An Excel Primer

Excel will be used in several labs throughout this course. This primer provides information on how to do some of the things you'll need to do. Remember that you can also reach out to your TA or lab group for help.

The examples in this primer are designed to work with Excel for Windows. If you use Excel for a Mac or in a browser some of the functionality and ways to access it may be different.

Acquiring and getting help with Excel

1. To acquire and run a local version of Excel go to https://is.oregonstate.edu/microsoft. Click download office then install it: This will also give local access to other Microsoft products such as OneNote and Word.
2. If you are having trouble accessing the Excel, contact the OSU help desk at https://is.oregonstate.edu/service-desk.

Working with data

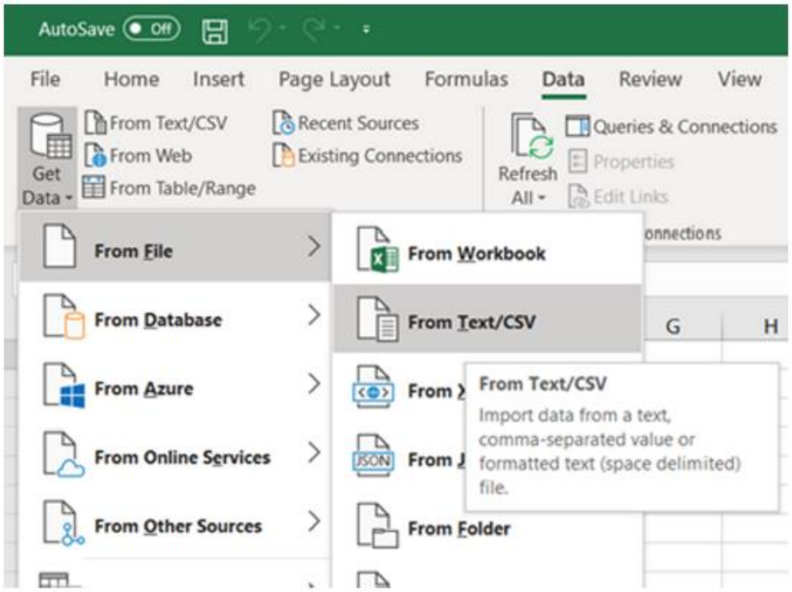
Importing data

Importing data is necessary for most of the things you will be doing with Excel. Here are some instructions for doing so. The menu options may slightly vary depending on the version of Excel that you are using.

1. Open a blank workbook in Excel.
2. Copy your data from your source and paste it into Excel.

Or

1. Click on the **Data** tab.
2. Click on the **New Query** icon.
3. Click on the **From a File** icon.
4. Select the option most appropriate for the data you are trying to import. Generally, data from analytical instruments such as the force probe on your cart can be saved as a .CSV file that imports with few problems to Excel.

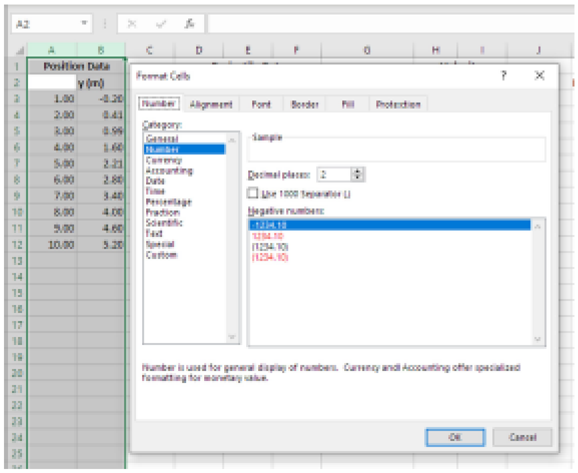


5. After selecting the file click **Open**

Formatting Cells

Sometimes copying data into Excel will result in the data being in a format that cannot be used in Excel formulas.

1. After copy/pasting data into Excel, Highlight the columns containing the data. Right click and select **Format Cells**.
2. A menu will pop up. Here, you can select the **Category** of data for the column. In order to use the data for Excel Formulas, you should select **Number** and then click "OK".



Cell references

Cells are labeled by giving the column (labeled by capital letters) and the row (labeled by a number). For example, the cell in the second column three rows down is labeled B3. Excel cells can hold a variety of types of data such as numerical values, dates, texts, and formulas.

