

# **Microsoft Excel Tutorial**

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## **Objective**

The purpose of this lab is to become familiar with the Microsoft Excel spreadsheet program. Many of the experiments performed in lab require the use of Excel in order to analyze the collected data. This tutorial will cover many of the tools available in Excel that will be used during the laboratory experiments to analyze data. After completing this tutorial you should be able to navigate through Excel's menus, have an understanding of the usefulness of Excel, and understand concepts such as copying and pasting, entering formulas, absolute and relative cell referencing, graphing, and regression analysis.

Each of these tools will be used extensively throughout the laboratory, so it is very important that you understand how and why these tools are used. It is also a good idea to save this section for future reference.

## **Practice Experiment**

In order to demonstrate many of the tools in Excel, you will be analyzing data from a fictional experiment. It is an experiment in projectile motion, showing the position of a projectile after being given an initial velocity and angle. You will be asked to perform several calculations, graph several groups of data, and perform types of analysis. The physics behind this experiment is not important for this lab; it is used to demonstrate Excel in a more practical way. The tutorial will start slow, assuming very little knowledge of Excel, but will progress quickly. You need to understand each step that is described in order to use that information in subsequent parts of the tutorial where each step might not be explained.

## Labeling & Entering Data

### Entering Text

To open a new Excel worksheet, double click on the Excel icon found on the desktop screen. Place the mouse cursor in cell A1 and click the left mouse button A1, and type 'Physics Experiment in Projectile Motion', and hit enter. That is how you input text into a cell. Now continue entering the labels as shown below.

	A	B	C	D	E	F	G	H	I
1	Physics Experiment in Projectile Motion								
2									
3	Angle	Velocity	X Velocity	Y Velocity					
4	0.785	110	77.81270961	77.75076992					
5									
6									
7		Calculated Position			Measured Position		Measured Velocity		
8	Time	X Position	Y Position		X Position	Y Position		Y Component	
9									
10									
11									
12									

Figure 1. Excel spreadsheet labels.

If you right click on the column heading Excel will display a popup menu with options for changing the cell format and the cell width. We won't discuss these tools, used for changing the look of you spreadsheet, but you should spend some time learning how to use them.

### Copying Text

Under the heading 'Time' we will begin entering the time starting with 0 ending at 15.5 and incrementing by 0.5. This is made easier by just typing in the first couple of rows and copying down the rest, letting Excel input the next correct Time into the cell. Follow the steps below to enter the times.

- ❖ First, simply enter 0 into cell A9. Then .5 into cell A10, and 1 into cell A11.
- ❖ With your mouse click on cell A9 and hold the mouse button down.
- ❖ With your mouse button held down drag your mouse down to cell A11 highlighting these cells.
- ❖ Move your mouse to the lower right corner of cell A11 until the mouse arrow turns into a '+'.
- ❖ When the mouse arrow has turned into the plus sign (+) hold down the left mouse button and drag down to cell A40.
- ❖ Notice when you are dragging down Excel is placing the next incremented time into the next cell.

Now you have just entered all the times used in our experiment with very little typing. This was only slightly easier than just typing in the data, but other times when there is a lot of incremented numbers to type this trick will come in very handy.

### Entering Data

In cell A4 enter 0.785, this is the angle, in radians, in which the projectile was launched. Enter 110 in cell B4, this is the initial velocity of the projectile. Starting at cell E9 enter the data shown below. These data represents data you might have recorded during an actual lab experiment.

Table 1

Measured Position	
X position	Y position
0	0
40	40
80	70
120	100
160	130
200	160
230	190
270	210
310	230
350	250
390	270
430	280
470	290
500	300
550	300
590	310
620	310
660	310
700	300
740	300
780	290
820	280
860	260
900	250
930	230
970	210
1010	180
1050	160
1090	130
1130	100
1160	60
1210	30

You should now be able to enter data into a cell as well as highlight cells and copy down. You will need to know these skills for the rest of the tutorial.

