# Linear Graphs

Graphs are a valuable tool for conveying and interpreting data. It can be much easier to see the trend in a data set from a visual graph than from a table of numbers. When conducting experiments, scientists can more easily draw conclusions from a graph when it is a straight line than when it is a curve. Data is often recalculated so as to make a graph that was a curve look like a straight line. [1] For these reasons, it is important to know how to work with straight line graphs.

THE LINE OF BEST FIT

Even if your data are meant to form a straight line, they almost certainly won't. If your data points all lie perfectly on a straight line, your teacher is more likely to be suspicious than pleased. When you do a lab, your job in creating a graph is to interpret the data to find the **line of best fit**, a line that represents your data and tries to remove any inconsistencies that crop up because of normal variation in data.

Don't join your data points dot-to-dot. Instead, draw one straight line that goes through as many data points as you can, with about half above it and about half below it. The line doesn't even have to pass through any points. It only has to "average them out".

Once you have your line of best fit, all future calculations about the experiment as a whole are done with that line, not your data points, since using one or two data points (even if they're actually on the line) gives them more importance than the others, and this introduces bias into the experiment.
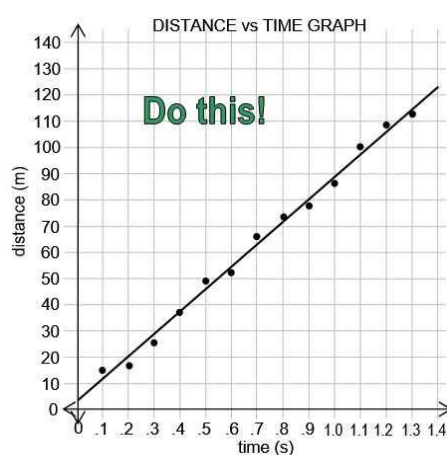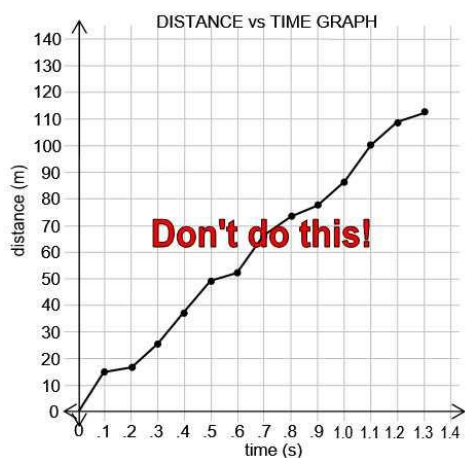
Other pitfalls in graphing

Don't just join the first data point to the last. If either point is off from where your line should be, the line you draw will look strange, and not be representative of your data.

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[1] There's more on this topic in the Phys 083 handout "Plotting the Right Variables to Obtain Straight Line Graphs", also available in the VCC Learning Centre.

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Don't redirect your line to account for points that obviously don't fit. If most of the data points look like a line, but one of them is far from the others, it's most likely a mistake called an **outlier** (it *lies out* of the range of the rest of the values). You can mentally throw this data point away and just use the others.

Don't force your line through (0, 0) if that's not where your data appear to go. Even if your data "should" include the origin, your best fit line might not pass through that point. If this happens, your data are trying to tell you something. Perhaps the y-intercept of the best fit line (or the amount off from the origin) is an indication of bias in your experiment. That will give you something to talk about in your discussion.

CALCULATIONS INVOLVING GRAPHS

Slope

Often the slope of a straight-line graph means something. There is more detail on calculating slope in the worksheet "How to Determine the Slope", but in brief:

[1] Use the line of best fit to calculate slope, not your data points.

[2] Select two easy-to-measure points on the line. Find their coordinates.

[3] Perform the standard rise-over-run calculation to find the value for slope.

[4] Since slope is rise over run, divide the units for the vertical axis by the units for the horizontal axis to find the correct units for the slope. (For example, if the graph is one of velocity in m/s vs. time in s, we divide $m/s \div s$ to get m/s^2, suggesting that the slope represents acceleration.)

Interpolation and Extrapolation

Sometimes a lab question will ask you to find a value from a graph that you did not measure during your experiment. The common term for this is **extrapolation**, or finding new information from old data. In terms of graphs, extrapolation is estimating a new point of the graph that is beyond the values you measured. (When a health organization estimates the number of flu cases in years to come, it extrapolates, since it obviously can't have data for years that haven't happened yet.) Conversely, **interpolation** is estimating a new point that is among the data points already collected.
(For example, if your graph of distance vs. time had a range of time values from 0 to 1.3 s, and you wanted to know what the distance was at 0.55 s, but you didn't measure the velocity at that time, you would interpolate to find it.)

To find a value that *would* fit onto your graph, the simple way is to find the number you want on one axis, follow along to the line, and then follow over to the other axis. On the graph on the right, the distance at time 0.55 s would be just over 50 m. To find a value that would *not* fit onto your graph, you have to find the equation of the line $y = mx + b$ and plug in the desired value.

DISTANCE vs TIME GRAPH