MEASUREMENTS, UNITS AND DIMENSIONS

ERRORS

1. **Accuracy:** Closeness of the measured value to the true value is called accuracy.
2. **Precision**: Closeness of the measurements done with an instrument to one another called precision.
3. **Error :** The difference between the measured value and true value of a physical quantity is called Error
4. **Type of errors** : 1) Systematic Errors 2) Random Errors and 3) Gross Errors

   1) Systematic Errors: These are due to a definite cause. These are always either positive or negative

   a) Constant Errors (Instrumental errors): The are due to i) imperfect design and ii) zero error
   b) Imperfection in experimental arrangement: In the calorimeter experiment, the loss of heat due to radiation, the effect on weighing due to buoyancy of air cannot be avoided.
   c) Environmental Errors like changes in temperature, pressure wind velocity etc.
   d) Personal errors (Observational errors) due to the improper setting of the apparatus, carelessness in taking observations

   2) Random Errors: Random fluctuations in temperature, voltage supply etc are the cause for random errors. Accurate value can be obtained by taking a number of readings and finding the arithmetic mean of all the readings.

   3) Gross Errors: These due to the carelessness of the observer in taking measurements towards the sources of error. In tangent galvanometer experiment, the coil should be placed in magnetic meridian position and other magnetic materials should be kept away. Neglecting this precaution result in gross errors No corrections can be applied to these errors. Care should be taken to avoid these errors

   "*When random errors and eliminated, the measurements are 'precise'. When all types of errors (systematic, random and gross) are eliminated the measurements are 'accurate'*"

5. Estimation of errors:

a) Absolute error (Δa) : The magnitude of the difference between the true value of a physical quantity and the individual measured value is called absolute error of that measurement

Absolute error = $\left|\text{True value} - \text{measured value}\right|$

$$\left|\Delta\alpha_i\right| = \left|\alpha_{mean} - \alpha_i\right|$$

Absolute error is always positive. It has the same units as that of the quantity measured

b) Mean absolute error $\left(\left|\alpha_{mean}\right|\right)$: The arithmetic mean of all the absolute errors is called mean absolute error (or) final absolute error.

Mean absolute error $\Delta\alpha_{mean} = \dfrac{|\Delta\alpha_1| + |\Delta\alpha_2| + |\Delta\alpha_3| + ... + |\Delta\alpha_n|}{n} = \dfrac{1}{n}\sum_{i=1}^{n}|\Delta\alpha_i|$

Mean absolute error is always positive and has the same units as the physical quantity measured

c) Relative Error: The relative (proportional) error of a physical quantity is the ratio of mean absolute error to the mean value of the quantity measured

Relative error $= \dfrac{\Delta\alpha_{mean}}{\Delta\alpha_{mean}}$

Relative error has no units

d) Percentage Error (δ_α) : When the relative error is multiplied by 100, it is called percentage error $\delta_\alpha = \left(\dfrac{\Delta\alpha_{mean}}{\alpha_{mean}} \times 100\right)\%$

6. Combination of errors:

a) **Error of a sum or a difference:**

i) Let x = a + b

Let $\Delta a \, and \, \Delta b$ be the absolute errors in a and b respectively. The values of a and b recorded in the experiment will be $(a \pm \Delta a) \, and \, (b \pm \Delta b)$

Let the error in x be Δx

Maximum possible value of $\Delta x = \Delta a + \Delta b$

Relative error, $\dfrac{\Delta x}{x} = \dfrac{\Delta a + \Delta b}{a + b}$

Percentage error, $\dfrac{\Delta x}{x}\% = \left[\left(\dfrac{\Delta a + \Delta b}{a + b}\right)100\right]\%$

ii) Let x = a – b

Maximum possible value of $\Delta x = \Delta a + \Delta b$

Relative error, $\dfrac{\Delta x}{x} = \dfrac{\Delta a + \Delta b}{a - b}$

Percentage error, $\dfrac{\Delta x}{x}\% = \left[\left(\dfrac{\Delta a + \Delta b}{a - b}\right)100\right]\%$

b) **Errors of multiplication or Division:**

i) Let x = a b

In multiplication, the maximum relative error, $\dfrac{\Delta x}{x} = \dfrac{\Delta a}{a} + \dfrac{\Delta b}{b}$

