# Physics Laboratory Excel Tutorial

(text adapted from Clemson University Physics and Astronomy Excel Tutorial)

## Graphing Data and Curve Fitting

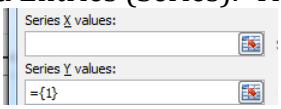
| | A | B | C |
|---|---|---|---|
| 1 | Calculation of π | | |
| 2 | Radius (cm) | Circumference (cm) | Error in circumference (cm) |
| 3 | 0.66 | 4.08 | 1 |
| 4 | 1.89 | 11.94 | 1 |
| 5 | 1.98 | 13.18 | 1 |
| 6 | 2.62 | 16.34 | 1 |
| 7 | 3.62 | 21.78 | 1 |
| 8 | 4.78 | 30.16 | 2 |

In this tutorial on graphing, we will examine data taken from an experiment in which the circumferences and radii of several circular objects were measured. The data is displayed on the screen shot to the left. Note that the error in the measurement of the radius is not given; suppose that from your knowledge of radius measurement techniques, you estimate it at +/- 7%.

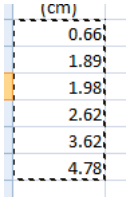
Of course, the equation associated with this data is $C=2\pi r$, or the circumference of the circle is equal to two times pi times the circle's radius. In this "experiment," the circumferences and radii are measured. We hope to be able to determine the value of π by fitting a straight line to the data.

It is our firm belief (although not necessarily the belief of everyone at this university) that beginning laboratory students should learn to plot their data by hand before using a computer application to learn this task. Nonetheless, here we show how to use Excel to plot the data and fit a curve to the data.

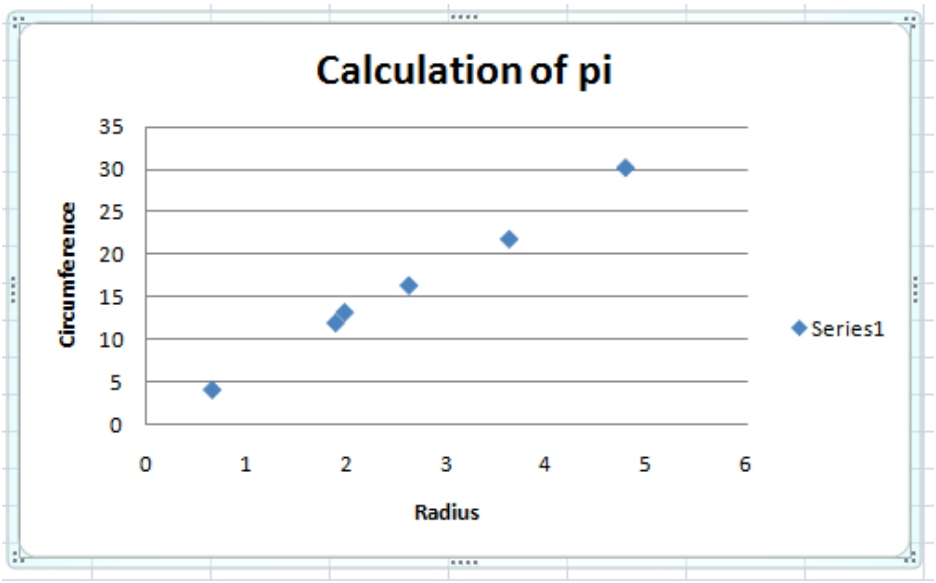
## How to Plot the Data

1. Enter the data onto the worksheet as shown in the above screenshot
2. Click on an empty cell.
3. Click on the "Insert" tab at the top of the screen.
4. Click on "Scatter".
5. Click on "Scatter with only Markers"  .
6. A completely blank chart should now appear. Position the cursor over the blank chart, right-click, and choose "Select Data".
7. Click on "Add" under "Legend Entries (Series). This will cause value boxes, like the ones displayed here, 

to appear.
8. Click on the Collapse Dialog button  at the right end of the "Series X Values" box. This will temporarily shrink the dialog window so you can highlight the x-values that you wish plotted on the horizontal axis.
9. When the dialog box shrinks, you can use the mouse to highlight the x-values that will be plotted along the horizontal axis (in this case the measured radii).

