ERRORS IN MEASUREMENT AND ANALYSIS

No Measurement is Accurate!

Errors occur because of:

1. Parallax error (incorrectly sighting the measurement).
2. Calibration error (if the scale is not accurately drawn).
3. Zero error (if the device doesn't have a zero or isn't correctly set to zero).
4. Damage (if the device is damaged or faulty).
5. Limit of reading of the measurement device (the measurement can only be as accurate as the smallest unit of measurement of the device).

Definitions

1. Limit of Reading: is the smallest unit of measurement on the measuring instrument.
2. The Greatest Possible Error (also called the absolute error): is equal to half the limit of reading.
3. The Upper and Lower Limits: are the smallest and largest value between which a measurement can lie.

Types of Errors

Basically Three types of errors are studied:-

1. Gross Errors
2. Systematic Errors
3. Random Errors

Gross Errors

Gross Errors mainly covers the human mistakes in reading instruments and recording and calculating measurement results.

Example:- Due to oversight, The read of Temperature as 31.5 while the actual reading may be 21.5 .

Gross Errors may be of any amount and then their mathematical analysis is impossible. Then these are avoided by adopting two means:-

1. Great care is must in reading and recording the data.

2. Two , Three or even more reading should be taken for the quantity under measurement.

Systematic Errors

Systematic Errors classified into three categories :-

1. Instrumental Errors
2. Environmental Errors
3. Observational Errors

Instrumental Errors

These errors arises due to three main reasons.

1. Due to inherent shortcoming in the instrument.

   Example:- If the spring used in permanent magnet instrument has become weak then instrument will always read high. Errors may caused because of friction , hysteresis , or even gear backlash.
2. Due to misuse of the instruments.
3. Due to Loading effects of instruments.

Environmental Errors

These errors are due to conditions external to the measuring Device including conditions in the are surrounding the instrument.

These may be effects of Temperature, Pressure, Humidity, Dust, Vibrations or of external magnetic or electrostatic fields.

Observational Errors

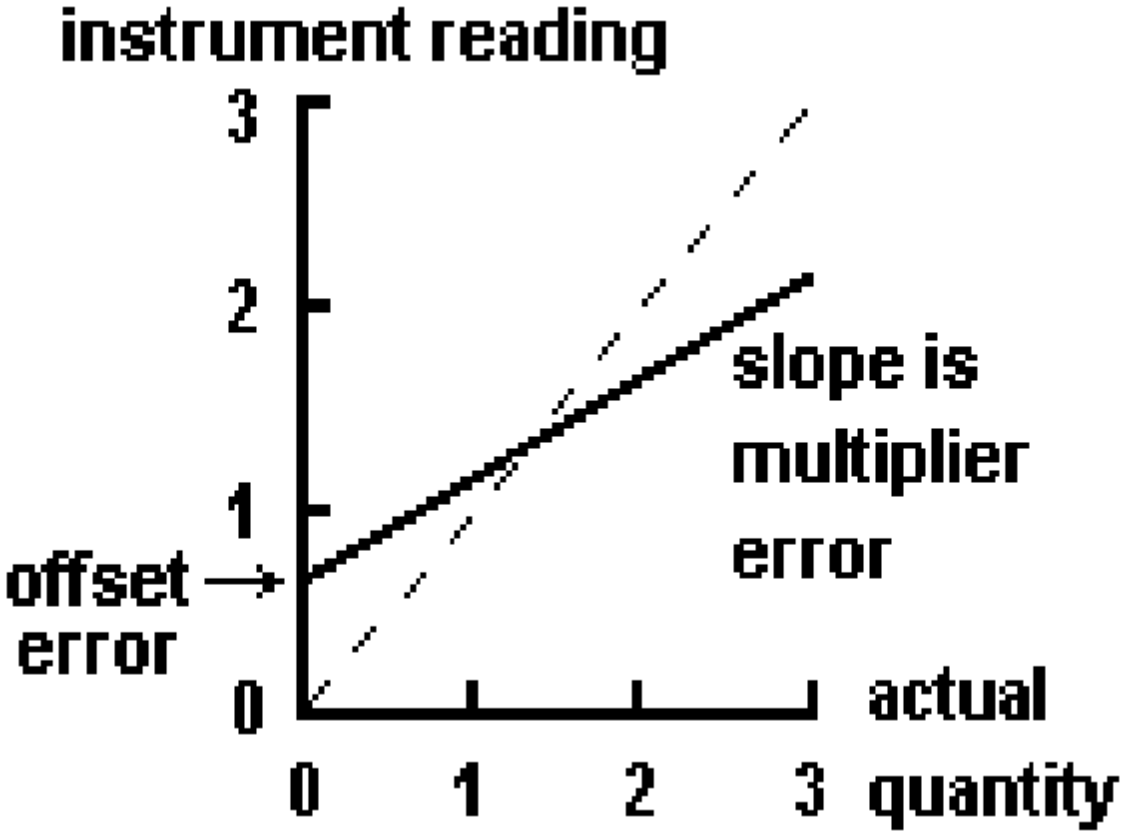
There are many sources of observational errors:-

