How to Create Graphs for Labs

Independent and Dependent Variables

Most experiments involve carefully setting up a set of initial conditions and making a measurement as the test is being performed. Then, for the next trial, usually one of the initial conditions is changed and a new measurement is made. The initial condition that the experimenter changes from one trial to the next is the *independent variable*. This is always graphed on the horizontal, or *x*-axis. The measurement being made for each trial is the *dependent variable*. This is always graphed on the vertical, or *y*-axis.

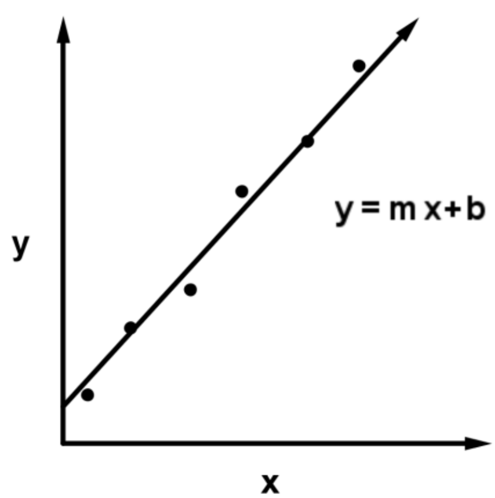
For example, if you want to know how long it takes someone to run 100 meters, you set up the course, find a runner, and time the runner with some sort of stopwatch. For the next trial, if you change the distance to 120 meters, then the distance is the independent variable and the time it takes the runner to finish is the dependent variable. It is considered poor experimental technique to change two parts of the experiment from one trial to the next. So, using the same example, if you changed the distance and changed the runner for the second trial, then your data is not going to be reliable.

Title and Axes

Every graph should have a descriptive title and accurate labels for the axes. Someone reading the title of your graph should understand what the data is showing. Please note that "Distance vs. Time" or "Graph 1" are *not* very descriptive. Each axis scale should allow you to clearly display the data using the entire area of the graph. The axes labels should have the correct units.

Best Fits Line (aka Regression Line)

- Do ***not*** connect all the data points!
- Draw a line through the middle of the points. Try to have as many above the line as below it. Also, hit at least two points – the farther apart, the better.
- Use the two points that are closest to the line and the formula, $\boldsymbol{slope = \frac{rise}{run} = m = \frac{y_2 - y_1}{x_2 - x_1}}$, to find the slope of the line.
- Use the slope, one of the points on the line, and the formula, $\boldsymbol{y = mx + b}$. Don't forget b = the *y*-intercept (where the graph crosses the y axis).
- ***Write the equation*** that models the relationship between the independent and dependent variables on ***EVERY LINEAR GRAPH***.



Interpolation and Extrapolation

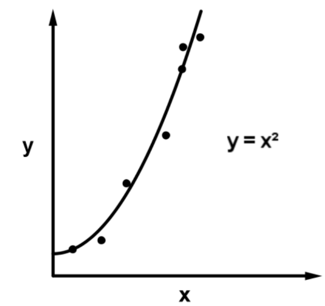
Once you have an equation, you can use it to predict values that you did not measure. Predicting values between existing data points is called ***interpolation***. Using your equation to predict values beyond existing data points is called ***extrapolation***. For example, if you measure the time it takes for someone to run 100 m, 120 m, 140 m, 160 m, and 180 m, you can use your data to create an equation that predicts how long it would take the runner to run 150 m (interpolation) or 200 m (extrapolation). The better you are at measuring your data, the better your graphs and equation will turn out, and the better your predictions will be.

Nonlinear Data

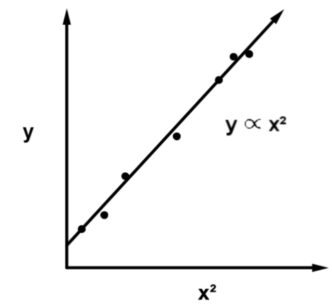
Many times you will not be able to fit a line to your data very well. You are trying to find a mathematical relationship between your independent and dependent variables. That relationship will not always be linear. However, you can always follow these steps to come up with a linear relationship.

Quadratic
When the dependent variable (*y*) increases at a much faster rate than the independent variable (*x*), the relationship between them is said to be *quadratic*. If your data looks like the original graph, you can make the data line up by squaring the independent variable (*x*).

Original Quadratic Graph

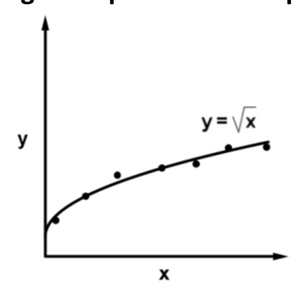


Transformed Quadratic Graph

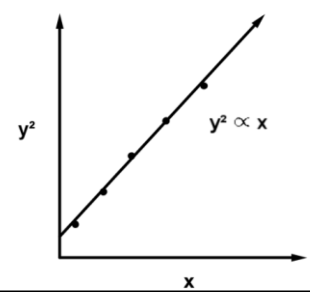


Square Root
When the dependent variable (*y*) increases at a much slower rate than the independent variable (*x*), the relationship between them is said to be a *square root*. If your data looks like the original graph , you can make the data line up by squaring the dependent variable (*y*).

Original Square Root Graph

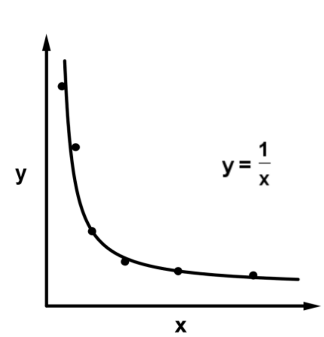


Transformed Square Root Graph

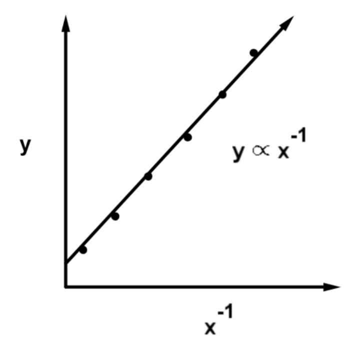


Inverse
When the dependent variable (*y*) decreases when the independent variable (*x*) increases, the relationship between them is said to be *inverse*. If your data looks like the original graph, you can make the data line up by graphing the inverse of the independent variable (*x*).

Original Inverse Graph



Transformed Inverse Graph



Finishing Your Analysis

Once you have transformed your data into a linear graph, you can find the best fits line, and finally the equation. (MAKE SURE YOU PUT THE EQUATION ON THE LINEAR GRAPH !!) This should be your goal when working with the data from your labs.

When you are writing up your lab, make sure that you refer to your graphs in your data analysis. Describe what the graphs indicate (i.e. what type of relationship the graph(s) indicate. Good Luck!