## Entering Formulas and Absolute Cell Referencing

In this section we will be calculating what the actual position of the projectile should be by using the formulas. Again, the formulas used in this section are not important, but the way they are entered and copied is important and will be used many times during the semester.

### Entering Formulas

We will now enter formulas in cells C4 and D4 to calculate the X and Y velocity components. We will use two different methods to enter the formulas to give a better understanding of the process.

\*Note: when asked to type ‘something’, only type what is in the quotations, not the quotations themselves.

Steps to enter formula into cell C4

- 1) Select cell C4 by clicking on it, then type ‘=’. The equals symbol tells Excel that the following information is a formula and not plain text.
- 2) Directly after the equals sign type ‘B4 \*’. This tells Excel to take what is in cell B4 and multiply it times what comes next.
- 3) Next, from the menu choose *Insert - Function* to open the *Paste Function* dialog box.
- 4) Under the Function Category choose the *Math & Trig* option. Then under *Function Name* scroll down and choose *COS*.
- 5) After choosing *COS*, the *COS* dialog box will open prompting you for the number of which to take the cosine of. In this box you enter A4 because this is the cell that holds the angle.
- 6) After choosing *OK* in the *COS* dialog box you should have a value of 77.81 in cell C4

Steps to enter formula into cell D4

- 1) Again select cell D4 by clicking on it, then type ‘=’.
- 2) This time after typing the equals sign uses your mouse and click on cell B4. Notice that this automatically enters the cell number into the formula.
- 3) After clicking on D4, type ‘\*sin(’, click on cell A4, and then close the parentheses. Notice how after typing sin( and clicking on A4 Excel placed A4 in the formula.
- 4) After the formula is typed in and you press enter, the value of cell D4 should be 77.75

Now you have two formulas using values found in other cells. This is called cell referencing. Cell referencing is a very powerful tool in Excel. It allows the user to enter long complicated formulas using other cells as inputs. Then when the value in a cell that is used as input is changed, Excel automatically recalculates the value in the cell that holds the formula. This allows the user to make many changes testing different ideas with very little effort.

### Absolute Cell Referencing

In this section formulas for projectile motion will be used to calculate the X & Y position for every time interval. This might seem to be a lot of formulas to enter, but Excel makes this task very easy. To start with, the equation,

$$X = V_{ox} \times t \quad (1)$$

will be used to calculate the X position in cell B9. To enter this formula type =C4\*A9 and press enter. Now select cell B9 by clicking on it, and with the menu items choose *Edit -> Copy*. The next step will paste the formula just copied into cell B10. To do this, select cell B10 and clicking *Edit -> Paste* from the menu. If cell B10 is selected, the formula that was copied into it will appear in the formula bar. Notice how it changed the row number from 9 to 10. This is very helpful, because for this X position we need to multiply the velocity times the time from cell B10 not B9. However, it also tried to find the velocity in cell C5. This won't work; since it needs to use Cell C4 no matter where the formula is copied. This is where Absolute Cell Referencing is necessary. By placing a '\$' in front of the column and row designations of the referenced cell, you fix that reference so that no matter where you copy the formula, it stays the same. For example, type \$C\$4 \* A9 into cell B9. Now copy this formula into B10 using the same method as before. See how the formula has changed and works correctly now.

The formula now needs to be entered into the remaining cells of the column. An easier way of doing this, other than copying and pasting, is to use the extend function. First, select cell B10, and then move your mouse to the lower right corner of the cell. Your mouse pointer will turn into a plus sign (+), and when this happens, click and hold down your left mouse button and drag down the column to cell B40, just as was done to copy the time in the previous section. This will copy cell B10 into every cell that is highlighted.

To calculate the Y position, enter the following formula for the vertical displacement in cell C9

$$Y = V_{oy} t - \frac{1}{2}gt^2 \quad (2)$$

by typing '=(D\$4\*A9)-(0.5\*9.8\*A9^2)' in the formula bar. Remember to use absolute cell referencing for the Y component of the velocity, and use parentheses. Now copy this formula all the way down to cell C40.

