$$s = \sqrt{\frac{d_1^2 + d_2^2 + \cdots + d_n^2}{n-1}}$$ If $n \leq 20$

↓

sample std. deviation

e) variance (V)

defined as sq. of std. deviation

expressed as:

$$V = (\sigma)^2 = (s)^2$$

f) Gausion probability curve

5th NEC

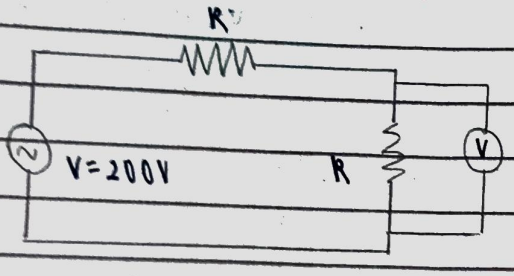

Fig (i)

Voltage Reading (V)	No. of observations
99.7	1
99.8	3
99.9	12
100.0	19
100.1	10
100.2	4
100.3	1

Table (i)

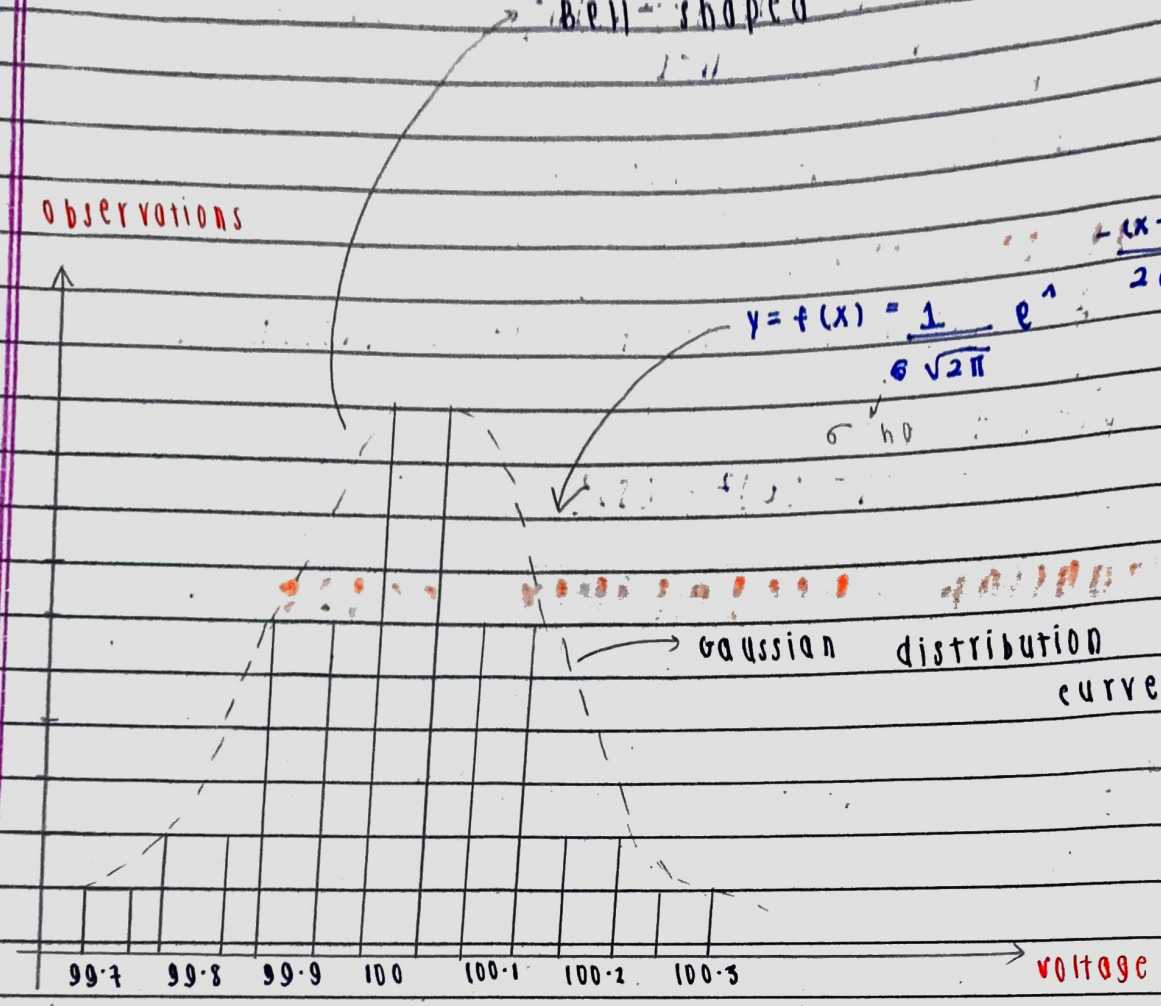

Fig (ii)

consider an eg. where V drop across the resistor is taken using voltmeter & following reading were obtained

Table (i) shows 50 V readings that were taken at a small time interval & recorded to the nearest 0·1 V voltage range.

