

Guide To Making And Using Plots

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1 Using the Plotting Tool

The easiest way to use the plotting tool is to use the manual interface.¹

This interface should be straightforward to use - enter your data and other information, and click “Make the plot!”

Unfortunately, there are a few limitations of this version. First, you have to manually enter all of your data - rather annoying, even if you copy and paste each cell. Second, there’s no way to save the data you have - if you close the page, you’ll need to re-enter all of your data.

In the interest of solving these problems, we added another way to use the plotting tool, which avoids those issues:

1. Make a copy (as **File** • **Make a Copy**) of the “Plotting Tool Data Table,” a Google Sheets template available at https://docs.google.com/spreadsheets/d/146pViJw76YfACaQEjldf__xntscm0JIL5px6Y-rMBiA.
2. Copy your data into that sheet. Since, like your data table, it’s a Google Sheet, this should be mostly be a matter of copying-and-pasting. This will be your saved, easily-editable backup copy.

¹<http://phylabs1.physics.sunysb.edu/~physlab/PlottingTool/PHY120sPlottingTool.html#manualinterface>

- If you are copying from another Google Sheet, you will need to “paste values only.” Right-click and selecting **Paste Special**, or use **Ctrl**+**Shift**+**V** (instead of just **Ctrl**+**V**).²
 - Don’t worry if this messes up the background colors - those don’t really matter; the plotting tool doesn’t need them.
3. Download this data table as a `.csv` file. Click on **File**►**Download as**►**Comma-separated values (.csv, current sheet)**.
 4. Go to the automatic interface³ and upload that `.csv` file.
 5. Click “Make the plot!”

While slightly more technically complicated, it can make your life easier if you learn how to do this, since you won’t have to re-enter your data every time.

In either case, in addition to a graph, the plotting tool will also provide a fit. This should agree with the results of the **LINEST** procedure described in the “Advanced Google Sheets” notes, if you choose to use that utility; if it does not, check that you copied all of your data correctly, and chose to set the fit through the origin (or not) in the same way.

2 Plotting in Excel

Plotting in Excel is also possible, but not recommended, because you have to do a lot more by hand. The plotting tool formats almost everything nicely for you; Excel does just about everything wrong.

For a plot in Excel, you need to ensure the following:

- Make a Scatter Plot, not a Line Plot. We look at data points, not some angled line!
- Add error bars to your scatter plot where necessary. You will need to do custom error bars with the appropriate “Uncertainty” cells of your data table here! (Note: Google Sheets cannot do custom error bars, so it *cannot* do everything we need in every lab.)
- Add a linear trendline (note that this is *not* the same thing as a line graph - this best fit line should not have corners in it!)
- You will need to get your uncertainties in slope (and intercept) from somewhere, so you will *need* to use the **LINEST** algorithm in your spreadsheet in this case.

²Otherwise, Google Sheets will assume you meant to copy formulas, but those formulas will refer to data not in the “Plotting Tool” sheet, and so you’ll get errors!

³<http://phylabs1.physics.sunysb.edu/~physlab/PlottingTool/PHY120sPlottingTool.html#automaticinterface>

In addition, the following alterations are recommended:

- If your version of Excel provides a background, delete this gray background. (This saves your printer some ink.)
- Turn on major and minor gridlines on both axes.
- Ensure that the data point colors, etc. chosen by Excel are visible on your printout. (Should be the case.)

This is, of course, in addition to all the usual accoutrements of a plot - a good title, axis labels (with units), etc.

3 Interpreting Data from Plots

Once you have a plot, with a best fit line, how do you interpret it?

Your best fit line will give you two numbers (each with an associated uncertainty): a slope and an intercept. (The latter may be removed depending on how you fit your line.)

First: what are the units on your slope? Some quick dimensional analysis reveals that the dimensions of slope are $[\text{slope}] = [y]/[x]$ - that is to say, the units on your slope should be your y-units over your x-units. Similarly, $[\text{intercept}] = [y]$ - the intercept units are the same as your y-units

Now that we have that, let's understand what this slope is telling us. Let's suppose we have a physics equation which claims that:

$$y = \frac{ABC}{D}x + EF$$

Here, x and y are the things we plot, and $A-F$ are other physical quantities.

Then, we run the fit, and it tells us that:

$$y = ax + b$$

Here, a and b are just numbers the plotting tool tells us (each with uncertainty).

Since both of these equations must hold, the number we are multiplying by x must actually *be the same*. Therefore, we can interpret our slope and intercept as giving us the equations:

$$a = \frac{ABC}{D}$$
$$b = EF$$

The numbers have to match, and so we set them equal to each other.

Now, if we had measured, say, A , C and D separately and wanted to calculate B , we could simply rearrange the first formula to give us:

$$B = \frac{aD}{AC}$$

Thus, we can calculate another quantity from our slope.

Be *very* aware that the slope itself is not always the quantity we want to calculate - it is often different from the quantity we're interested in by some other factors!

Also keep in mind that if you swap your axes, you'll get a different slope. You have to interpret your slope from *your* arrangement of axes, so check this! (The easiest way: check your units!)