The last formula will be for the velocity in the y direction. Velocity in the y direction is given by the equation

$$V_y = \frac{\Delta Y}{\Delta t} = \frac{(Y_i - Y_{i-1})}{(t_i - t_{i-1})} \quad (3)$$

where  $Y_i$  and  $Y_{i-1}$  are two successive positions at two successive times,  $t_i$  and  $t_{i-1}$ . To find this velocity for every time interval enter the formula ‘=(F10-F9)/(A10-A9)’ into cell **H10** and copy it down to cell **H40**. Following this the spreadsheet should look like the one below.

Physics Experiment in Projectile Motion						
Angle	Velocity	X Velocity	Y Velocity			
0.785	110	77.61270961	77.75076992			
Time	Calculated Position		Measured Position		Measured Velocity	
	X Position	Y Position	X Position	Y Position	Y Component	
0	0.00	0.00	0	0		
0.5	38.91	37.65	40	40	80	
1	77.81	72.85	80	70	60	
1.5	116.72	105.60	120	100	60	
2	155.63	135.90	160	130	60	
2.5	194.53	163.75	200	160	60	
3	233.44	189.15	230	190	60	
3.5	272.34	212.10	270	210	40	
4	311.25	232.60	310	230	40	
4.5	350.16	250.65	350	250	40	
5	389.06	266.25	390	270	40	
5.5	427.97	279.40	430	280	20	
6	466.88	290.10	470	290	20	
6.5	505.78	298.36	500	300	20	
7	544.69	304.16	550	300	0	
7.5	583.60	307.51	590	310	20	
8	622.50	308.41	620	310	0	
8.5	661.41	306.86	660	310	0	
9	700.31	302.86	700	300	-20	
9.5	739.22	296.41	740	300	0	
10	778.13	287.51	780	290	-20	
10.5	817.03	276.16	820	280	-20	
11	855.94	262.36	860	260	-40	
11.5	894.85	246.11	900	250	-20	
12	933.75	227.41	930	230	-40	
12.5	972.66	206.26	970	210	-40	
13	1011.57	182.66	1010	180	-60	
13.5	1050.47	156.61	1050	160	-40	
14	1089.38	128.11	1090	130	-60	
14.5	1128.28	97.16	1130	100	-60	
15	1167.19	63.76	1160	60	-80	
15.5	1206.10	27.91	1210	30	-60	

Figure 2. Excel spreadsheet with labels and data entries.

**Graphing**

Many times during the laboratory results have to be displayed in the form of a graph. This section will show how to create a graph and add the appropriate labels. Two graphs will be made. One will show the XY position of the projectile, and the other will show the velocity of the projectile on the way down. The second graph will be used in the next section about analysis.

To create the first graph choose, from the menu, *Insert – Chart*. This will open the *Chart Wizard*. From the *Chart Type* list choose the *XY (Scatter)*. From the *Chart Sub-Type* choose the box with the curved lines and no dots. Click the *NEXT* button to move to the *Source Data* page.

Excel has already chosen data to graph, but we are going to choose our own data. Excel must be told what data to graph, because Excel rarely chooses the correct data on its own. To input the data to the graph click on the *Series* tab. Under the box labeled *Series* click the *Remove* button until the box is empty. Now the new series may be entered by doing the following:

- ❖ Click the add button to add the first series.
- ❖ Type ‘Calculated Position’ in the name box.
- ❖ In the X values box type ‘=sheet1!B9:B40’
- ❖ In the Y values box type ‘=sheet1!C9:C40’
- ❖ Click the add button to add the next series
- ❖ Type ‘Measured Position’ in the name box.
- ❖ As another way of entering a series, click on the little red arrow on the side of the X values box
- ❖ Highlight cells E9 through E40 with the mouse.
- ❖ The screen should show the cell range listed in the X values box on the screen.
- ❖ Click on the little red arrow on the side of the X values box to record the values
- ❖ Do this again for the Y values using F9 through F40.
- ❖ Click on the Next button.

