

Classification of Measuring Instruments:

The measuring instruments may be classified into two groups:

① Absolute Instruments: (standard instrument)
They are used for calibrating other instruments. It is used as standard measurements and kept by national laboratories and similar institutions.

② Secondary Instruments:

They are direct reading instruments, and calibrated by comparison with the absolute instruments, they are used in all our laboratories.

* Instrument Selection:- The following check list is a guide to select the optimum instrument:-

① Accuracy:- It is the difference between the measured and the actual value.

② Range:- Describes the highest and lowest value that the instrument can read it, and if the instrument is single range or multi-range.

③ operation:- * manually or automatically selection of range.

* Operated manually or remotely controlled

* multi-function (AVO) or single function (voltmeter)

* power requirement (AC or DC).

- ④ Reliability: The ability of Instrument to give identical indications for the same repeated measured values.
- ⑤ Response characteristics: The response of the measured value for any change in the input.
- ⑥ Stability: The ability of the instrument to return to zero after the measurement process is ended.
- ⑦ Environment: The ability of instrument to work in a severe condition (shocks, vibrations, hot or cold weather, humidity).
- ⑧ Isolation & Screening: The ability of the instrument to work in electric or magnetic field, so it should be isolate and shielded internally to overcome the field.

Instrumentation Error

Error: Is the deviation of the (measured) value from the true (actual) value.

Errors may come from different sources, they are usually classified under three main types:-

① Gross Errors: (Human Errors)

- SOURCES {
- Misreading of instrument
 - Incorrect adjustment
 - Improper application.
 - Computational mistake.
- خطأ القراءة
خطأ الضبط
خطأ التطبيق
خطأ الحسابات

② Systematic Errors: (shortcomings of the instrument)

It can be divided into two types:-

a) Instrumental Errors: This error is due to:-

- Mechanical structure of the instrument. (defective or worn parts, friction due to the movements, stretching of springs).
- Errors due to the calibration.

b) Environmental Errors: This error is due to:-

- * Condition external to the measuring devices, such as (change in temperature, humidity, pressure).
- * Magnetic or electrostatic field affecting the measurement device.

③ Random Errors: الأخطاء العشوائية

These errors are due to unknown causes and occur even when all systematic errors and gross errors are eliminated.

The best way to avoid or to overcome the

→ 3 ←

Random errors is to increase the number of readings and using statistical means to obtain the best approximation of the true value of the quantity.

Errors Formulas:-

* Absolute Error = $\Delta x = X_T - X_m$ (الخط المطلق) — (1)

where: Δx : is the absolute error.

X_T : True value (actual) حقيقي

X_m : measured value (apparent) ظاهري

* Percentage Error ($E\%$):

$$E\% = \frac{X_T - X_m}{X_T} \times 100\%$$

$$E\% = \frac{\Delta x}{X_T} \times 100\% \quad \text{--- (2)}$$

* Relative accuracy (A) = $1 - \left(\frac{X_T - X_m}{X_T} \right)$ ← Relative error — (3)

* Percentage accuracy (α) = $A \times 100\%$ — (4)

⇒ For N measured values

* $X_{av} = \frac{X_1 + X_2 + X_3 + \dots + X_n}{N}$ — (5)

where X_n : value of N th measurement.

* precision = $1 - \left| \frac{X_n - X_{av}}{X_{av}} \right|$ — (6)

Example: The expected value of voltage across a resistor is (50)V, the measured value was (49)

calculate:-

- 1 - Absolute error
- 2 - Percentage error
- 3 - Relative accuracy
- 4 - Percentage accuracy

Sol:

* $\Delta x = 50 - 49 = 1 \text{ Volt}$

→ 4 ←

$$\begin{aligned} \text{2- percentage error} &= \frac{\Delta X}{X_T} \times 100\% \\ &= \frac{50 - 49}{50} \times 100\% \end{aligned}$$

$$\text{Relative error} = 2\%$$

$$\text{3- } (A) = 1 - \frac{50 - 49}{50} = 1 - \frac{1}{50} = 0.98$$

$$\text{4- } (a) = A \times 100\% = 0.98 \times 100\% = 98\%$$

Example (2): Calculate the precision of the 3rd measurement of the following set of eight measurements?

N: 1 2 3 4 5 6 7 8

X_n: 24 26 23 25 22 27 24 28

$$\text{Ans: } \bar{X}_{av} = \frac{24 + 26 + 23 + 25 + 22 + 27 + 24 + 28}{8}$$

$$\bar{X}_{av} = 24.875$$

$$\text{precision of } (X_3) = 1 - \left| \frac{23 - 24.875}{24.875} \right|$$

$$\downarrow$$

دقة القياس = 0.924