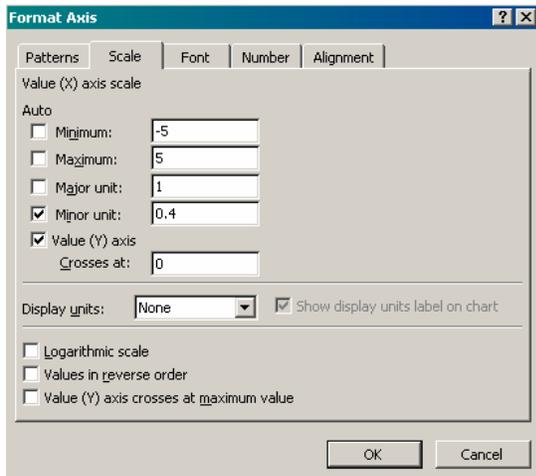


Figure 33: The Format Axis Dialog Box.

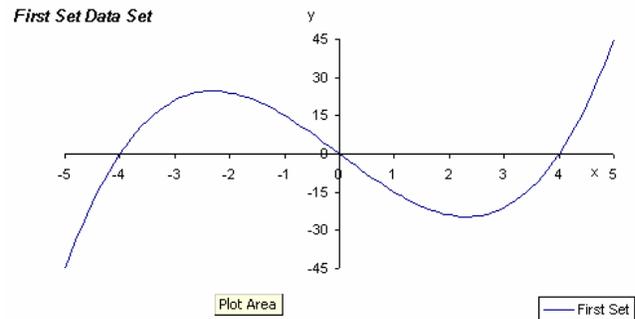


Figure 34: The modified graph.

Using the Format Axis dialog box, we can change the font for the scale, change the axis markers, the alignment of the markers, the axis pattern, and the scale. In Figure 33, we change the x-axis minimum value to  $-5$ , the maximum value to  $5$ , and the major unit to  $1$ . As with the other Format dialog boxes, this one can be opened by right-clicking and selecting the appropriate entry on the pop-up menu or by double-clicking.

So, making the various changes produces our modified graph in Figure 34. Having modified our graph, there is one more thing to discuss, how to easily add data series to a graph.

**Adding a Data Series to a Graph:** Rather than using Copy/Paste to add a data series to our graph, we will use the Source Data option. However, we must know *where* our data is. I entered the second data series on Sheet 2 in columns A and B between rows 1 and 101, inclusive. Opening the Source Data dialog box, Figure 35, by right-clicking either the Chart Area or the Plot Area, we see the format of the x-values and y-values of the series,

=Sheet1!\$A\$1:\$A\$101, following an equal sign we need the sheet name, an exclamation point, and then the ranges of the data values with the cells specified as fixed cells using dollar signs.

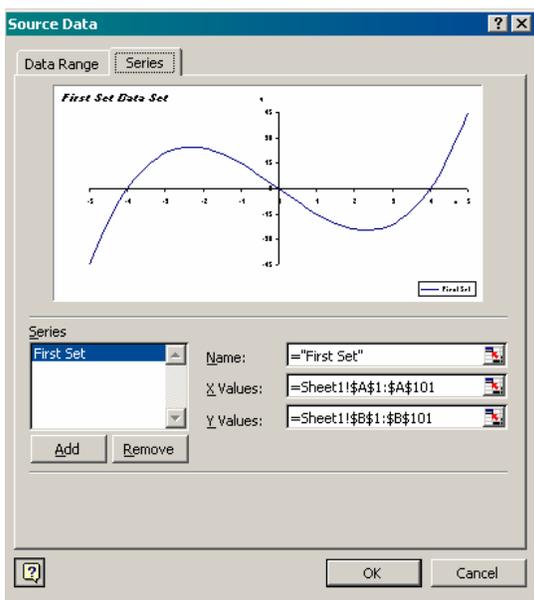


Figure 35: The Series Tab in the Source Data Dialog Box.