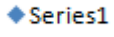


10. When finished click the Expand Dialog  button which will return the dialog window to maximum size.
11. Repeat steps 8 and 9 for the "Series Y Values", which will tell the computer where along the vertical axis to place the data points.
12. Click "OK". A graph should now be visible.
13. Click "OK" again. The graph should no longer be hidden. However, it lacks titles for the x and y axes, as well as for the entire graph.
14. Double click somewhere in the chart area. The buttons on the top should change.
15. Click on "Layout 1" in the Chart Layout area  .
16. You should now be able to type titles for the x axis, the y axis, and the entire graph. Select a title so it looks like this  . What you type appears in the formula bar at the top, and will appear on the graph when you hit enter. Your graph should now look like this:

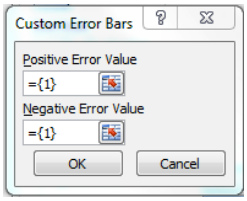



**Making the Graph Look Nice**

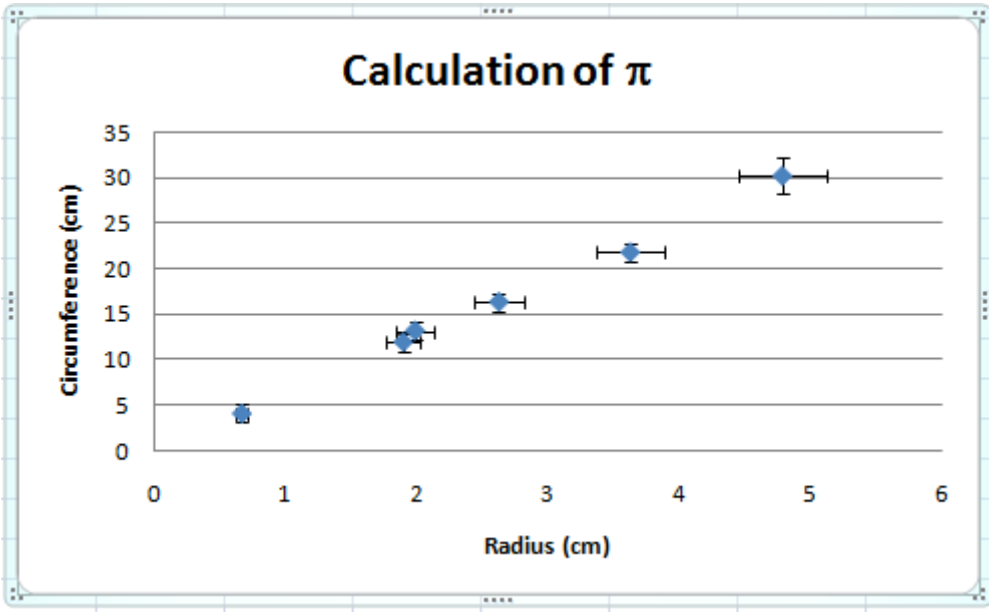
Now that you have plotted the data, take a minute or two to put the finishing touches on the graph.

1. Include units on each axis title: double-click on each axis title and edit.
2. Delete the legend box  by right-clicking on it and choosing "Delete".
3. Add appropriate symbols. For example, change "pi" to "π" by double clicking on the graph title, deleting the "i", clicking and dragging so the "p" is highlighted, placing the mouse over the "p" and right-clicking, choosing "Font…", and under "Latin text font:" choosing "symbol". Then click "OK".

