Indeterminate errors (Random errors)

Indeterminate errors represent random fluctuations in measuring devices that are beyond the control of analyst. They are bidirectional. They are small in magnitude. But the accumulated effect can cause a considerable deviation to the mean. It is not possible to determine the magnitude of individual random error since they are small in magnitude.

Normal error curve and its properties:

To understand the nature of random errors and to understand the development of normal error curve, the following two points have to be considered.

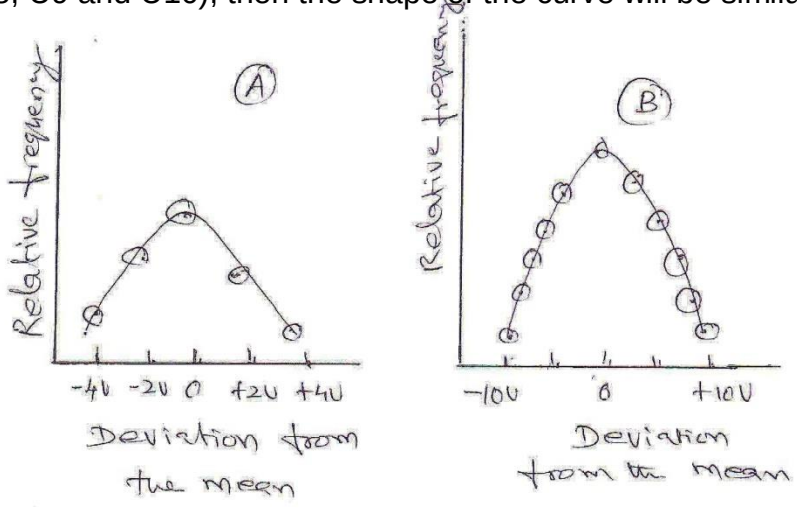
1. In a particular measurement, assume that there are four small random errors (U1, U2, U3 and U4) combine to give an overall error.
2. They have equal probability of occurring with a magnitude of deviation, ±U.

The possible combinations of the four random errors (U1, U2, U3 and U4) in a measurement are tabulated below.

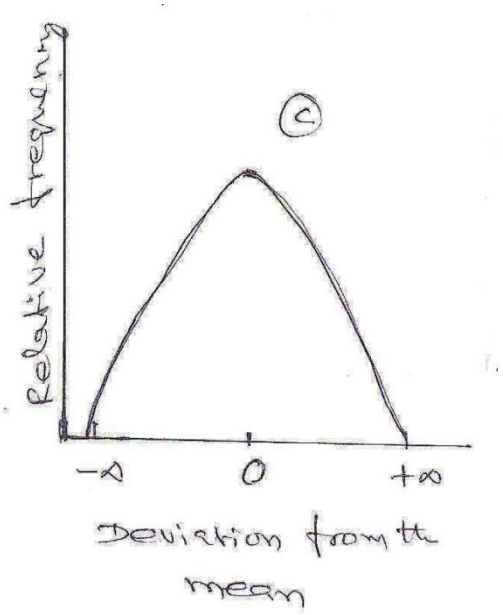
Combination of uncertainties (errors)	Magnitude of the random error	Number of combinations	Relative frequency
+U1+U2+U3+U4	4U	1	1/16 = 0.0625
-U1+U2+U3+U4 +U1-U2+U3+U4 +U1+U2-U3+U4 +U1+U2+U3-U4	2U	4	4/16 = 0.250
-U1-U2+U3+U4 +U1+U2-U3-U4 +U1-U2+U3-U4 -U1+U2-U3+U4 -U1+U2+U3-U4 +U1-U2-U3+U4	0U	6	6/16 = 0.375
+U1-U2-U3-U4 -U1+U2-U3-U4 -U1-U2+U3-U4 -U1-U2-U3+U4	-2U	4	4/16 = 0.250
-U1-U2-U3-U4	-4U	1	1/16 = 0.0625

When we plot the relative frequency and the magnitude of error we get, Fig. A.

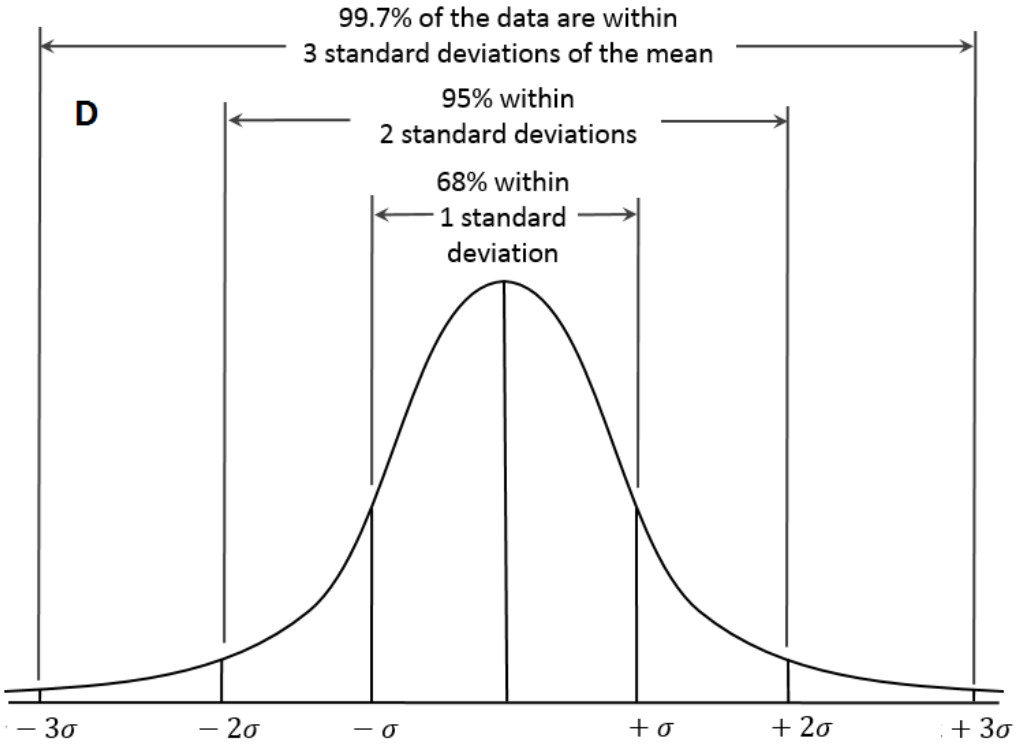
When the same procedure is applied for a measurement having ten uncertainties (U!, U2, U3, U4, U5, U6, U7, U8, U9 and U10), then the shape of the curve will be similar (Fig. B).



When the same procedure is applied for a very large number of individual random errors, a smooth bell shaped curve is obtained (Fig. C).



When the deviation is replaced with the standard deviation (or true standard deviation) of the large number of individual measurements, then also the shape of the curve is the same (Fig. D) and such a plot is called normal error curve or Gaussian curve.



Properties of a normal error curve

1. Zero indeterminate error occurs with maximum frequency.
2. A symmetry about the maximum indicates that the negative and positive errors occur with equal frequency. 3. An exponential decrease in frequency occurs as the magnitude of the error increases.
4. The distribution of the normal error curve (Fig. D. above), can be described mathematically in terms of three parameters.

$$Y = [\exp(-(x-\mu)^2/2\sigma^2)]/\sigma(2\pi)^{½}$$

x = values of individual measurements
μ = Arithmetic mean for an infinite number of such measurements (true mean)
σ = True standard deviation