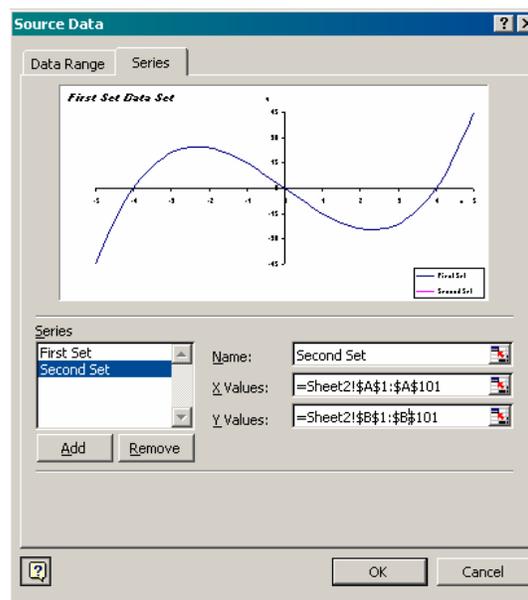


Figure 36: The Second Data Series Added.

To add our data series, we select Add to generate a new series, name the data series, if desired, and specify the location of the data. Figure 36 displays the newly added second data set, “Second Set”. Clicking OK adds our second data set to the graph and adds an entry to the legend; of course the title needs to be changed now, Figure 37.

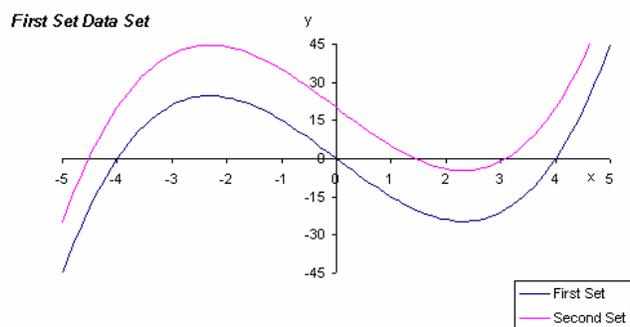


Figure 37: Both data series displayed in the graph.

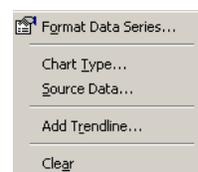


Figure 38: Right-clicking a curve generates this pop-up menu.

Using the Location... entry in the pop-up menus in Figure 26 and Figure 27, we can move the graph, if desired to another sheet. If we are creating graphs that we want to include in documents, it is helpful to have easy access to the graph and the corresponding data: we would want to place the graph on the same page as the data so that we can modify the data and the graph easily. If we are creating a MS Excel document to be used by students as part of an assignment, the placement of the graph will depend on what we would like the student to be able to see. It is important to remember that if we want the user to be able to access both the graph and the data elements on the worksheet then we must make these elements easy to access: putting the graph and the corresponding data on the same worksheet may be best.

Changing the appearance of the curves is helpful for graph comparison. To do this, we right-click the desired curve and select Format Data Series on the pop-up menu, Figure 38. We can change the type of Line as well as the Weight, Style, and Color and choose to include or not include Markers for the individual data values, setting both their Foreground and Background colors, on the Patterns tab. It is important to note that Markers

are best for a small number of data values rather than for closely spaced data values; the same can be said for Data Labels.

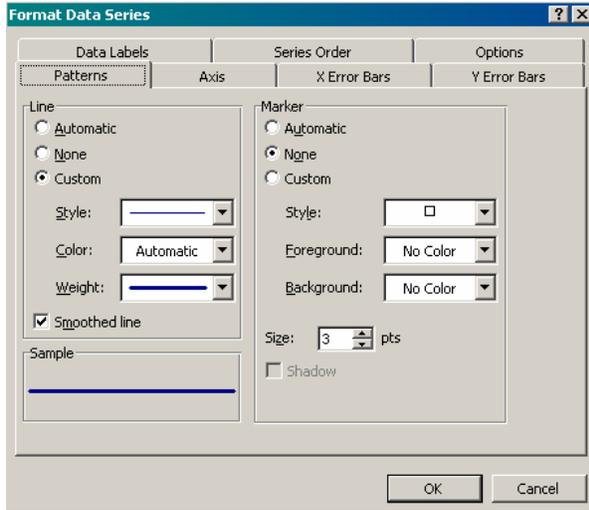


Figure 39: Changing the Curve for the First Data Series.

