

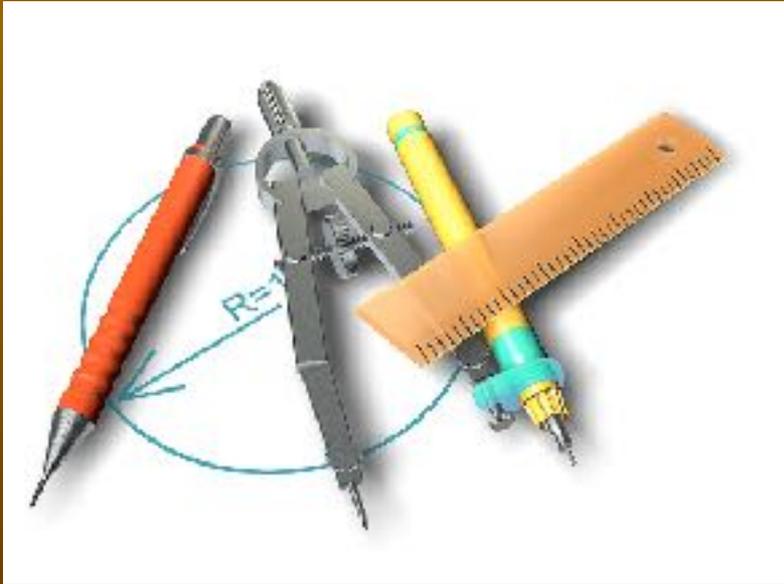
1.3 QUANTITATIVE SKILLS

Scientific notation is a way to express, large numbers the form of exponents as the product of a number (between 1 and 10) and raised to a power of 10.

Examples:

to write 650 000, use 6.5×10^5

to write .000543 use 5.43×10^{-4}



Scientists usually limit the number to one place holder to the left of the decimal, followed by a specific number of digits or significant figures.

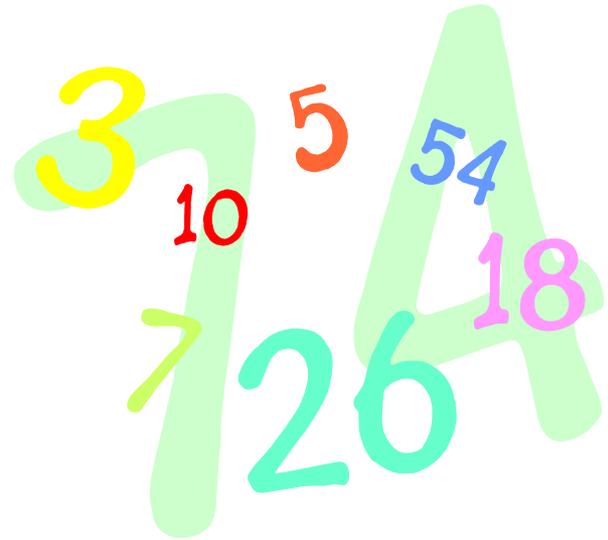
The number of significant figures is determined by the measurements or values the number has been derived from.



Example: If you measure 10.2 mL of water in a pipette that is accurate to .1mL then you could consider all of the numbers (the 1, 0 and 2) as significant.

But if you measure 10 mL of water in a graduated cylinder that only has calibrations every 1 mL, then you would only have two significant figures (the 1 and 0).

When you are writing scientific notation for numbers, you are to limit the significant figures or “sig. figs.”



When adding or subtracting numbers with exponents, you can never have more sig. figs. than the least number you are adding.

Example: $12.5 + 12.15 = 24.65$ is rounded up to 24.7 because the least number of sig. figs is from 12.5 and is three places values.

The rule for multiplication and division with significant figures is similar. You must limit the significant figures to the least number available in the series.

Example: $2.54 \times 3.003 = 7.62762$ when using a calculator.