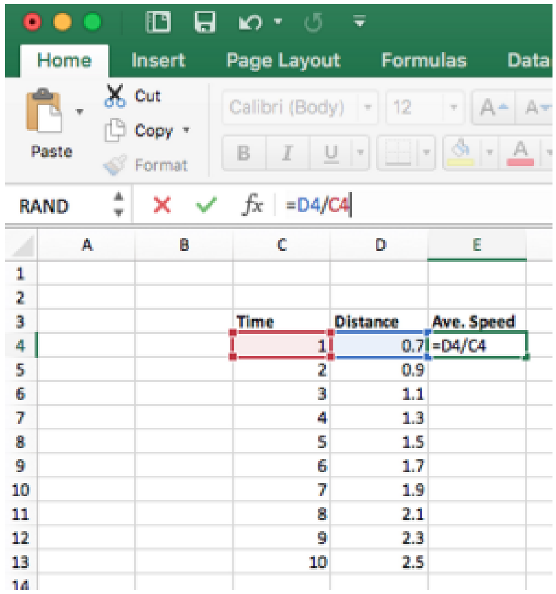
- Cells in Excel hold numerical values, as well as other types of values such as text and dates, as needed.
- Any cell reference preceded by a dollar sign is an absolute reference that will not change if references to the cell are, for example, copy and pasted.
    - For example, *$B4* will always refer to the second column of the spreadsheet, though the row (4) may be updated if used in an Excel formula. *B$4* will similarly always refer to the fourth row, though the column may be updated if used in an Excel formula. *B4* will always refer to the second column and fourth row of the spreadsheet, no matter what. This can be a handy way to store "constants" that have to be reused repeatedly elsewhere in the spreadsheet.

Formulas

Formulas in Excel can be used to calculate a value in the selected cell by substituting values from other cells and performing mathematical operations. For example, if the distance traveled is in cell *D4* and the time it took is in cell *C4*, you can have Excel calculate the average velocity over that time interval in cell *D4* by entering *"=D4/C4*" in cell *E4*. Formulas always begin with an "=" sign.

a. You can insert formulas by typing directly in the cell or by selecting the cell and entering the formula in the "formula bar", the text field just above the C and D column headings in the image above.

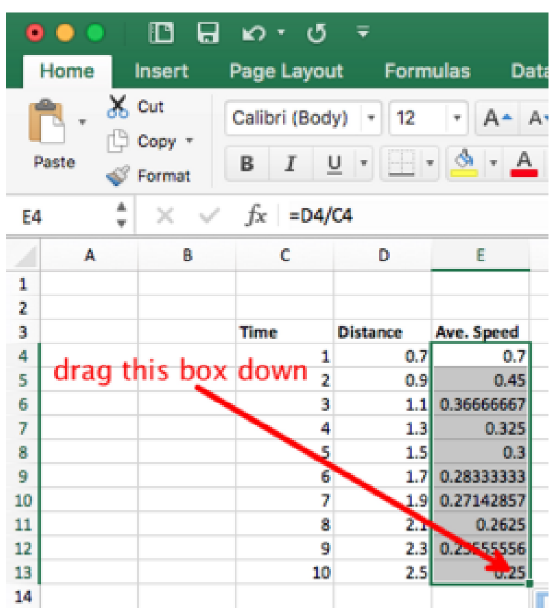
b. Exponents are entered using the carat ^ character. For example, to calculate the cube of the value in cell *A17*, enter "=*A17*^3" in whichever cell you would like that value to appear.



c. Excel has many built-in functions that can be used for calculations such as trigonometric functions, exponentials and logarithms, statistical functions, and many more. Their properties are well described in Excel's help, and you can investigate what's available using the **Formula Builder** available at **Insert > Function**…

d. If you have a long set of columns in which the same calculation must be performed but with different values in each row, you can "drag down" a formula and Excel will copy the formula into every cell in the column you drag over intelligently updating the cell references. (Any absolute references, as defined above, will not be updated.)

e. To drag a formula down, click on the cell containing the formula to select it. Hover the cursor over the bottom right corner of the selected cell until a small square appears just on that corner. Click on



the square and drag the formula down over all the cells in which you wish a (suitably updated) copy of that formula to appear:

Numerical Analysis Skills

Numerical analysis is the use of algorithms to computationally compute a result. Excel, which offers a variety of tools to analyze the data collected in labs.