-- Parallax, i.e. Apparent displacement when the line of vision is not normal to the scale.

-- Inaccurate estimate of average reading.

-- Wrong scale reading and wrong recording the data.

-- Incorrect conversion of units between consecutive reading.



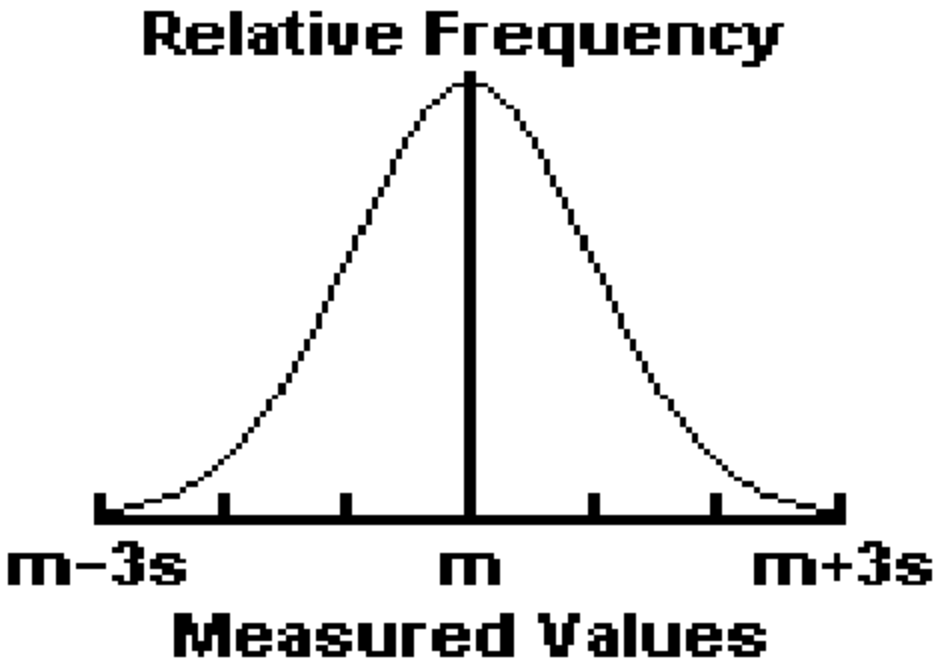
Here in Graph, Full Line shows the systematic Error in non Linear Instrument.

While Broken Line shows response of an ideal instrument without Error.

Random Errors

The quantity being measured is affected by many happenings in the universe. We are aware for some of the factors influencing the measurement, but about the rest we are unaware. The errors caused by happening or disturbances about which we are unaware are Random Errors. Its also known as residual Errors.

Example of Random Error



The Gaussian normal distribution. m = mean of measurements. s = standard deviation of measurements. 68% of the measurements lie in the interval m - s < x < m + s; 95% lie within m - 2s < x < m + 2s; and 99.7% lie within m - 3s < x < m + 3s.