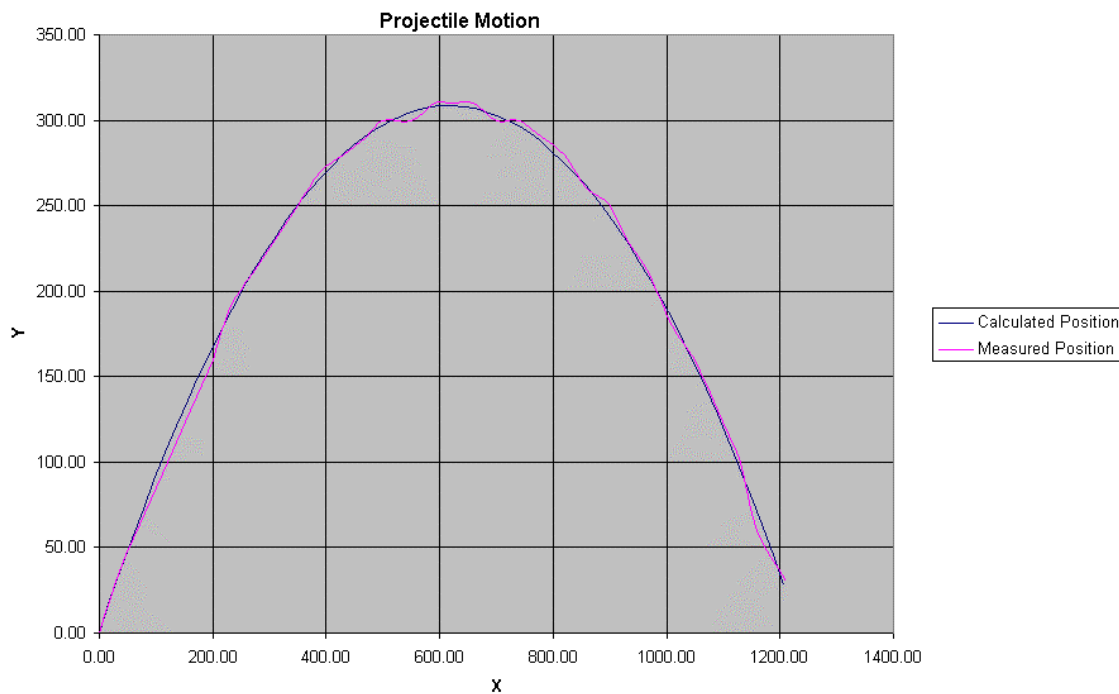


Figure 3. Graph of Y displacement versus X displacement for projectile motion.

After those steps, all the data ranges should be entered and a picture of the graph should appear in the Chart wizard box. Next, type in a chart title and the names of the XY axis. You can make many changes on this page by choosing the other tabs. These options will not be investigated here, but they should be tried independently. If there is a fear of losing results or messing up what has been done, the spreadsheet can be saved. If any mistakes are made the saved spreadsheet can be opened and the procedure can be started again where it was before the mistake. When other options are checked the changes on the graph are shown to the side. After all the desired changes are made, click *Next*. Choose the radio button labeled 'As New Sheet' and click *Finish*. The graph should appear as Figure 3.

### Velocity Graph

Use the steps above to make a graph of the Y component of the velocity. The tabs at the lower left of the spreadsheet can be used to switch back and forth between views of the spreadsheet and chart. Use the range A10:A40 as the X values and the range H10:H40 as the Y values. This graph should look similar to the one in Figure 4.