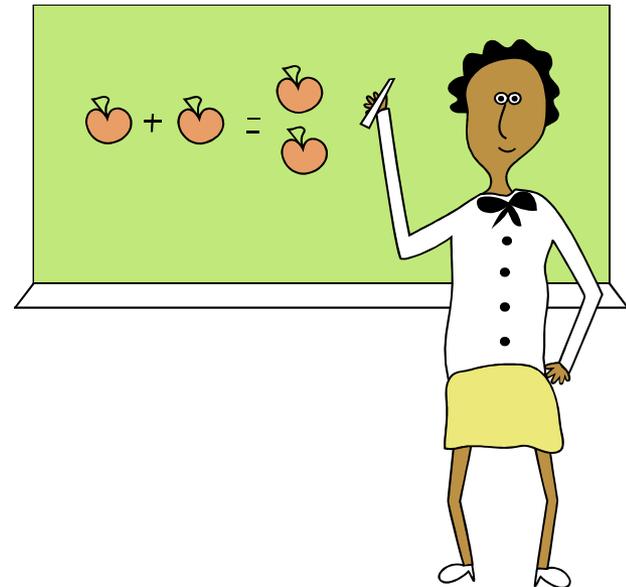
How should this be expressed in sig. figs?

Because we are limited to 3 sig. figs from the number 2.54, round up to 7.63.

Look at some examples of math manipulations with exponents using significant figures.

When adding or subtracting numbers with exponents the exponents of each number must be the same before you can do the operation.

**Example: $(1.9 \times 10^{-3}) - (1.5 \times 10^{-4}) =$
 $(19 \times 10^{-4}) - (1.5 \times 10^{-4}) = 17.5 \times 10^{-4}$**



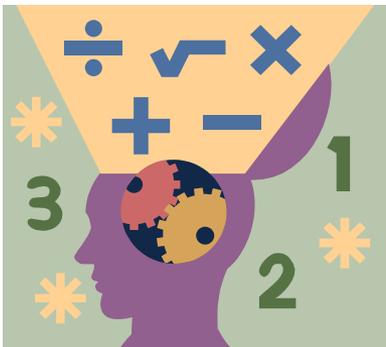
In scientific notation , it is 1.8×10^{-3} remembering to have one number to the left of the decimal and to use correct significant figures.

When multiplying numbers with base 10 exponents, multiply the first factors, and then add the exponents.

Example, $(3.1 \times 10^5) (4.5 \times 10^5) = 13.95 \times 10^{10}$

To make this answer correct for scientific notation and significant figures it should be written as 1.4×10^{11} .

When dividing numbers, the exponents are subtracted, numerator exponent minus denominator exponent.



Example:
$$\frac{9 \times 10^5}{3 \times 10^3} = 3 \times 10^2$$

In this case the sig. figs are already correct

Le Systeme international d'Unites (SI) has been officially recognized and adopted by nearly all countries for measuring and calibrating in science labs.



The Base Units and abbreviations of SI are below.

Length	Meter, m
Volume	Liter, l or L
Mass	Gram, g (used as metric base unit) Kilogram, kg (used as SI base unit)

The prefixes and symbols listed below are used to form names and symbols of the decimal multiples and sub multiples of the SI Units:

Metric Prefixes

Symbol

Multiplication Factor

Giga	G	$10^9 = 1\ 000\ 000\ 000$
Mega	M	$10^6 = 1\ 000\ 000$
Kilo	k	$10^3 = 1\ 000$
Hecto	h	$10^2 = 100$
Deka	dk	$10^1 = 10$
Base Unit	(m, l, g)	$10^0 = 1$
Deci	d	$10^{-1} = .1$
Centi	c	$10^{-2} = .01$
Milli	m	$10^{-3} = .001$
Micro	μ	$10^{-6} = .000\ 001$
Nano	n	$10^{-9} = .000\ 000\ 01$

There are also occasions when you will need to convert from the US and UK measurements to Metric/SI units. These conversions are listed below.

Gallons to Liters	1 gal= 3.8 L
Liters to Gallons	1 L, l= .264 gal
Meters to Yards	1 m= 1.094 yd
Yards to Meters	1 yd= .914 m
Grams to Ounces	1 g= .035 oz
Ounces to Grams	1 oz= 28.35 g
Kilograms to Pounds	1 kg= 2.2 lb
Pounds to Kilograms	1 lb= 454 g
Miles to Kilometers	1 mi= 1.609km
Kilometers to Miles	1 km= .621 mi