Statistical Analysis of Data

The Experimental Data is obtained in Two Forms of the tests:-

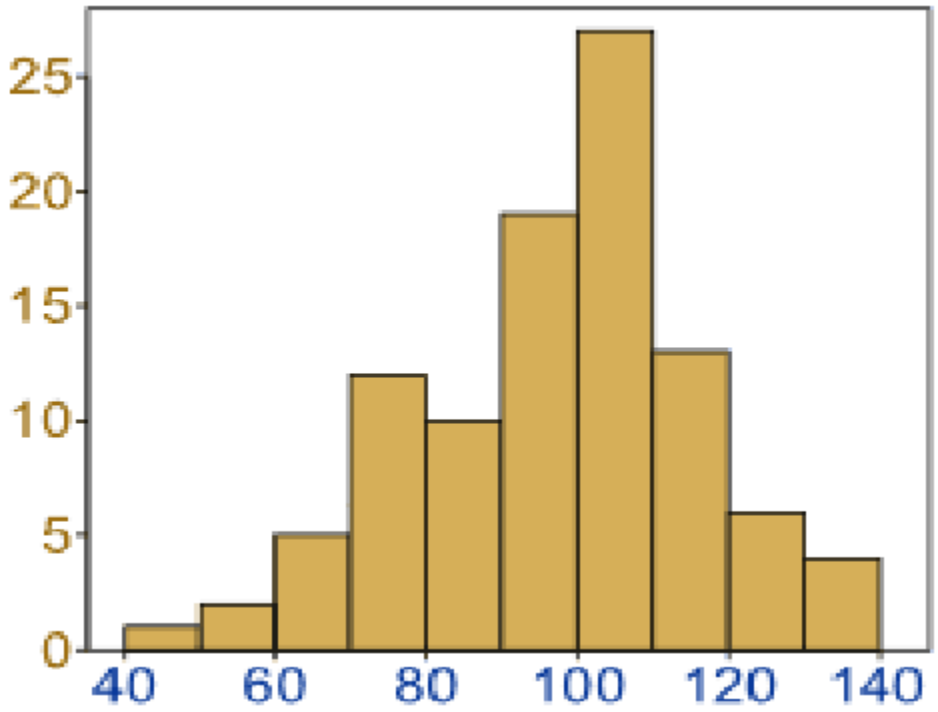
1. Multi sample Test
2. Single Sample Test

1. Multi sample Test:- In this test, The Repeated measurement of a given quantity are done using different test conditions such as employing different instruments, Different ways of measurement and by employing different observers.

2. Single Sample Test :- A single measurement for succession of measurement done under identical conditions excepting for time is known as single sample Test.

Histogram

When The Number of multi sample observations are taken experimentally, There is a scatter of the data about some central value. One method presenting test results in the form of histogram. It is also called frequency distribution curve.