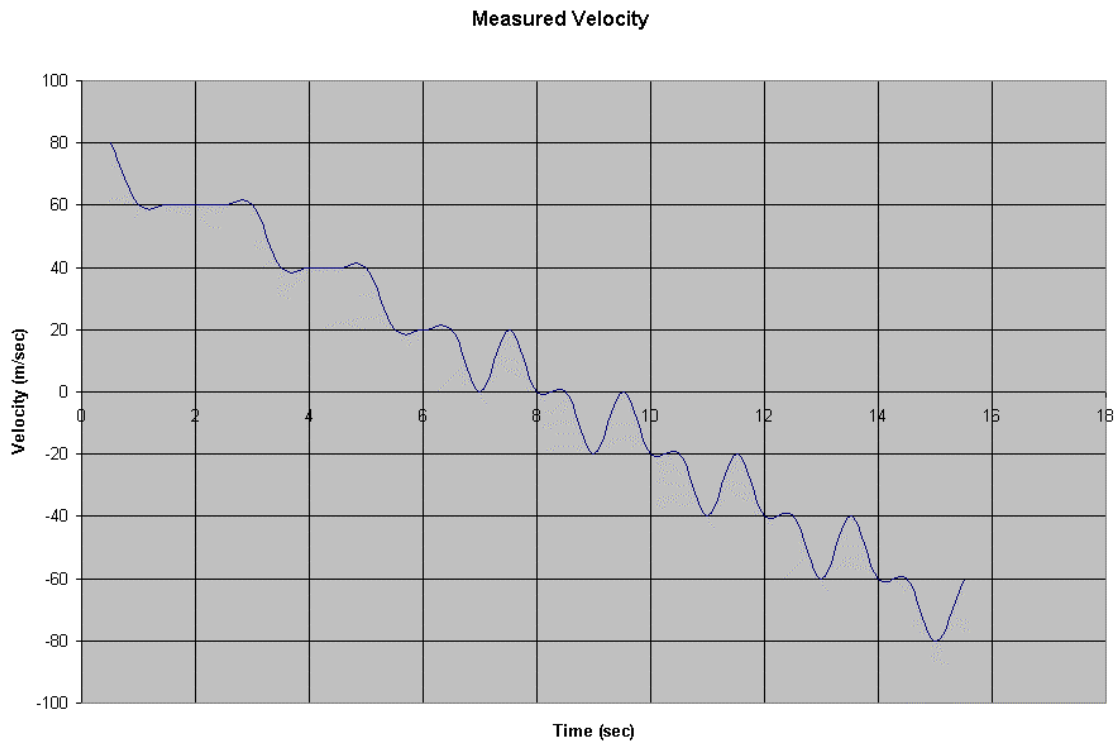


Figure 4, Graph of velocity versus time.

Since graphs of one kind or another have to be produced for many of the labs, it is important to learn as much as possible about how to graph and the options available in



the *Chart Wizard* dialog box. There are many options available after the chart is made by right-clicking on different parts of the graph. If the line is right-clicked, a pop up menu will appear and if 'Format Data Series' is chosen, a dialog window with tabs will appear. The line can be eliminated and replaced with markers indicating individual data points. It is suggested that these be investigated independently now, or at a later time to change the graph to look like the one in Figure 5.

