Graphing: Advanced

The basic requirements for 1101/1125/1225 graphing are the same as 1114/1118 lab courses (see "Graphing: Basic" at http://www.langaraphysics.com/graphingbasic.pdf). Additionally, the following are also required:

1. For non-linear relationship, one needs to decide the quantities to be plotted: they are not simply the raw data.
2. The uncertainties for each data point need to be plotted, in both x and y directions;
3. The uncertainty of the slope needs to be calculated, as well as the slope itself.

The changes above are reflected in the steps below:

Steps for drawing a graph – Modified for 1101/1125/1225

1. (modified) Decide what quantities you are going to plot on each axis. Your goal is to achieve a linear graph:

Theoretical Equation	What to plot	The slope will be
$F = k\Delta x$	Δx on x-axis, F on y-axis	k
$T = 2\pi\sqrt{\frac{L}{g}}$	$\sqrt{L}$ on x-axis, T on y-axis	$\frac{2\pi}{\sqrt{g}}$

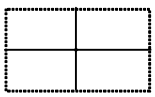
2. (modified) Tabulate the data that is going to be plotted. Your table must show the values for both the x-axis and the y-axis and their uncertainties. Appropriate uncertainty propagation may have to be done.

3. (same as before) Choose the orientation of the graph paper and the scale of each axis based on the data. You want the data to cover a large portion of the graph paper, and you want to use easily divisible numbers only (2, 5 and 10) when converting each block of the graph to real units. For example, 1 block is 0.2 Amp, 10 m/s, or 5 N, etc.

4. (same as before) Label axes with the quantity name, quantity symbol and the unit. Mark the axes every 5 or 10 units.

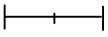
5. (same as before) Write the title of the graph. The title should be descriptive, giving people more information to help them understand the graph, rather than repeating the names of the axes.

6. (modified) Plot the data points. Since each data has uncertainties, it should look like a rectangular box with width of $2\delta x$ and height of $2\delta y$. If an uncertainty is too small to be graphed, it will not be shown, but you should explain that on the graph with a short note. See the examples below.



In general, a data point is a box

δx is too small to be drawn



δy is too small to be drawn

7. (modified) Draw the best fit line with a long plastic ruler. The best fit line is a single straight line that passes through all of the data boxes and is as close as possible to all the centers. Treat all points equally unless you have good physical reasons to neglect certain points. If you do neglect any points, write your reasons on the graph. Note that the origin is usually not one of your data points, so do not force the line through the origin.

8. (new) Draw the "worst-fit" line. This is another straight line that also passes through all of the data boxes, but has a slope that is as different as possible from the best-fit line.

9. (modified) Calculate the slopes of the best-fit line and the "worst-fit" line on the graph paper. Choose two points on each line that are far apart. Write their coordinates (x_1, y_1) and (x_2, y_2) on the graph. Do not use data points! The slopes should have unit and should be kept to 5 non-zero digits.

10. Also calculate on the graph the uncertainty of the slope:

    $\delta\text{slope} = |\ \text{slope}_{\text{best}} - \text{slope}_{\text{worst}}\ |$.

Graphing Example