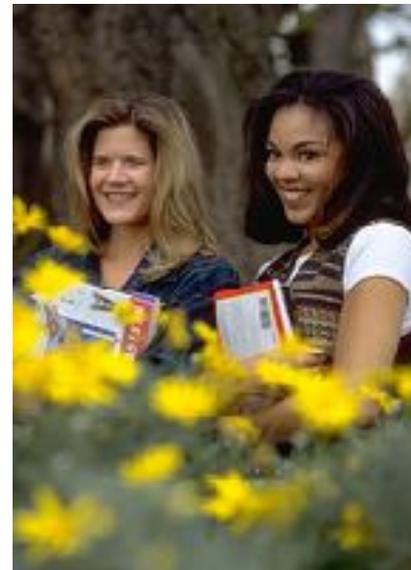
A common method of converting and calculating is referred to as Dimensional Analysis or Factor/Label method.

To successfully use these conversion charts, the following formula based on the cancellation of units is useful:

$$\text{Given Value} \times \frac{\text{Conversion factor}}{1} = \text{Answer}$$

This could also be thought of as:

$$\text{old unit} \times \frac{\text{new unit}}{1 \text{ old unit}} = \text{new unit}$$



Note that the conversion factor may also be expressed as the denominator when appropriate.

Here is a simple example of dimensional analysis. See how each unit cancels by the conversion factor.



Example: To convert 25 feet into meters

$$25 \text{ ft} \times \frac{1 \text{ yd}}{3 \text{ ft}} \times \frac{1.094 \text{ m}}{1 \text{ yd}} = 9.117 \text{ meters}$$

Graphing is another important skill to master. Here are some general rules about graphing data:

Title the graph

Set up the independent variable along the X axis

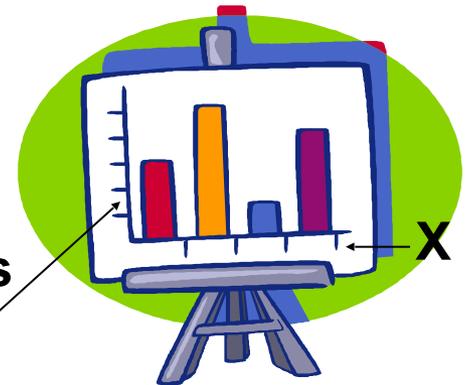
Set up the dependent variable along the Y axis

Label each axis and give the appropriate units

Make proportional increments along each axis so the graph is spread out over the entire graph area

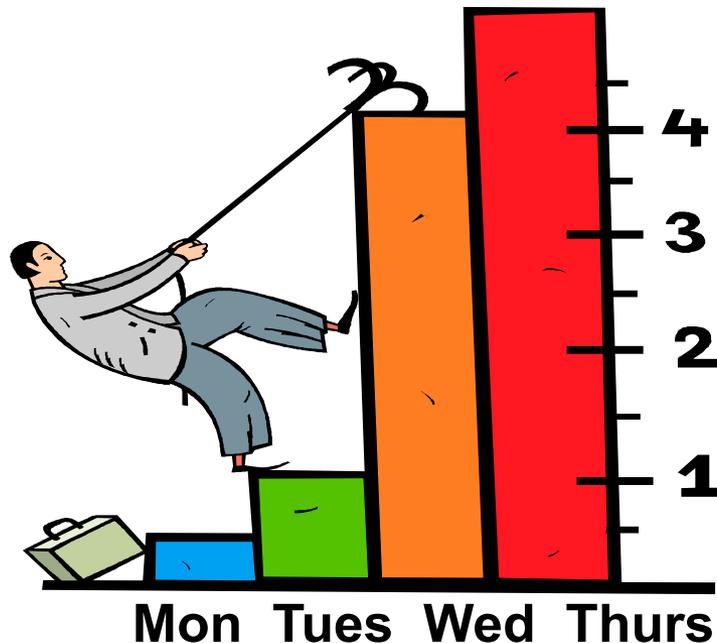
Plot points and sketch a curve if needed. Use a straight edge to connect points unless told to extrapolate a line.

Label EACH curve if more than one is plotted.