The nominal (true) value of measured voltage was 100V. The result of this series of measurement can be presented graphically in the form of histogram

↓

bar graph

In which the no. of observations is plotted against each observed voltage reading. This bell shaped curve is known as Gaussion probability curve

↓

It's eqn is given by:

$$y = f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\bar{x})^2}{2\sigma^2}}$$

- $\bar{x}$: mean
- e : exp power
- σ : std. deviation
- y : no. of observations

Probable Error

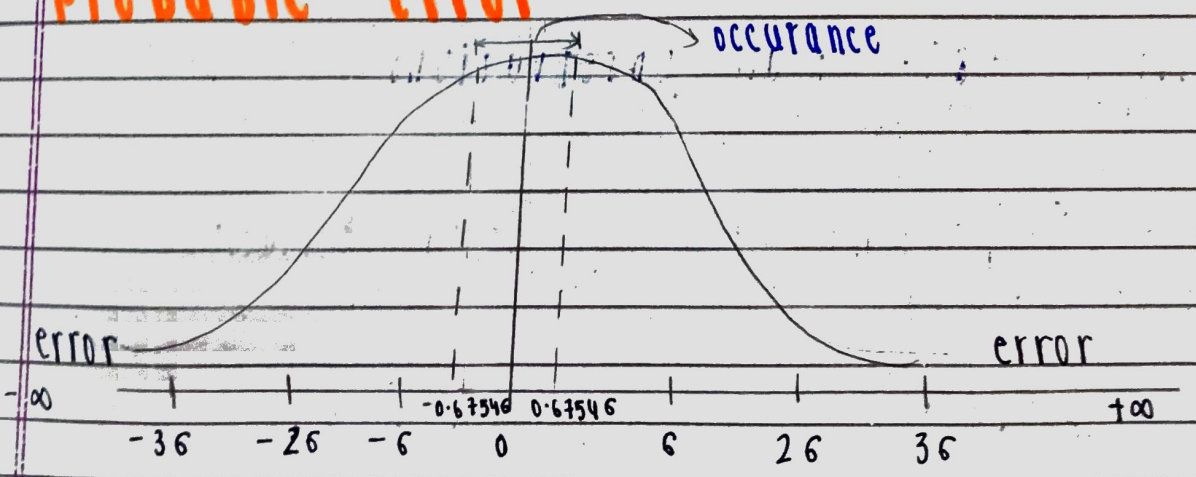

Fig (i)

Deviation	Fraction of area in Gaussian prob. curve
$\pm 0.6754\,\sigma$	0.5
$\pm \sigma$	0.6828
$\pm 2\sigma$	0.9546
$\pm 3\sigma$	0.9972

Table (i)

Area under Gaussian prob curve in fig (i) betⁿ $-\infty$ to $+\infty$ represents entire no. of observations

&

the area under curve betⁿ limit $-\sigma$ to σ rep. observations that differs from the mean by no more than σ

Integration of area under the curve within the limit $\pm\sigma$ gives total no. of observation within that limit.

Approx. 68% of all observations lie betⁿ the limit $\pm\sigma$ from the mean.

The corresponding value of other deviations are given in table (i).

- The probable error is denoted by 'r'

ξ is given by:

$$r = \pm\ 0.6754\ \sigma$$

This value is probable in the sense that there is 50-50 chances that the new value will lie betn $-r$ & $+r$

some formula

(i) probable error of one reading (r)

$r = \pm\ 0.6754\ \sigma$ for $n \geq 20$

$= \pm\ 0.6754\ s$ for $n < 20$

(ii) probable error of mean (rm):

$r_m = \frac{r}{\sqrt{n-1}}$ for $n < 20$

$= \frac{r}{\sqrt{n}}$ for $n \geq 20$

Numerical

1. Following 10 observation were recorded when measuring voltage

41.7, 42, 41.8, 42, 42.1, 41.9, 42.5, 41.9, 42, 41.9.