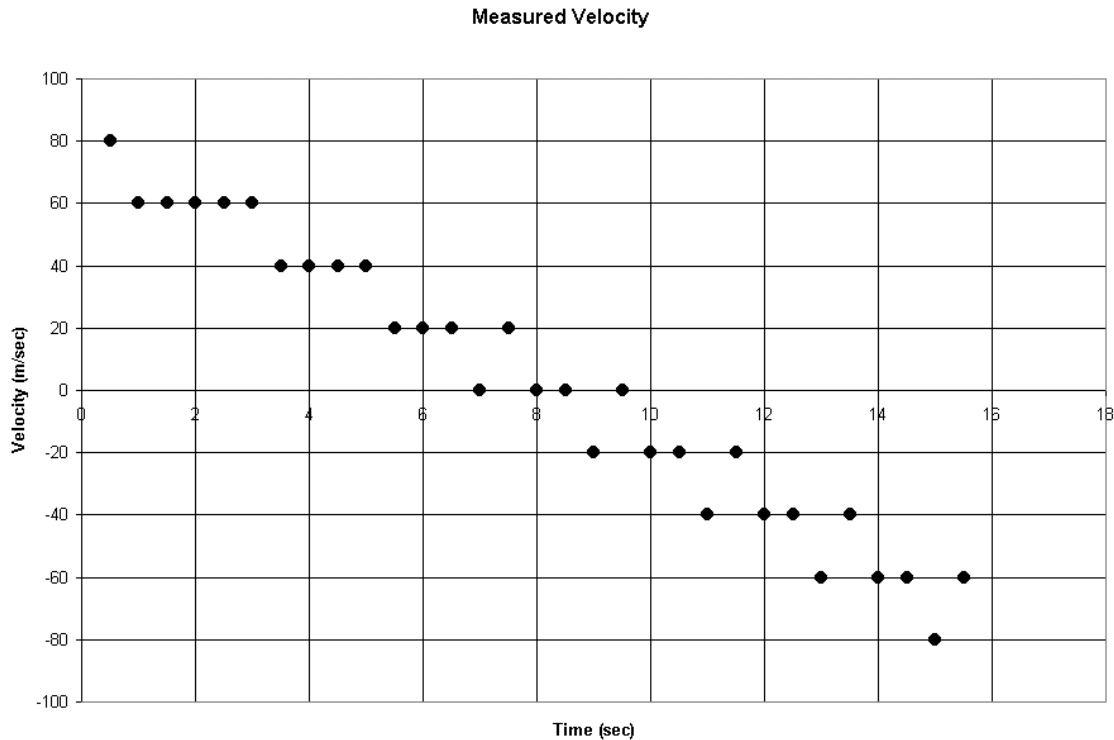


Figure 5. Reformatted graph of Figure 4.

### Analysis

As can be seen by looking at the velocity graph above, the measured data might not look uniform. It is clear that the velocity is increasing with time, but it is difficult to find the slope from this graph. However, there are a couple of tools that Excel provides to help find this information, and in this section, two ways will be used to find the slope of selected data. In this example, the analysis is to measure the slope of the velocity and that is the acceleration. This analysis should show that the acceleration is a constant from the time the projectile begins to move upward until it returns to the ground.

## Trendline

The first and easiest way to find the slope, is to use the graph and add a trend line. This is done with the following steps:

- ❖ Click on the line of the graph to select the data.
- ❖ Then right click on this line to view the popup menu, and choose *Add Trendline* to open the *Add Trendline* dialog box.
- ❖ If *Add Trendline* is not one of the options presented then the data points have not been selected on the graph.
- ❖ In the *Add Trendline* dialog box there are two tabs. Under the *Type* tab choose the *Linear* trendline.
- ❖ Under the *Options* tab check the *Display equation on chart* box. Then click *OK*.

This should produce a line through the middle of the data points, and an equation on the graph for this line containing the slope and intercept. The slope of this equation should be close to  $-9.8 \text{ m/s}^2$ , and is a measurement of the acceleration due to gravity.

Congratulations are in order since the tools of Excel have now been used to analyze data and find a result.