Percentage error, $\dfrac{\Delta x}{x}\% = \left(\dfrac{\Delta a}{a} + \dfrac{\Delta b}{b}\right)100\%$

ii) Let $x = \dfrac{a}{b}$

In division also, maximum relative error

$$\frac{\Delta x}{x}\% = \left(\frac{\Delta a}{a} + \frac{\Delta b}{b}\right)100\%$$

c) Errors of a measured quantity that involves product of powers of observed quantities:

i) Let $x = a^n$

Maximum relative error, $\frac{\Delta x}{x}\% = \left(n\frac{\Delta a}{a}100\right)\%$

ii) Let $x = \frac{a^p b^q}{c^r}$

Maximum relative error, $\frac{\Delta x}{x} = p\frac{\Delta a}{a} + q\frac{\Delta b}{b} + r\frac{\Delta c}{c}$

Percentage error, $\frac{\Delta x}{x}\% = \left(p\frac{\Delta a}{a} + q\frac{\Delta b}{b} + r\frac{\Delta c}{c}\right)100\%$

SHORT ANSWER QUESTIONS

1. How do the random errors differ from systematic errors?

Ans.

Random errors	1. **Systematic errors**
1. These errors occur at random in sign and magnitude, they occur irregularly	1. The errors which are always in systematic way or in one direction known as systematic errors
2. Errors in electrical measuring instruments due to voltage fluctuations are random errors	2. Least count error, zero error and parallax errors under certain conditions are systematic errors
3. These errors can not be eliminated	3. These errors can be eliminated by taking suitable corrections
4. These are estimated by statistical methods	4. These are estimated and eliminated by selecting proper procedure or proper

2. What are random errors? Distinguish between random errors and systematic errors

Ans. **Random errors**:

These errors are at random with respect to the sign and magnitude. They occur in irregular manner some times increasing, some times decreasing with changing magnitudes.

Eg (i) The random fluctuations in temperature, voltage supply etc are causes for random errors.

These errors can not be eliminated but it can be minimized by repeating the experiment a number of times and taking the arithmetic mean of all readings.

Random errors	2. Systematic errors
1. These errors occur at random in sign and magnitude, they occur irregularly	1. The errors which are always in systematic way or in one direction known as systematic errors
2. Errors in electrical measuring instruments due to voltage fluctuations are random errors	2. Least count error, zero error and parallax errors under certain conditions are systematic errors
3. These errors can not be eliminated	3. These errors can be eliminated by taking suitable corrections
4. These are estimated by statistical methods	4. These are estimated and eliminated by selecting proper procedure or proper

3. State the different types of errors present in a measurement.

Ans. 1.<u>Systematic errors:-</u>

The errors which are arise due to certain cause are called systematic errors. These are always either positive (or) negative

Systematic errors are classified into different types

They are

a) Constant errors

b) Evironmental errors

c) Imperfection in experimental technique (or) procedures

d) Personal errors

<u>a) Constant errors :-</u>

Systematic errors with constant magnitude are called constant errors. These are also called instrumental errors.

These are arising due to (i) imperfect design (ii) zero error in the instrument. These errors can be determined before hand and the measurements can be corrected for

Eg :- least count error

<u>b) Environmental errors (Errors due to external causes)</u>

These errors are due to changes in the environment. During an experimental measurement, there may be changes in temperature, pressure, wind velocity etc. These errors systematically affect the measurement

These errors can be taken care of by applying suitable corrections

<u>c) Imperfection in experimental technique (or) procedure</u>

These are due to imperfection in experimental arrangement, procedure followed and experiment technique employed.

Eg : 1) The loss of heat due to radiation in calorimetric experiments

2) The effect on weighing due to buoyancy of air.

<u>d) Personal errors:-</u>

These are due to personal peculiarities of the experimenter. These are due to lack of proper setting
of the apparatus, carelessness in taking observations.
These errors can be minimized by
(i) Selecting better instruments with higher resolution.
(ii) Taking care to avoid personal bias as far as possible
(iii) Improving the experimental techniques

2.<u>Random errors</u>:

These errors are at random with respect to the sign and magnitude. They occur in irregular manner some times increasing, some times decreasing with changing magnitudes.
Eg (i) The random fluctuations in temperature, voltage supply etc are causes for random errors.
These errors can not be eliminated but it can be minimized by repeating the experiment number of times and taking the arithmetic mean of all readings.