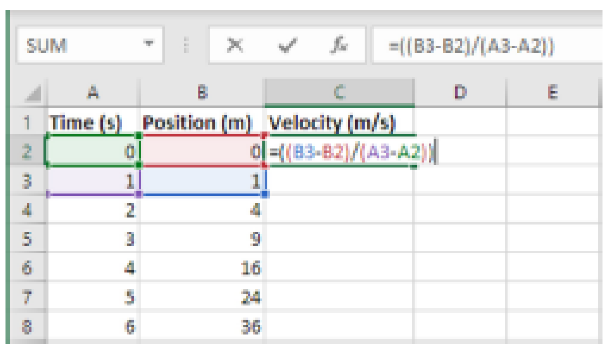
Finding Slopes (aka Derivatives)

1) A derivative is the slope of a tangent line at a given point on a graph. It tells you about how one value changes with respect to the other. For example, the slope of position with respect to time tells you how the position of an object changes for a given amount of time, or in other words the velocity of an object.

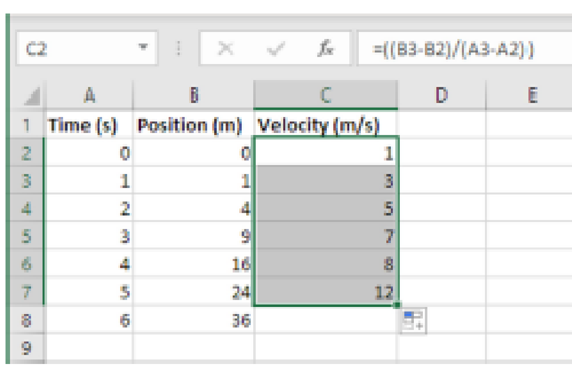
2) Slope is calculated by dividing the change in the values plotted on the vertical axis over the change in the values plotted on the horizontal axis. The equation below gives an example for calculating the slope between two points: (x_1, y_1) and (x_2, y_2).

$$\text{slope between } (x_1, y_1) \text{ and } (x_2, y_2) = (y_2 - y_1) / (x_2 - x_1)$$

3) Consider some sample data below. The time (column A) and position (column B) of an object at that time has been recorded in the spreadsheet. The next step is to calculate the slope (which would be the velocity of the object) for each data point. In this example, you would start by calculating the slope for time t=0s. In cell *C2*, type "*=((B3 - B2)/(A3-A2))*". This finds the change in position and divides that by the change in time between data points. This calculates the slope according to the formula above.



4) The velocity (slope) has now been calculated for one point. Click on the cell where the derivative was calculated, click on the green box in the bottom right-hand corner and drag it down to the second-to-last cell. Excel defaults to empty cells in formulas being zero, which means if you drag the formula



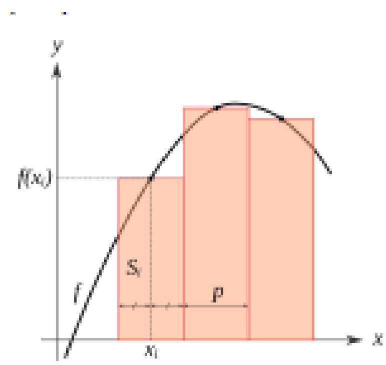
down Excel will give you a value for the velocity but it will not actually be a true value. The slope for that last data point cannot be calculated because the position is not known for time t=11s. This means that we don't have data to use for the slope formula.

Finding Areas Under a Curve (aka Integrals)

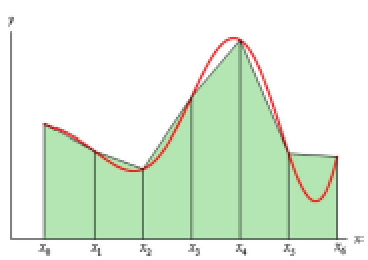
The "integral" of a function is the area under its curve between two points. If you have taken calculus, you may be familiar with the notation for an integral: $\Delta v = \int_{t_1}^{t_2} a\, dt$. This equation says that the change in the velocity between two times t_1 and t_2 is the area underneath the acceleration curve (as a function of time) between those two times. Here's an example of how to find the change in the velocity from the acceleration vs. time by finding the area under the acceleration vs. time curve.