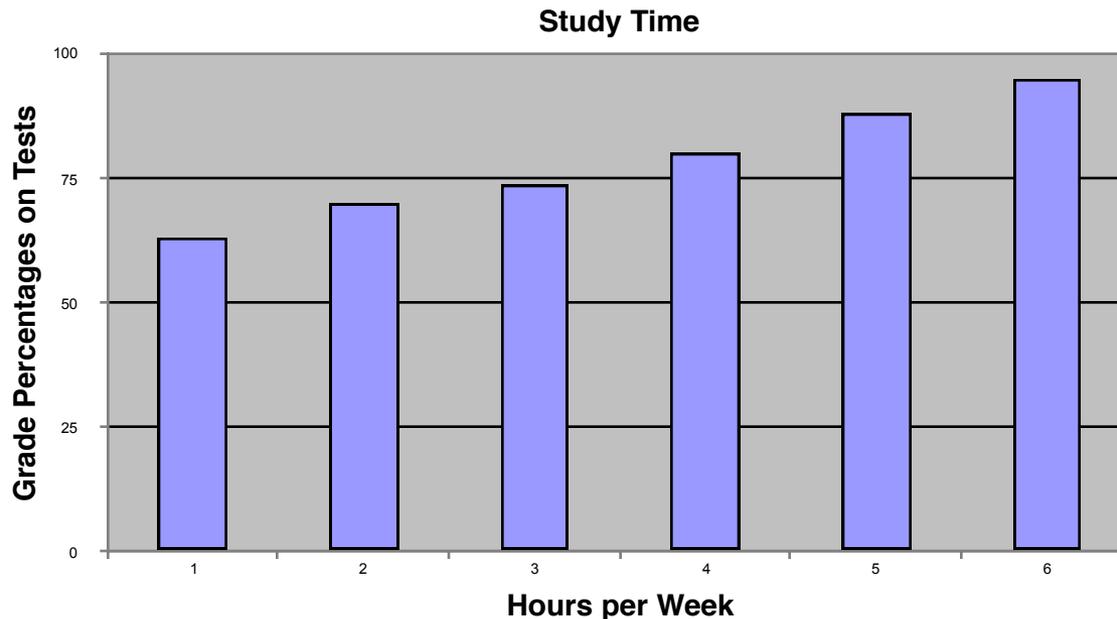
An independent variable may also be called predictor, controlled, manipulated, or explanatory variables, and are values controlled or selected by the experimenter to determine its relationship to an observed phenomenon.

Time is often the independent variable in an experiment. This is the information generally plotted along the horizontal or x axis of a graph.