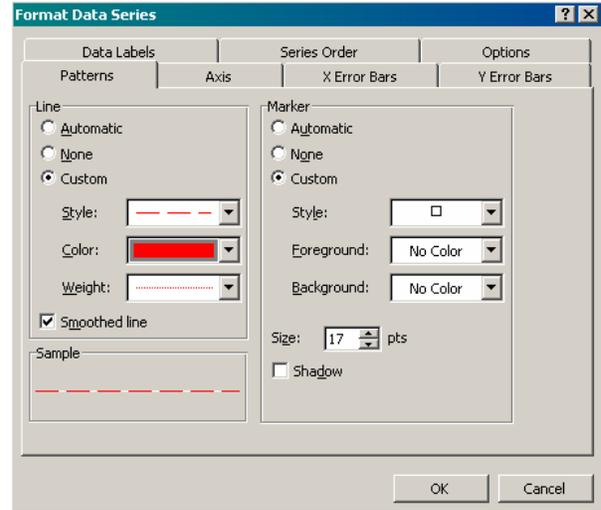


Figure 40: Changing the Curve for the Second Data Series.

Then, we change the desired attributes of the curves as desired, Figures 39 and 40. Here, we change the color of each curve, setting one to have a solid blue thicker curve, Figure 39, and the other to have a lighter weight broken red curve, Figure 40.

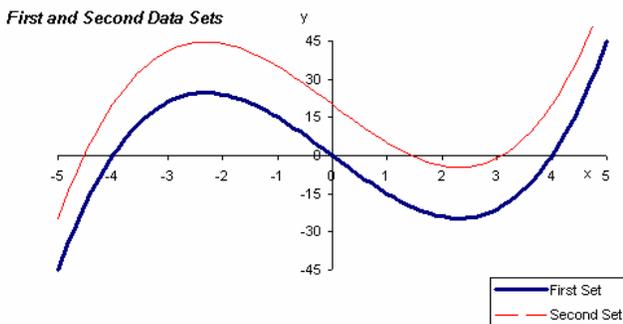


Figure 41: Our New Graph.

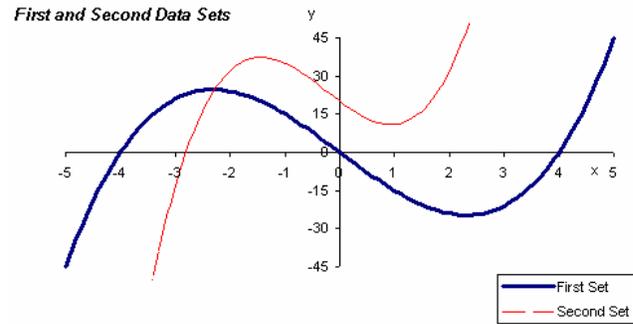


Figure 42: The second curve modified by changing the parameters.

Finally, after completing our graph modifications, Figure 41, we can see the benefits of using the fixed cells for our parameters since we can change the second curve by simply changing the parameter values, Figure 42.

As discussed, right-clicking the graph allows us to access pop up menus for graph components that we may want to modify. In order to easily access the pop up menu for the desired graph component, we can use the textboxes that MS Excel provides. As we move the cursor over the graph, MS Excel displays a textbox that indicates the component that will appear at the top of the pop up menu that will be displayed when we right-click the graph, for example right-clicking the graph displayed in Figure 34 would produce a pop up menu that would allow us to open the Format Plot Area dialog box; double left-clicking the plot area would open the Format Plot Area dialog box as well. These textboxes are helpful when we want to format components such as specific data series and the axes for the graph.

It is important to consider effective color contrast for those with partial sight or visual impairments and the size of worksheet elements for those with motor skills limitations/impairments. Darker colors are easier to see as are thicker lines/curves, and small elements/icons can be difficult for those with partial sight or visual impairments to see; if you would like to learn more about effective use of color contrast, please visit [http://www.lighthouse.org/color\\_contrast.htm](http://www.lighthouse.org/color_contrast.htm).