3.<u>Gross errors</u>:

These errors are due to carelessness of the experimenter neglecting the source of error and reading to instrument incorrectly.
Eg: In a tangent galvanometer experiment, the coil is to be placed exactly in the magnetic meridian. Other wise the reading gives the gross errors.

4. **Define the terms (i) mean absolute error (ii) relative errors and (iii) percentage error. How are they calculated?**

(i) Mean absolute error $\left(\left|\alpha_{mean}\right|\right)$: The arithmetic mean of all the absolute errors is called mean absolute error (or) final absolute error
Mean absolute error

$$\Delta\alpha_{mean} = \frac{\left|\Delta\alpha_1\right| + \left|\Delta\alpha_2\right| + \left|\Delta\alpha_3\right| + ... + \left|\Delta\alpha_n\right|}{n}$$

$$= \frac{1}{n}\sum_{i=1}^{n}\left|\Delta\alpha_i\right|$$

Mean absolute error is always positive and has the same units as the physical quantity measured

(ii) Relative Error: The relative (proportional) error of a physical quantity is the ratio of mean absolute error to the mean value of the quantity measured

$$\text{Relative error} = \frac{\Delta\alpha_{mean}}{\Delta\alpha_{mean}}$$

Relative error has no units

(iii) Percentage Error $\left(\delta_\alpha\right)$: When the relative error is multiplied by 100, it is called percentage error

$$\delta_\alpha = \left(\frac{\Delta\alpha_{mean}}{\alpha_{mean}} \times 100\right)\%$$

VERY SHORT ANSWER QUESTIONS

1. What is an error? What are constant errors?

Ans. The uncertainty involved in the measurement of the physical quantity by any instrument is called error. Systematic errors with constant magnitude are called constant errors.

2. Mention different kinds of errors

Ans. Errors are of three kinds

1) Systematic errors:-

The errors which arise due to definite cause are called systematic errors. These errors always either positive or negative.

2) Random errors:-

These errors are at random with respect to the sign and magnitude. These occur irregularly. Some times increasing, some times decreasing with changing magnitudes.

3) Gross errors:-

These errors are due to carelessness of the experimenter, neglecting the source of error and reading the instrument incorrectly

3. Explain briefly what systematic errors.

Ans. The errors due to a definite cause and which follow a particular rule are called systematic errors. They always occur in one direction.

These errors are due to changes in the external conditions like changes in temperature, pressure etc, and imperfection in experimental procedure and carelessness in taking observations.

4. What are the causes for environmental errors?

Ans. Environmental errors are due to changes in the environment like change in temperature, pressure, humidity etc.

5. What type of errors are met with in calorimetric experiment?

Ans. Calorimetric experiments are met with the systematic errors. In this type of experiments, source of errors is known even though we can not eliminate the error due to imperfection in experimental technique or procedure.

6. What are gross errors? Give an example.

Ans. These errors are due to carelessness of the experimenter neglecting the source of error and reading to instrument incorrectly.

Eg: In a tangent galvanometer experiment, the coil is to be placed exactly in the magnetic meridian. Other wise the reading gives the gross errors.

7. What are random errors? Give an example.

Ans. Theses errors occur at random in sign and magnitude. They occur irregularly. These are arising due to the disturbance in experimental conditions which can not be predicted.

Ex: due to change in voltage supply, change in temperature

8. Distinguish between accuracy and precision?

Ans.

Accuracy	Precision
1) Closeness of the measured value to the true value is called accuracy	1) Closeness of the measurements done with an instrument to one another called precision
2) It depends on the errors and also on the precision of the measuring instrument	2) It depends on the least count of the measuring instrument. Smaller is the least count more precise the measurement

9. What is mean absolute error? State its formula.

Ans. The arithmetic mean of all the absolute errors is called mean absolute error (or) final absolute error

Mean absolute error

$$\Delta\alpha_{mean} = \frac{|\Delta\alpha_1| + |\Delta\alpha_2| + |\Delta\alpha_3| + \ldots.. + |\Delta\alpha_n|}{n} = \frac{1}{n}\sum_{i=1}^{n}|\Delta\alpha_i|$$

Mean absolute error is always positive and has the same units as the physical quantity measured