There are several methods of finding areas (integrating data) in Excel:

- The midpoint rule estimates the area under the curve as a series of pure rectangles (centered on the data point). As you can imagine, this results in poor accuracy when the data (integrand) is changing rapidly.



- The trapezoidal rule estimates the area under the curve as a series of trapezoids. This greatly increases the accuracy, regardless of the change in the integrand. To calculate the velocity at any given time, we need to calculate the integral of acceleration over time. Since we have a limited number of data points, the trapezoidal method will give us the greatest accuracy for our calculated velocity and position data. This is what we suggest using in lab.



Note that the plots above demonstrate the areas that a midpoint/trapezoidal rule use to calculate the area under the curve. They do not represent what an area under the curve plot looks like. The area under the curve plot will look like any other scatter plot you produce.

An Excel Primer

Consider a dataset that looks like the following. We have acceleration data and we want to get the velocity at each time by finding the area under the acceleration vs. time curve up to that moment.

	A	B	C
1	Time (s)	Acceleration (m/s^2)	Calculated Velocity (m/s)
2	0.02	0	
3	0.06	0.5	
4	0.1	0.6	
5	0.14	0.7	
6	0.18	0.8	
7	0.22	1.06	
8	0.26	1.24	
9	0.3	1.42	
10	0.34	1.6	
11	0.38	1.78	
12	0.42	1.96	
13	0.46	2.14	
14	0.5	2.32	
15	0.54	2.5	

We need to calculate the area of the first trapezoid, which is given by

$$\{[a(t = 0.02) + a(t = 0.06)]/2\}\,\Delta t,$$

where Δt is the base of the trapezoid, and *a(t=0.02)* and *a(t=0.06)* are the top corners of the trapezoid.

a. We can calculate the base of the trapezoid Δ*t*, the change in time between cells, by using the formula "*=(A3-A2)*" in cell *C3*.

b. Next, we need to calculate the average of the heights of the trapezoid. We will do this by averaging the acceleration at two adjacent point resulting in the formula *((B2+B3)/2)*.

c. The area of the trapezoid is the base times the average of the heights. This gives the formula
d. *=(A3-A2)*((B2+B3)/2)*. This is the area of the first trapezoid that is width *Δt*.

RIGHT | × ✓ fx | =(A3-A2)*((B2+B3)/2)+C2

	A	B	C
1	Time (s)	Acceleration (m/s^2)	Change in Velocity (m/s)
2	0.02	0	
3	0.06	0.5	=(A3-A2)*((B2+B3)/2)+C2
4	0.1	0.6	
5	0.14	0.7	

e. An integral sums the area of all of these trapezoids that we are calculating. In cell *C3*, we will need to add the area in *C2*. In cell *C4*, we will need to add the area in *C3*, and so on. So in our formula we add the area from the previous calculation. In cell *C3* type "*=(A3-A2)*((B2+B3)/2)+C2*". Remember to pay attention to parentheses.
   - Leave the first area cell, *C2,* blank, since there's no previous time to use.

f. Now drag the formula in *C3* down to the last time, t=0.54s. Column C now contains the velocity of the object at each time! (Strictly speaking, it contains the change in the velocity from the initial time, which is exactly the velocity at that time if the initial velocity was zero. We cannot calculate the velocity at time 0.54s because we do not have data about the acceleration at the next time, 0.56s.) Now you have data about the velocity at each point in time, except for the very last time recorded. This data can then be plotted.

An Excel Primer

	A	B	C
1	Time (s)	Acceleration (m/s^2)	Change in Velocity (m/s)
2	0.02	0	
3	0.06	0.5	0.01
4	0.1	0.6	0.032
5	0.14	0.7	0.058
6	0.18	0.8	0.088
7	0.22	1.06	0.1252
8	0.26	1.24	0.1712
9	0.3	1.42	0.2244
10	0.34	1.6	0.2848
11	0.38	1.78	0.3524
12	0.42	1.96	0.4272
13	0.46	2.14	0.5092
14	0.5	2.32	0.5984
15	0.54	2.5	0.6948

Plotting and Fitting Data

Each lab will require you to visualize the data you've collected. Graphical Analysis will often plot things for you, and fitting data in that program is relatively easy. You will also be asked to generate plots in Excel as well. This will guide you on how to create scatter plots, the most commonly used plot for the labs you will be doing.