4. Add error bars.
   a. Select the "Layout" tab at the top of the screen, click the "Error bars" pull down menu, and click "More error bars options…". The "Format error bars" window should appear.
   b. Click "custom" and "Specify Value". The "Custom Error Bars" window should appear. "Positive Error Value" means how far above each data point the error bar should extend, and "Negative Error Value" means how far below each data point the error bar should extend. Since (in this example) we measured the error in the circumference, use the Collapse Dialog Button, and highlight the values in column C. Do this for both Positive Error Value and Negative Error Value. Then hit OK.




   c. Note that Excel has chosen horizontal error bars, which you now have to fix. Position the cursor over a horizontal error bar, and leave it there for a moment till you see "Series 1 X Error Bars" appear on the screen. Then right-click. Choose "Format Error Bars…". The "Format Error Bars" window should appear again, only now it should describe "Horizontal Error Bars". In this example, we have estimated the error in measuring the radius at +/- 7%, so click "percentage" and then enter 7.0. Hit Close. You are finished adding error bars to your graph, which should now look like this:



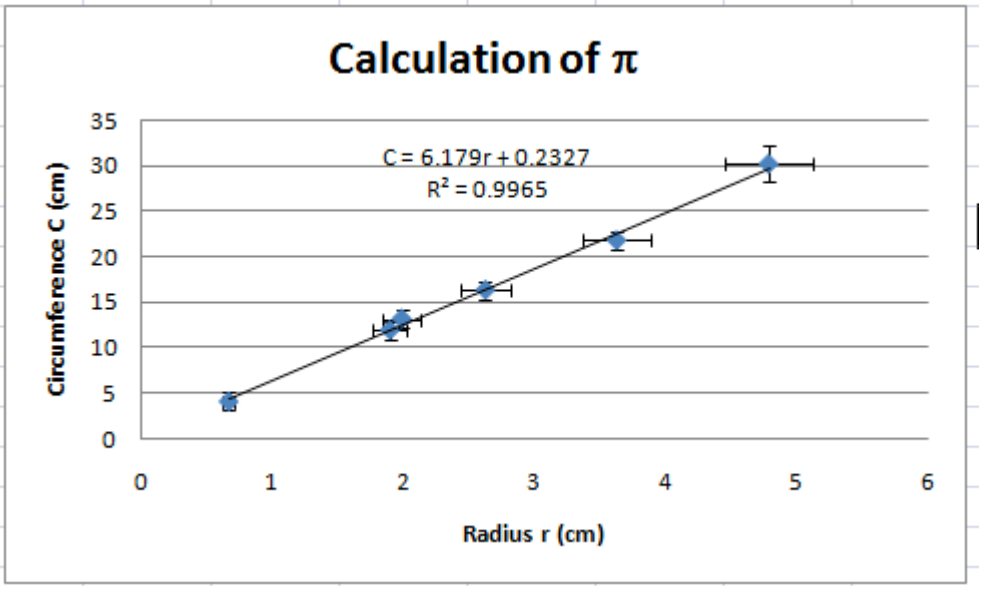
Sometimes, after you make a nice-looking graph of your data, you want to make a fit to the data and plot it as well. If you want to fit a straight line to the data, you need to do a "linear fit". Follow the steps below to make a linear fit to a dataset (Excel can also do other types of fit, besides linear fits).

**Fitting the Data, and Plotting the Fit**

1. Choose the "Layout" tab at the top of the screen.
2. Click "trendline".
3. Select "more trendline options". The "Format Trendline" window should appear.
4. Choose "linear", and click "Display Equation on chart" and "Display R-squared value on chart". Then click close.
5. Move the equation and R-squared value where you want them by clicking and dragging.
6. The equation mentions "y" and "x" but we are trying to relate "circumference" and "radius". Make the equation easier to understand by:
   a. Editing the x axis label to be radius r (cm) and the y axis label to be circumference C (cm)
   b. Editing the equation by changing "y" to "C" and "x" to "r".

   By doing these things, you are in essence telling your TA that you really do understand what was actually measured, and also that you know what you're doing using Excel to make plots instead of plotting things by hand.

The final result of your graph should look something like this:




Now that you have finished making the graph, the real thinking begins! A good graph will help you make sense of your data, and perhaps relate the data to your expectations. The slope of the linear fit is 6.179, and the y-intercept is 0.2327. What values would you have expected for the slope and y-intercept of the linear fit to this data?