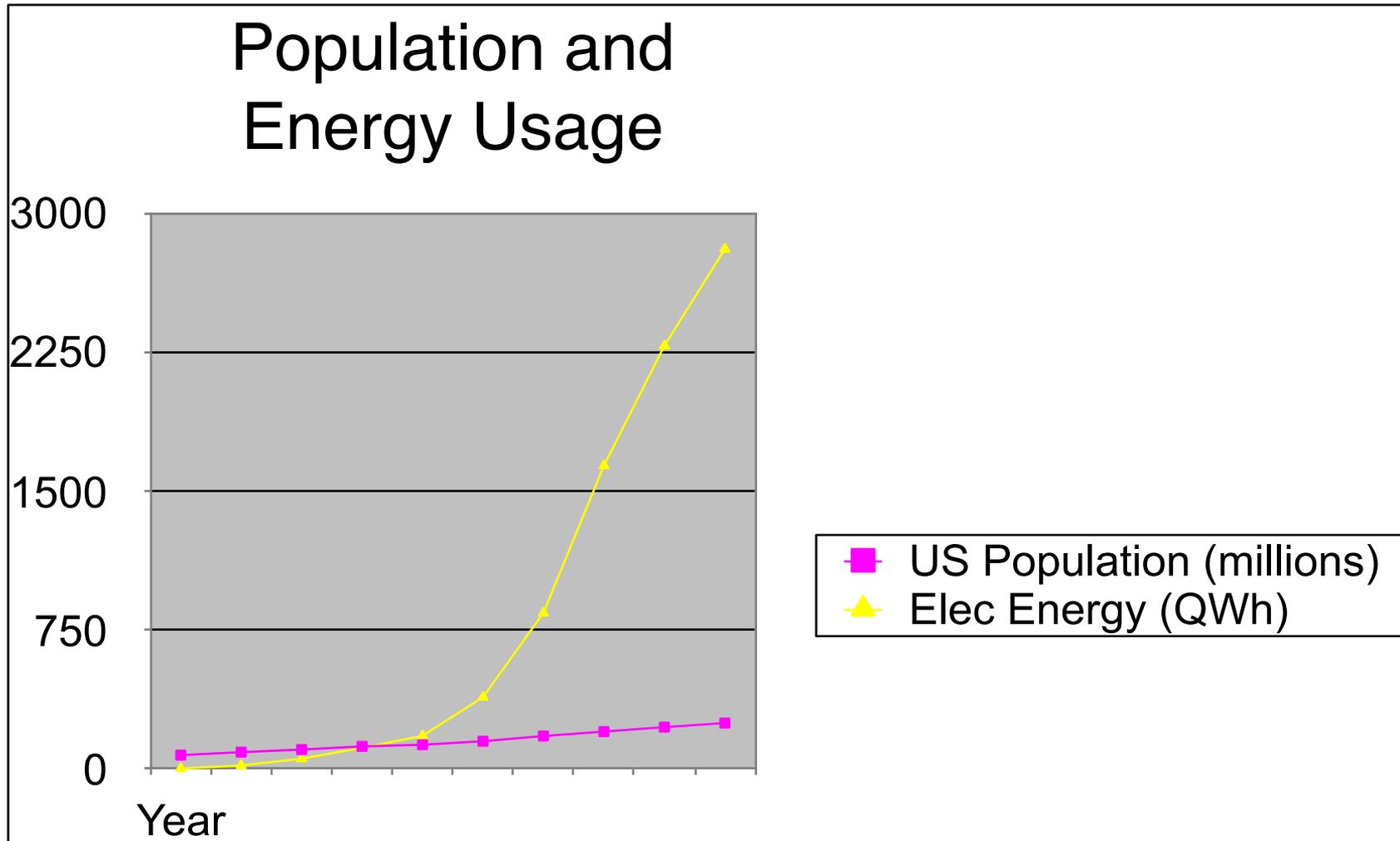
A dependent variable is the observed phenomenon measured in an experiment. Dependent variables generally cannot be controlled.

If the independent variable is changed or actively controlled, the dependent variable value then changes as a result.