10. What is relative error? State its formula.

Ans. The relative (proportional) error of a physical quantity is the ratio of mean absolute error to the mean value of the quantity measured

$$\text{Relative error} = \frac{\Delta\alpha_{mean}}{\Delta\alpha_{mean}}$$

Relative error has no units

11. What is absolute error? State its formula.

Ans. The magnitude of the difference between the true value of a physical quantity and the individual measurement value is called absolute error of that measurement

Absolute error = $|\text{True value} - \text{measured value}|$

$$|\Delta\alpha_i| = |\alpha_{mean} - \alpha_i|$$

Absolute error is always positive. It has the same units as that of the quantity measured

SOLVED PROBLEMS

1. In an experiment, the values of refractive index of glass were found to the 1.54, 1.53, 1.44, 1.56 and 1.45 in successive measurement. Calculate (i) mean value of refractive index of glass (ii) absolute error in each measurement (iii) mean absolute error (iv) relative error and (v) percentage error.

Sol. i) Mean value of refractive index is given by

$$\mu_{mean} = \frac{1.54+1.53+1.44+1.54+1.56+1.45}{6} = 1.51$$

ii) The errors in the measurement are :

$1.51-1.54=-0.03$

$1.51-153=-0.02$

$1.51-1.44=+0.07;$

$1.51-1.54=-0.03$

$1.51-1.56=-0.05$

and $1.51-1.45=+0.06$

The absolute errors are

0.03, 0.02, 0.07, 0.03, 0.05 and 0.06

iii) Mean absolute error in the value of μ is

$$\Delta\mu_{mean}=\frac{0.03+0.02+0.07+0.03+0.05+0.06}{6}=\frac{0.26}{6}=0.04$$

iv) Relative error in the value of μ,

$$=\frac{\Delta\mu_{mean}}{\mu_{mean}}=\frac{0.04}{1.51}=0.02649=0.03$$

v) Percentage error in the value of $\mu=0.03\times100=3\%$

2. Two objects A and B are of lengths 5 cm and 7 cm determined with errors 0.01 cm and 0.2 cm respectively. What is the error in determining (a) the total length and (b) the difference in their lengths?

Sol. a = 5 cm, $\Delta a=0.1cm$

$b=7cm, \Delta b=0.2cm$

If $x=a+b$, then

$\Delta x=\Delta a+\Delta b=0.1+0.2=0.3cm$ and $x=(5+7)\pm(0.3)=(12\pm0.3)\,cm$

If x is the difference between the lengths, then

$\Delta x=\Delta a+\Delta b=0.3cm$ and $x=|5-7|\pm0.3=(2\pm0.3)\,cm$

3. The length and breadth of a rectangular object are 25.2 cm and 16.8 cm respectively and have been measured to an accuracy of 0.1 cm. Find the relative error and percentage error in the area of the object. (2009-March)

A. Area $A=l\times b$

$l=25.2cm$ and $\Delta l=0.1cm$

b = 16.8 cm and $\Delta b=0.1cm$

$\therefore$ Relative error in area

$$\left(\frac{\Delta A}{A}\right)=\left(\frac{\Delta l}{l}\right)+\left(\frac{\Delta b}{b}\right)=\left(\frac{0.1}{25.2}\right)+\left(\frac{0.1}{16.8}\right)=0.004+0.006=0.01$$

Percentage error $\left(\frac{\Delta A}{A}\right)100=0.01\times100$

Percentage error $(\delta A)=1\%$

4. In an experiment to determine the value of acceleration due to gravity g using a simple pendulum, the measured value of length of the pendulum is 31.4 cm known to 1 mm accuracy and the time period for 100 oscillations of pendulum is 112.0s known to 0.01s accuracy. Find the accuracy in determining the value of g.

A. Accuracy is to be taken as the error involved

$l = 31.4\,\text{cm}$ and $\Delta l = 1\,\text{mm} = 0.1\,\text{mm}$

$\mathrm{T} = \dfrac{112.0}{100} = 1.12\text{s}$ and $\Delta\mathrm{T} = 0.01\text{s}$

But, $\mathrm{g} = 4\pi^2\left(\dfrac{l}{\mathrm{T}^2}\right)$

$\therefore \dfrac{\Delta\mathrm{g}}{\mathrm{g}} = \left(\dfrac{\Delta l}{l}\right) + 2\left(\dfrac{\Delta\mathrm{T}}{\mathrm{T}}\right) = \left(\dfrac{0.1}{31.4}\right) + 2\left(\dfrac{0.01}{1.12}\right) = 0.003 + 0.02 = 0.023$