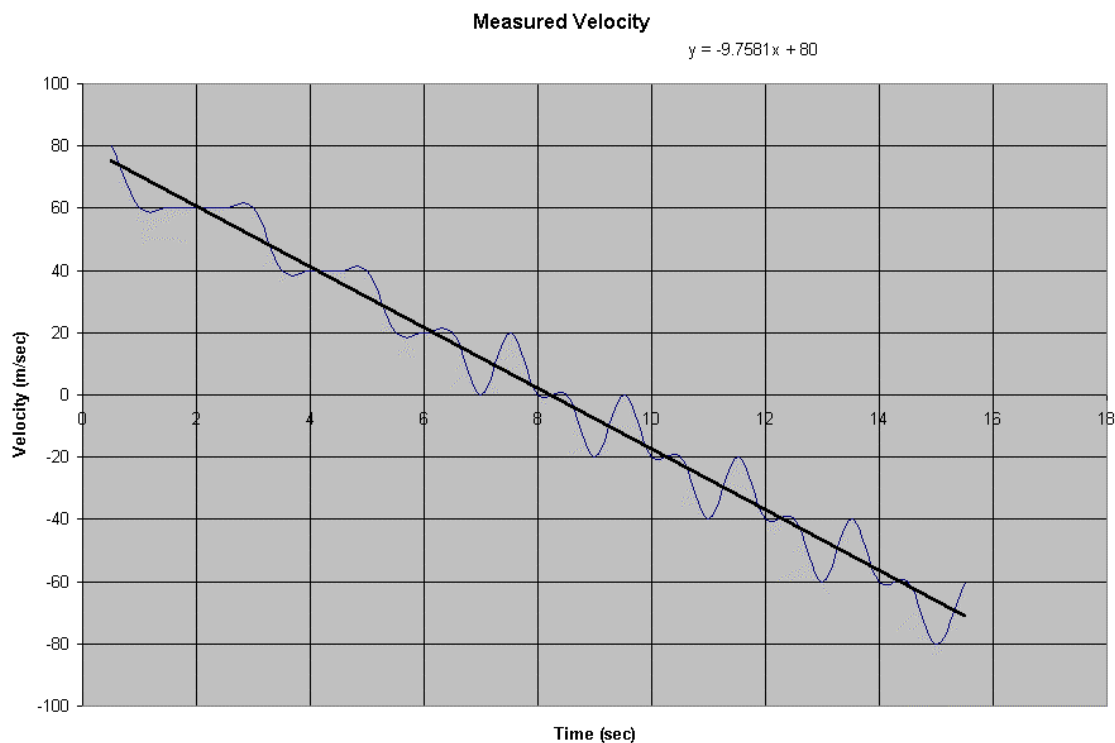


Figure 6. Velocity versus time with trendline added.

## Regressions Analysis

Another way to find the slope as well as other useful information about the data is through regression analysis. The data used for this tool is selected similar to how the data is selected for the graph. The results of the calculations are displayed on the spreadsheet in a chosen range of cells. The steps are listed below.

- ❖ On the menu choose *Tools - Data Analysis* to open the *Data Analysis* dialog box.
- ❖ If *Data Analysis* is not under *Tools* in the menu, the chart may be selected instead of the spreadsheet. If this is the case simply click somewhere on the spreadsheet and try again.
- ❖ In the *Data Analysis* dialog box scroll down to find *Regression*.
- ❖ Choose *Regression* and click *OK* to open the *Regression* dialog box.
- ❖ Click the little red arrow in the *Y Range* box and highlight the cells H10:H40 as was done to select data for the graph. Then click the little red arrow again to record those cells.
- ❖ Click the little red arrow in the *X Range* box and highlight the cells A10:A40.
- ❖ Click the *Output Range* radio button and then click the little red arrow in that box.
- ❖ Then choose cell A45 by clicking on it, and then again click the little red arrow to record this cell.
- ❖ The *Output Range* tells Excel where to put all the data that is calculated.
- ❖ Then click *OK*.

A report summary should be generated like the one in Figure 7. This report shows the slope as the *X Variable* under the *coefficient* heading. as well as the Y intercept and the standard deviations.

44									
45	SUMMARY OUTPUT								
46									
47	Regression Statistics								
48	Multiple R	0.963096736							
49	R Square	0.966479193							
50	Adjusted R Sq	0.965323303							
51	Standard Error	8.402751284							
52	Observations	31							
53									
54	ANOVA								
55		df	SS	MS	F	Significance F			
56	Regression	1	59036.29032	59036.29032	836.1343048	6.17983E-23			
57	Residual	29	2047.580645	70.60622914					
58	Total	30	61083.87097						
59									
60		Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
61	Intercept	80	3.092895931	25.86572642	1.39364E-21	73.67431411	86.32568589	73.67431411	86.32568589
62	X Variable 1	-9.758064516	0.337462612	-28.91598701	6.17983E-23	-10.44825343	-9.067875602	-10.44825343	-9.067875602
63									
64									
65									

Figure 7. Linear regression summary report.

## **Summary**

This tutorial was meant to cover some of the basics that will be used in laboratory to report and analyze results. There are many more tools that Excel has available, and these can be learned as needed. With this tutorial all of the data analyses necessary for this lab class can be performed. Spreadsheets are used in a wide variety of fields, and can be put into practice in many other disciplines.