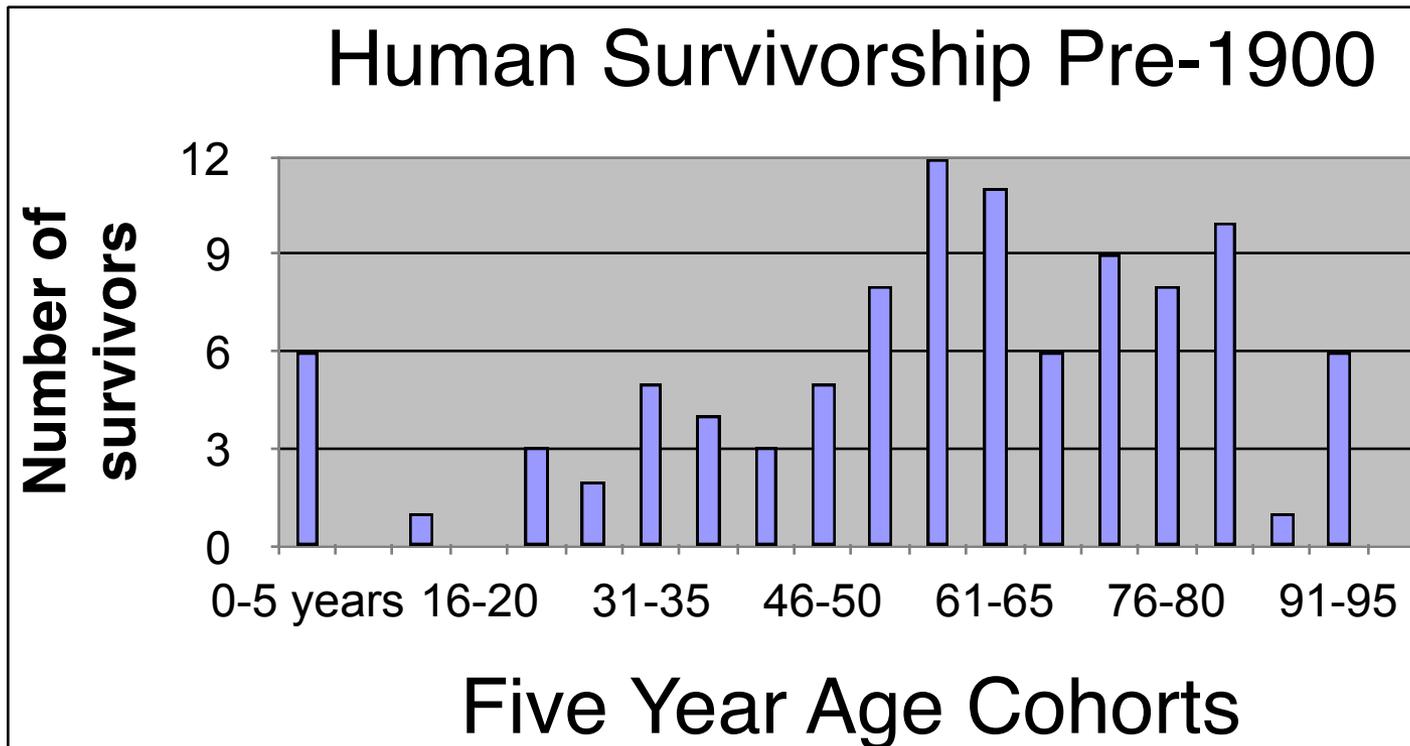


Dependent variables are generally plotted along the vertical or y axis on a graph.

A line graph is more appropriate for data that changes over time as illustrated below.



A bar graph or histogram may be appropriate for comparing data sets.

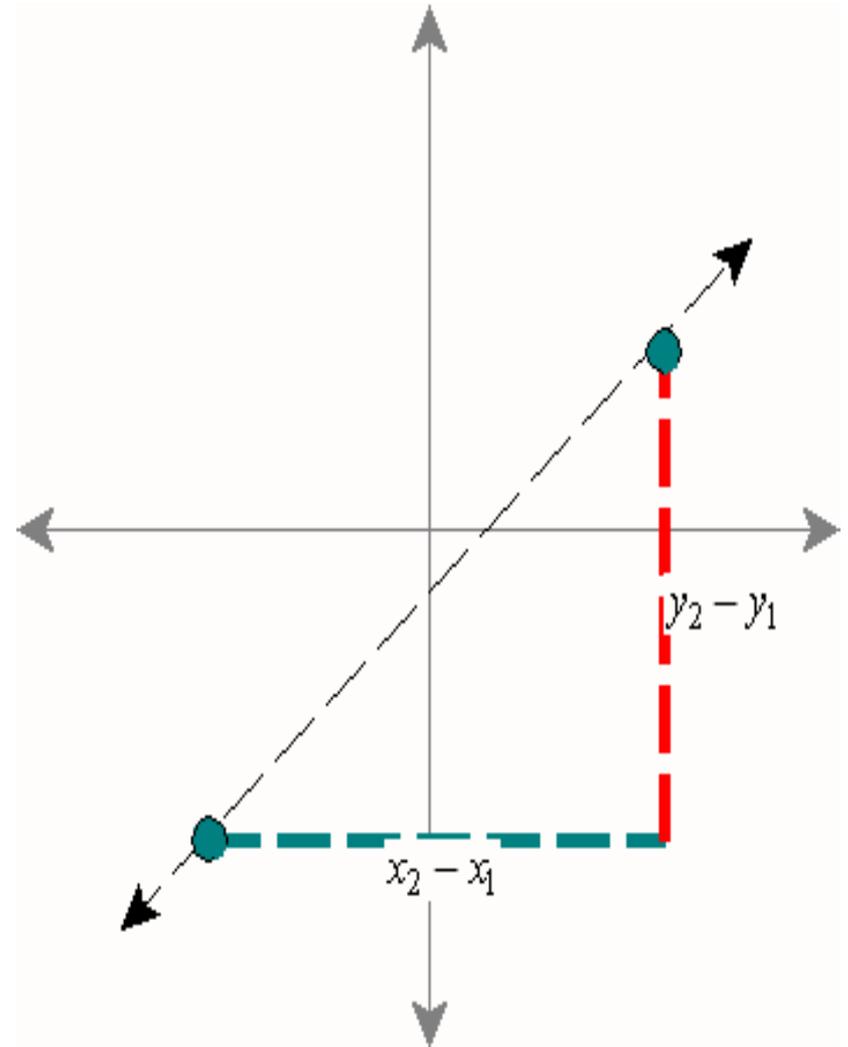


Calculating the slope of the line or linear regression can be useful when examining trends on a graph.

