Scientific Graphs
Equations of a Line

Mathematical Graphs and Scientific Graphs

In mathematics, graphs are made while studying functions to give a feel for the shape of the graph of a function. Mathematical graphs have been discussed in detail in the previous section.

In science, graphs are made to show relationships between physical quantities, for example the relationship between the density of water and its temperature. A scientific graph is often made when a relationship is unknown and an experiment has been performed to determine the dependence of one quantity on another. Scientific graphs will be discussed in more detail in this section.

Scientific Graphs

Scientific graphs are usually based on an experiment carried out to determine the relationship between two physical quantities when one is expected to depend on the other. You may know that the density of water depends on its temperature and you may perform an experiment that allows you to measure the density of water at different temperatures. By plotting your data on a graph you may be able to determine the relationship between the density and temperature.

You may find that the density varies linearly with temperature or that the density varies parabolically with the temperature. Often, the plotted points of the data are examined and a functional relationship is inferred. In the case of a linear relationship, a “best-fit” line is drawn with a straightedge that ***comes close*** to all of the points. **It is never expected that the line pass through any of the points due to experimental error.**

Graphing and Interpreting Scientific Data

When finding the equation relating the dependent variable to the independent variable on a scientific graph, letters should be used which represent the quantities graphed. For our example of a density vs. temperature graph for water, T would be a good independent variable for temperature and ρ would be a good dependent variable for density. (In physics, ρ is used for density, because d is commonly diameter which may be involved in a calculation of density.)

Some general rules for graphing you should follow are:

- Graphs should always be done on graph paper and should take up most of the space on the page.
- When graphing data the independent variable is plotted on the horizontal axis and the dependent variable is plotted on the vertical axis. An appropriate range and scale must be chosen for each axis.
- Each axis should be clearly labeled with the name and/or symbol of the quantity being plotted along with the appropriate units.
- Graphs should always have a descriptive title summarizing what the graph represents.

For our example, if a linear relationship between density and temperature is found, one will want to find the slope and an equation for the “best-fit” line $\rho = mT + b$.

The slope of a scientific graph is defined the same way as the slope for a mathematical graph, that is the change in the dependent variable divided by the change in the independent variable. Units must always be included when calculating or stating the slope of a scientific graph.

The slope of a linear graph of density versus temperature would be calculated using $slope = m = \frac{\Delta\rho}{\Delta T}$. In the metric system, density is measured in kg/m^3 and temperature in °C or K (Kelvin). The slope in our example would then have units of kg/(m^3 °C). The intercepts will also have units.

To calculate the slope of the "best-fit" line on a scientific graph one must choose two points on the ***line*** that are very far apart. If the graph has been made with a good scale on graph paper with at least 10 squares per inch, one should always be able to choose the points so that the change in each variable has ***three significant figures***. **Data points should never be used to calculate the slope of a "best-fit" line *even if* they seem to be on the line.** If you misplot 1 or 2 data points on a graph with 8 or 10 data points, the misplotted points will have very little effect on the "best-fit" line you draw. But, if you happen to use the value of a misplotted data point in the calculation of a slope, it can have a very large effect.

Given two points (T_1, ρ_1) and (T_2, ρ_2), the slope is $m = \frac{\rho_1 - \rho_2}{T_1 - T_2}$. An equation can be quickly written for the line in the point-slope form $(\rho - \rho_1) = m\,(T - T_1)$ or $(\rho - \rho_2) = m\,(T - T_2)$, using either point.

For a scientific graph, the slope and intercept of a line are ***never*** reported as fractions. They are always reported in decimal notation or scientific notation and ***always*** include units.

The correct procedure for graphing and interpreting scientific data will be developed in class for our example by providing a set of possible experimental values of temperature and density for a sample of water.

Temperature (°C)	Density (kg/m^3)
37.8	993.8
40.5	992.2
46.0	988.6
57.3	983.8
60.3	982.0
62.6	980.9
73.8	975.3
79.4	972.7

Exercise 1. For the graph made in class for the density of water, calculate the slope to three significant figures and be sure to include units.

Exercise 2. Use the point-slope equation and write down two equations for the line in the graph for the density of water (one equation using each of the two points you chose to calculate the slope).

Exercise 3. Put the equations you found in Exercise 2 into slope-intercept form. Are the intercepts in close agreement? Do they agree with the intercept seen on the graph?