1. In Excel, drag and select all of the data that you want to plot. For ease of plotting, your independent variable (in most cases, time) should be to the left of your dependent variable (position, for example).

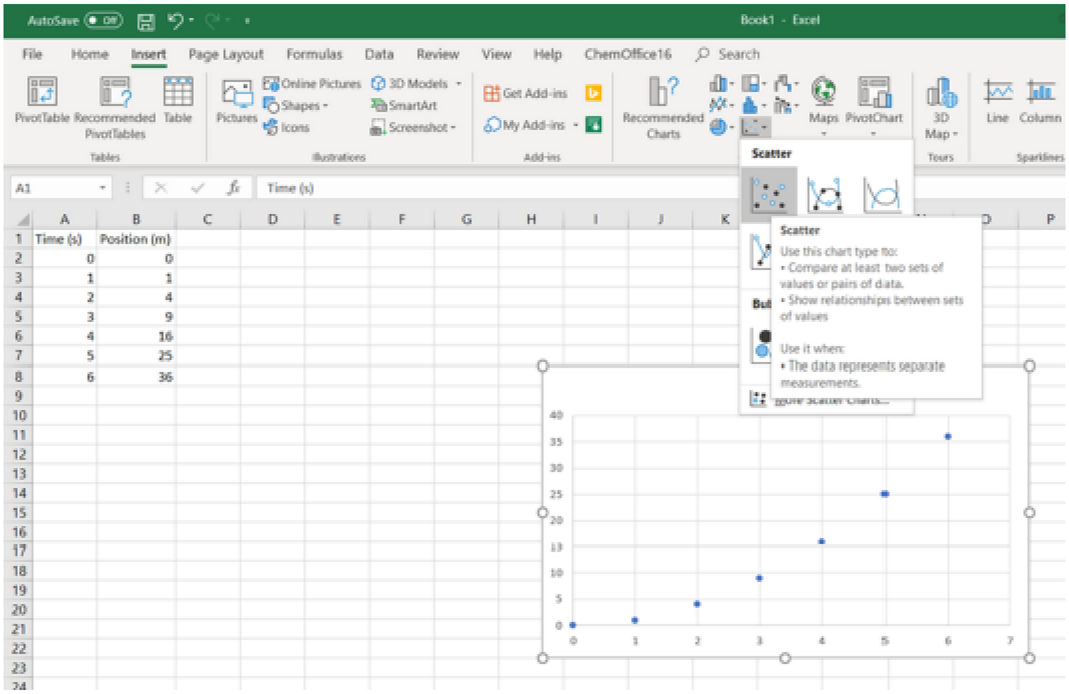
8R x 2C

	A	B	C
1	Time (s)	Position (m)	
2	0	0	
3	1	1	
4	2	4	
5	3	9	
6	4	16	
7	5	25	
8	6	36	
9			

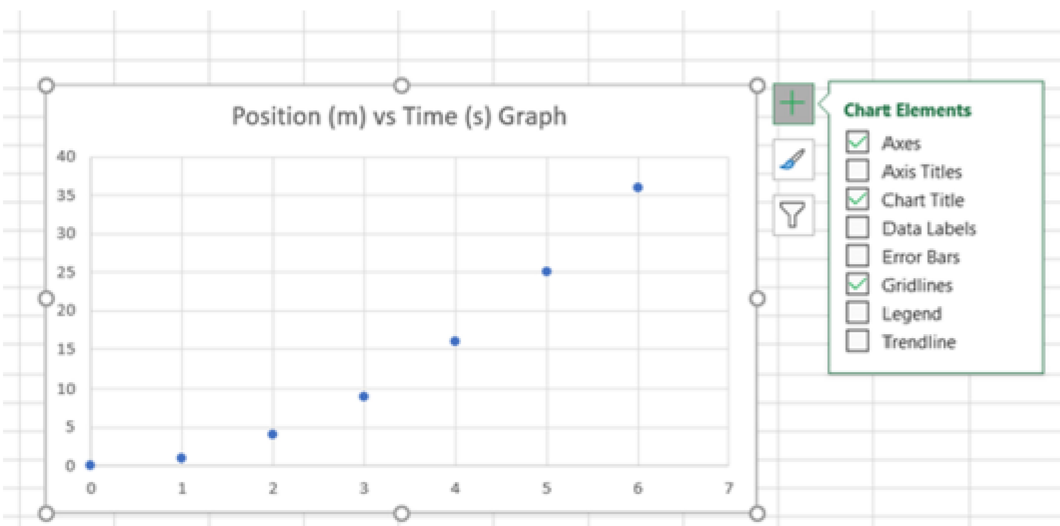
2. Select the Insert tab. In the section titled **Charts** select the scatter plot icon shown below.