Remember the math formula:

$$m = (y_2 - y_1) / (x_2 - x_1)$$

(rise over run) which uses the difference of two points from the y axis and two points from the x axis.



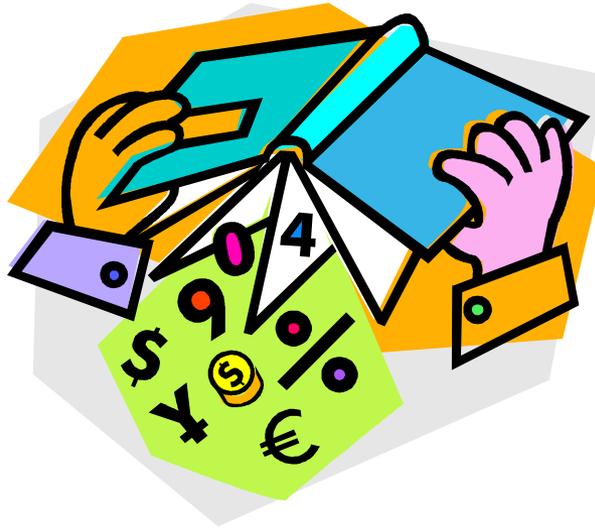
When you are studying data such as a list of measurements or a histogram, there are three values which are used to describe the “central tendency” of the information. These basic statistics terms are Mean, Median and Mode.

(A) The mean represents the arithmetic average of the distribution. If you add $5 + 5 + 5 + 10 + 15 = 40$, then to calculate the average you divide 40 by 5 (the number of items added) and find 9 as the mean

The mean (average) size is calculated using the following formula where n represents the number of values in the data set, and \sum means to take the sum of the values (x) in a sample:

$$\bar{x} = \frac{\sum x}{n}$$

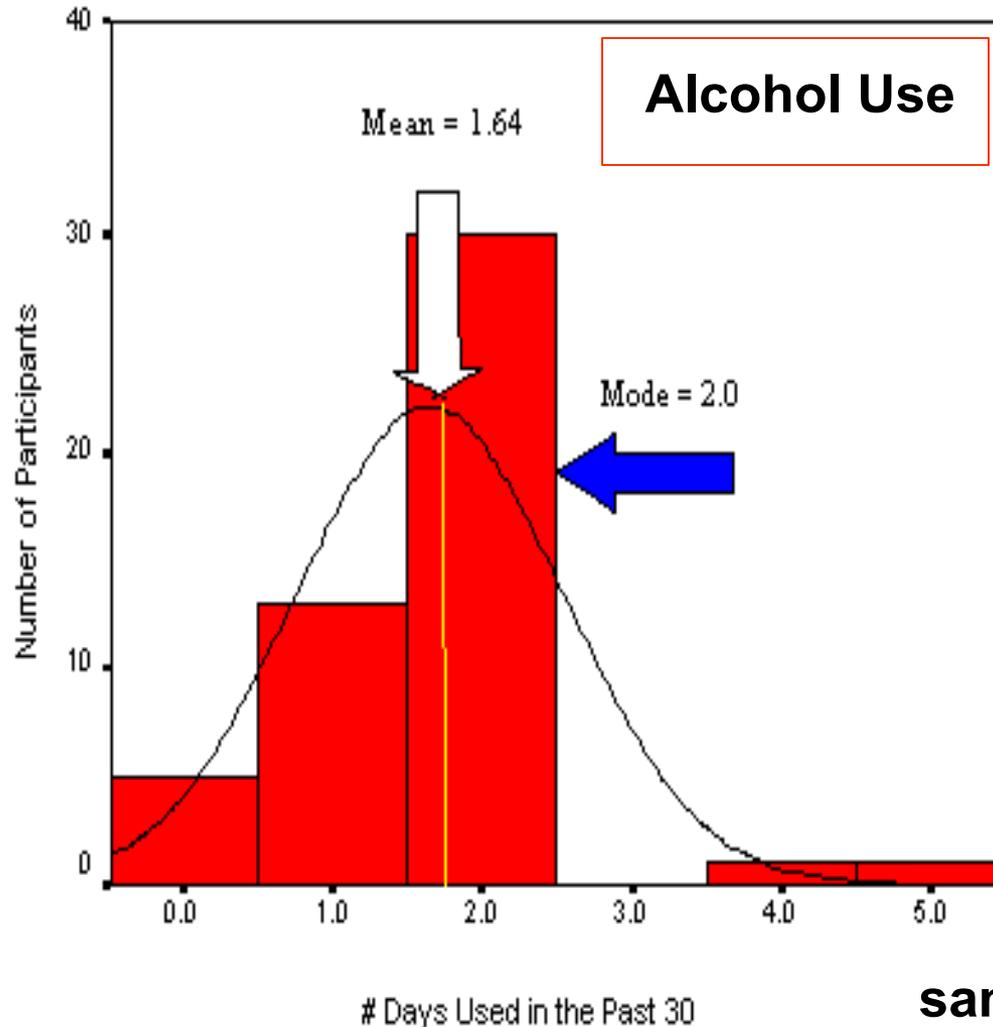
(B) The median is represented as the midpoint in a data array for which equal numbers of observations occur above and below.