find: i) mean
ii) std deviation
iii) prob error of ~~one~~ reading
iv) prob error of mean
v) range

ii) mean

$$\bar{x} = \frac{41.7 + 42 + 41.8 + 42 + 42.1 + 41.9 + 42.5 + 41.9 + 42 + 41.9}{10}$$

$$= 41.98$$

iii) std. deviation

41.98

	x	$x - \bar{x}$	d^2
1.	41.7	-0.28	0.0784
2.	42	0.02	0.0004
3.	41.8	-0.18	0.0324
4.	42	0.02	0.0004
5.	42.1	0.12	0.0144
6.	41.9	-0.08	0.0064
7.	42.5	0.52	-0.2704
8.	41.9	-0.08	0.0064
9.	42	0.02	0.0004
10.	41.9	-0.08	0.0064

FOR $n < 20$

std. deviation $s = \sqrt{\frac{\Sigma (x - \bar{x})^2}{n-1}}$

$= \sqrt{\frac{0.4196}{9}}$

$= 0.2159$

iii) Prob error of one reading (for $n < 20$)

$r = \pm 0.6754\, s$

$= \pm 0.6754 * 0.2159$

$= \pm 0.1458$

iv) Prob error of mean (for $n < 20$)

$r_m = \frac{r}{\sqrt{n-1}}$

$= \pm \frac{0.1458}{\sqrt{10-1}}$

$= \pm 0.0486$

v) Range: 41.7 - 42.5

↓ lowest reading

↳ highest reading

static & dynamic characteristics of measurement system

When an i/p is applied to a system or instrument, the response doesn't take its max. or const. value immediately.

There will be some delay in time known as transient / dynamic period.

Behaviour shown by system during this period is known as transient / dynamic characteristics

After the transient period the response takes its const. value. This time period is steady state period

Behaviour shown by system during this period is static characteristics

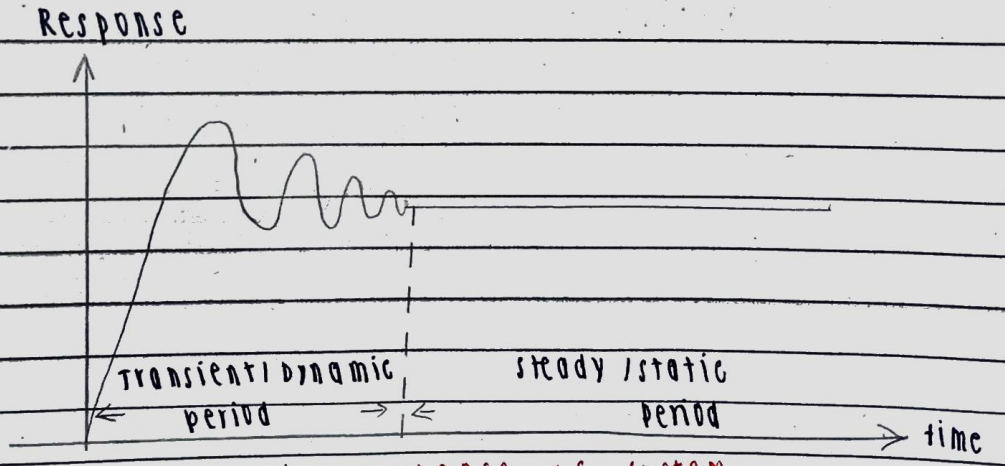

Fig: Response of system

Dynamic characteristics

(i) Speed of Response
Rapidity in which an instrument responds to change of quantity under measurement.

(ii) Response time
Time reqd by the system / instrument to settle its final steady state position, after the application of i/p

(iii) measuring lag
Delay in response of an instrument to a change in the measured quantity.

static characteristics

(i) Accuracy
specifies the diff. betn measured value & the true value of quantity.

It is the closeness w. which an instrument reading approaches to the true value of quantity.

Deviation from the true value is the indication of how accurately a measurement has been done.

Concept of accuracy usually refer to the full scale reading

(ii) Precision / Repeatability

specifies the repeatation of set of reading each made independently w. the same instrument.

It is used in measurement to describe the consistency of results.

↑ precision means tight cluster of repeated results while

↓ precision indicates a broad scattering of results.

- TO differentiate betn accuracy & precision

Consider an instrument that has defect in its operation.

The instrument may give result that is highly repeatable from measurement to measurement

yet

far from the t.v.

The data obtained from this instrument would be

- ↑ (highly) precised

but,

- inaccurate.

∴ precision does not guarantee accuracy.

Although,
accuracy requires precision.