3. You should usually choose the default scatter plot, with unconnected points. Only choose the one with lines if you need to better visualize where the points are. Don't choose it if, as is usually the case, you're going to fit the data with a curve. Whatever you choose, your data points should be visible.

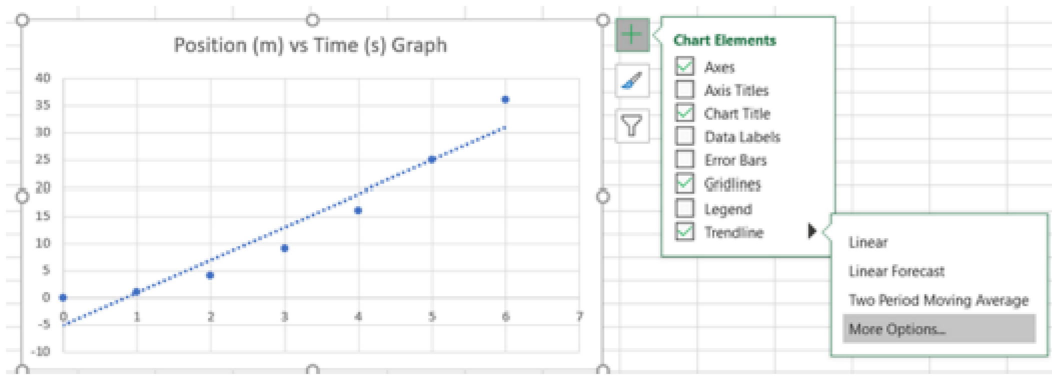
An Excel Primer



4. Always add a title to your plot and appropriate axes labels. To do this, click on the plot. In the **Design** tab, on the left you will see an option to **Add Chart Element**. Clicking on this will allow you to add a plot title, axes labels, and more. Alternatively, when you click on the plot a green plus sign will appear on the top right corner of the plot. Clicking on this will reveal a menu where you may select what elements you want on the plot. For example, if you have two lines plotted you will want to add a Legend to the plot.



5. Often you will want to include a trendline on your plots to get a value of the slope of the line or other parameters. If you click the **Trendline** option, a linear trendline will appear on the graph and an arrow will show up next to the check box in the chart elements section. Click on **More Options**.



6. Now you can select the type of fit you want (linear, logarithmic, polynomial, etc.). You should also select the option **Display Equation on Chart** to get the fit parameters, such as slope and the intercept of the data.

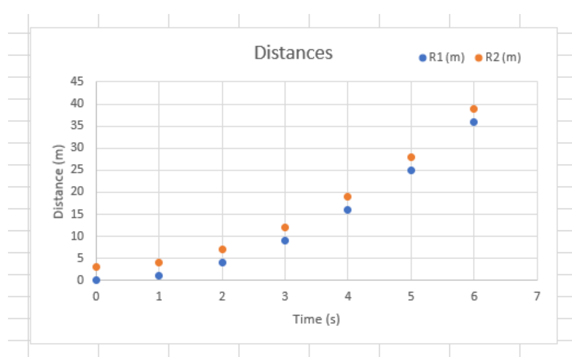
Plotting multiple data sets

You can easily plot more than one set of data on the same graph if they share the same x-values. To do so, arrange the data so the x-values are in the first column. Each column after that should include one set of data to plot.

1. Select all the columns containing data.

	A	B	C	D
1	Time (s)	R1 (m)	R2 (m)	
2	0	0	3	
3	1	1	4	
4	2	4	7	
5	3	9	12	
6	4	16	19	
7	5	25	28	
8	6	36	39	
9				

2. Insert a graph, as before. Your new graph should have multiple data sets in different colors and shapes.



Notice that the graph now includes a legend (upper right), identifying each set of points. You can reshape the legend as well as change the colors and styles of the points.

3. You can also use different y-axis scales for the data sets. Right click on the data set, select "Format Data Series", and choose "Secondary Axis." The data will be plotted using the scale on the right, rather than the scale on the left.