This is obtained by listing the observed number values in order and then counting up or down to find the midpoint, and this value is usually not equal to the mean.

In the previous example $5 + 5 + 5 + 10 + 15$, the median is 10, but the arithmetic average was 9.

(C) The mode is the value that occurs most often in a data set. For example, the mode of the sample [1, 3, 6, 6, 6, 6, 7, 7, 12, 12, 17] is 6.



Measures of variation are used to tell if the numbers in the data are close together or spread far apart.

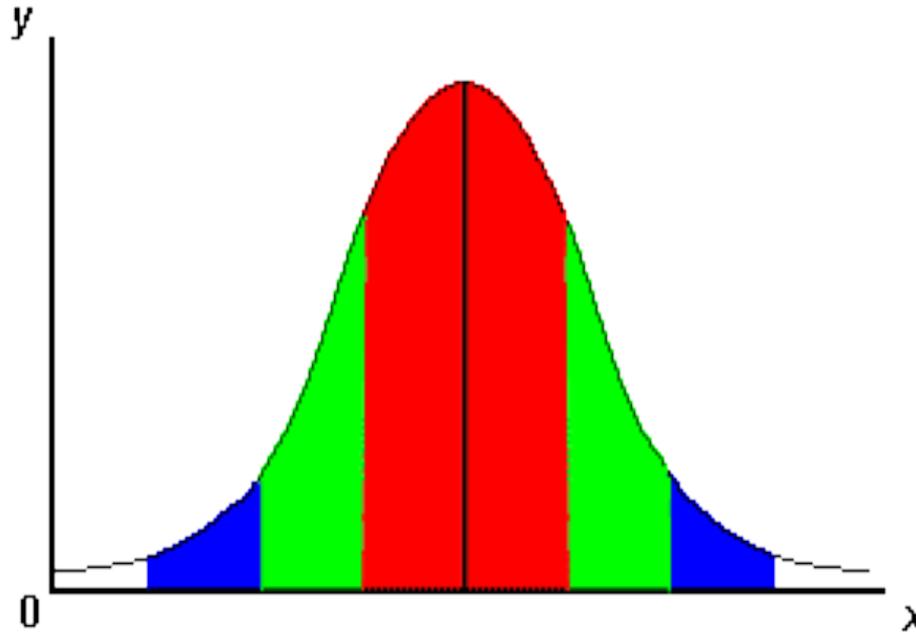
The standard deviation is commonly used and shows the average amount the numbers are deviating from the mean.

Example: the standard deviation is represented by:

$$s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

Remember s = standard deviation, x = values in the sample, sample mean, and sample size.

In a “normal distribution of data,” one standard deviation away from the mean in either direction on the horizontal axis (red) accounts for about 68 percent of the group.



Two standard deviations away from the mean (red and green) account for about 95 percent, and about 99 percent of data falls within three standard deviations from the mean.