Graphing (preview)

Graphing of data is an effective tool for exploring the relationships between physical quantities.

The easiest type of graph to work with is LINEAR; the relationship between the two variables is a straight line of the form: $y = mx + b$, where m is the slope and b is the y-intercept. Both the slope and the y-intercept have physical meaning, and physical values can be found from a graph. For example, the restoring force of a spring is a linear function of the extension. The slope of the line is the spring constant, and the y-intercept is the minimum force necessary to start the spring's stretch.

Sometimes, the relationship between physical quantities is not linear, but related through a power or root. The formula can be rearranged to fit the $y = mx + b$ straight-line equation formula, and measured data will allow us to calculate other physical quantities directly from the graph.

Example: The acceleration due to gravity, g, can be found by measuring the period, T, of a pendulum for various lengths, L. The relationship is given by:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

A plot of measured values of T vs. L would not be linear, so a slope would be meaningless. However, a T vs. $\sqrt{L}$ plot would be linear, and the acceleration due to gravity can be found from its slope.

The error bars on the graph are the uncertainty in T and the uncertainty in $\sqrt{L}$. Note that they are not simply the uncertainties of the raw data, but can be calculated from the uncertainties of the raw data using uncertainty propagation. The uncertainty in the acceleration due to gravity will come from the uncertainty in the slope, which comes from the "best fit" and "worst fit" straight lines.

Raw data: T and L	Desired quantity: g
Graphing data: y-axis: T , x-axis: $\sqrt{L}$	Find the desired quantity from the slope of the graph: $slope = \frac{2\pi}{\sqrt{g}}$, so $g = \left(\frac{2\pi}{\text{slope}}\right)^2$
Uncertainty for graphing data: $\delta y = \delta T$, $\frac{\delta x}{x} = \frac{\delta L}{2L}$, so $\delta x = \frac{\delta L}{2L} x = \frac{\delta L}{2L}\sqrt{L} = \frac{\delta L}{2\sqrt{L}}$	Find the uncertainty of the desired quantity: $\frac{\delta g}{g} = 2\frac{\delta \text{slope}}{\text{slope}}$

In Part I of the lab, you will be given several physical relationships, all of them non-linear. Similar to the example above, you will decide what quantities should be plotted on the x and y axes to achieve a linear graph, how to calculate the uncertainty for the graphing data (error bars) from the uncertainties of the raw data, and how to calculate the desired quantity (and its uncertainty) from the slope (and its uncertainty). In Part II of the lab, you will go through the entire process analyzing some given, made-up data, to experience how one measures a physical quantity using linear graph.

To get prepared for the "Graphing" lab, also read the "Graphing: Advanced" and "1101/1125/1225 Sample Lab Report 2" documents from your online lab manual.