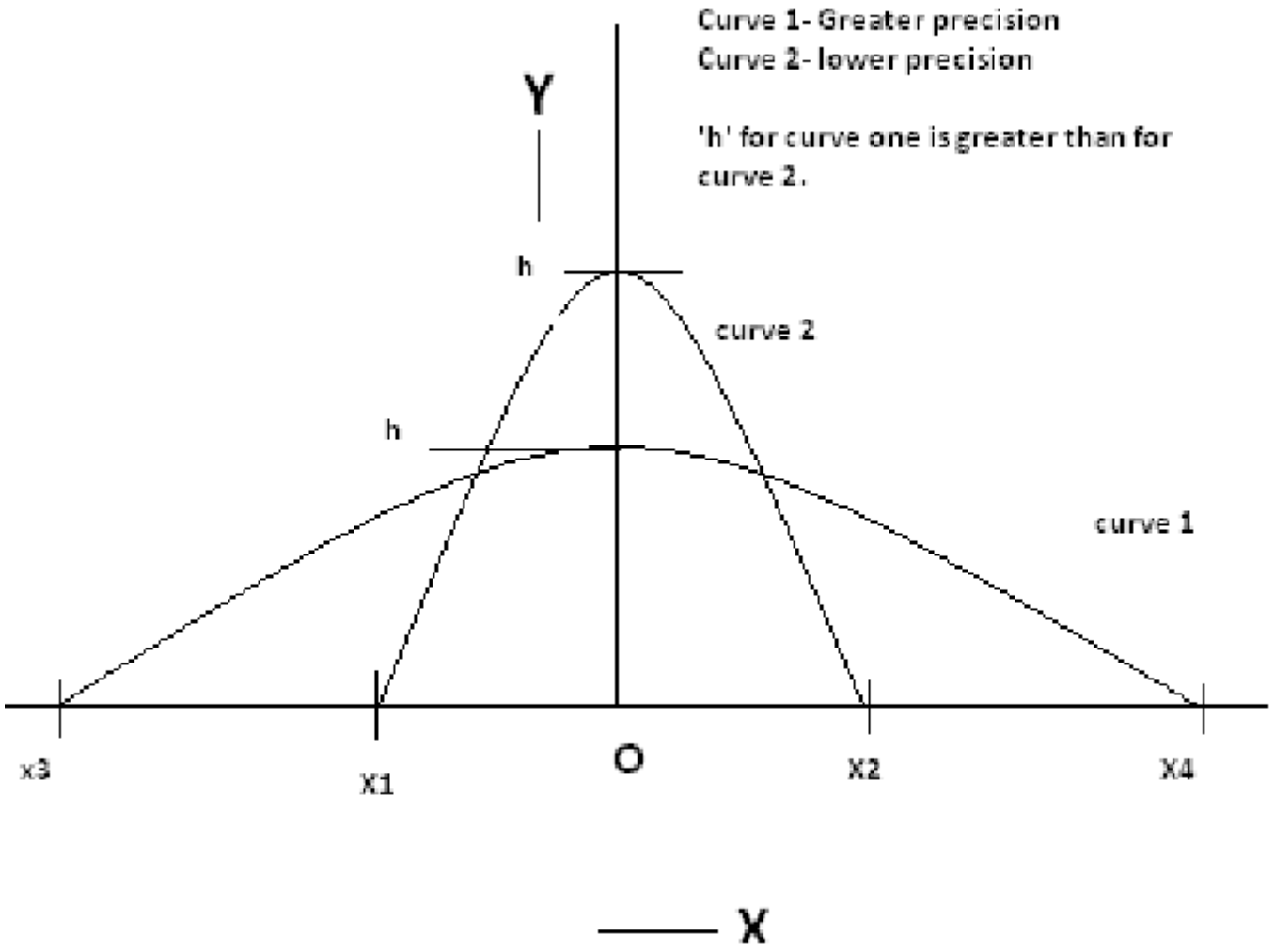
A Histogram is a graphical display of data using bars of different heights.
It is similar to a Bar Chart, but a histogram groups numbers into ranges
And you decide what ranges to use.

Arithmetic Mean

The best approximation that can be made of a number of readings of the same quantity is the arithmetic mean. It is also called Mean value. This mean is computed by summing all the values and dividing by the number of measurements.

Dispersion from the Mean

The property which denotes the extent to which the values are dispersed about the central value is termed as dispersion. It also known as spread or scatter. See Fig. 1.1, it shows two sets of data. In one case(curve 1) the values vary from x1 to x2 and in other curve 2 the values vary from x3 to x4. Though their central value is the same, clearly set of data represented by curve 1 has a smaller dispersion than that of the data represented by curve 2.



Curves showing different ranges and precisionindices

There are certain terms which must be defined as they form the basis defining the measure of dispersion of data:

1. Range
2. Deviation
3. Average deviation
4. Standard deviation
5. variance

Range And Deviation

The simplest possible measure of dispersion is the range which is the difference between greatest and least values of data. E.g. the range of curve 1 is (X2-X1) and that of the curve 2 is (X4-X3).

Deviation:- Deviation is departure of the observed reading from the arithmetic mean of the group of readings.

Average And Standard Deviation

Average deviation is defined as the sum of the absolute values of deviations divided by the number of readings. The absolute value of deviation is the value without respect to its sign.

Standard deviation is defined as the square root of the sum of the individual derivations squared, divided by the number of readings. It is the important term in analysis of random numbers.

Variance

The variance is the mean square deviation which is same as Standard deviation except that square root is not extracted.