Relative error in determining g is 0.023 and percentage error = 0.023×100=2.3%

$\dfrac{l}{\mathrm{T}^2} = \dfrac{31.4}{(1.12)^2} = 25.03\text{cm/s}^2$. The value of 2.3% of 25.03 is $\dfrac{25.03\times 2.3}{100} = 0.58$

$\therefore \dfrac{l}{\mathrm{T}^2} = (25.03 \pm 0.58)\,\text{cm/s}^2$

5. A rectangular metal slab of mass 33.333 g has its length 8.0 cm, breadth 5.0 cm and thickness 1 mm. The mass is measured with accuracy up to 1 mg with a sensitive balance. The length and breadth are measured with a vernier calipers having a least count of 0.01 cm. The thickness is measured with a screw gauge of l.c. 0.01 mm. Calculate the percentage accuracy in density calculated from the above measurement.

A. The percentage error itself gives the percentage accuracy.

Density $\mathrm{d} = \dfrac{\text{Mass}}{\text{Volume}} = \dfrac{\mathrm{M}}{l\mathrm{bh}}$

$\therefore$ The maximum relative error is given by $\dfrac{\Delta\mathrm{d}}{\mathrm{d}} = \left(\dfrac{\Delta\mathrm{M}}{\mathrm{M}}\right) + \left(\dfrac{\Delta l}{l}\right) + \left(\dfrac{\Delta\mathrm{b}}{\mathrm{b}}\right) + \left(\dfrac{\Delta\mathrm{h}}{\mathrm{h}}\right)$

Given l = 8.0 cm and $\Delta l = 0.01\text{cm}$; b = 5.0 cm and $\Delta\mathrm{b} = 0.01\text{cm}$

h = 1 mm and $\Delta\mathrm{h} = 0.01$ mm and M = 33.333g and $\Delta\mathrm{M} = 1\text{mg} = 0.001\text{g}$

The percentage error = $\left(\dfrac{\Delta\mathrm{M}}{\mathrm{m}} + \dfrac{\Delta l}{l} + \dfrac{\Delta\mathrm{b}}{\mathrm{b}} + \dfrac{\Delta\mathrm{h}}{\mathrm{h}}\right)\times 100$

$= \left(\dfrac{0.001}{33.333} + \dfrac{0.01}{8.0} + \dfrac{0.01}{5} + \dfrac{0.04}{1}\right)\times 100 = 1.328$

The percentage error = 1.3%

6. The error in the measurement of the length of a simple pendulum is 0.1% and the error in the time period is 2%. What is the possible percentage of error in the physical quantity having the dimensional formula LT^{-2}.

A. Percentage error in LT^{-2} = $\left(\dfrac{\Delta\mathrm{L}}{\mathrm{L}} + 2.\dfrac{\Delta\mathrm{T}}{\mathrm{T}}\right)\times 100 = \left(\dfrac{0.1}{100} + 2.\dfrac{2}{100}\right)\times 100 = 4.1\%$

Exercise

1. **In the measurement of a physical quantity $X = \frac{A^2B}{C^{1/3}D^3}$. The percentage errors introduced in the measurements of the quantities A,B,C and D are 2%,2%,4% and 5% respectively. Then the minimum amount of percentage of error in the measurement of X is contributed by which quantity ?**

Sol: $X = \frac{A^2B}{C^{1/3}D^3}$

% Error contributed by A = $2\left(\frac{|\Delta A|}{A}\times 100\right) = 2(2) = 4\%$

% Error contributed by B = $1\left(\frac{|\Delta B|}{B}\times 100\right) = 1(2) = 2\%$

% Error contributed by C = $1\left(\frac{|\Delta C|}{C}\times 100\right) = \frac{1}{3}(4) = \frac{4}{3}\%$

% Error contributed by D = $3\left(\frac{|\Delta D|}{D}\times 100\right) = 3(5) = 15\%$

$\therefore$ Minimum % of error is contributed by 'C'.

2. **Dimensional formula for a physical quantity X is $M^{-1}L^3T^{-2}$. The errors in measuring the quantities M,L and T respectively are 2 %, 3 % and 4%. Find the maximum percentage error that occurs in measuring the quantity X?**

Sol: $\frac{|\Delta M|}{M}\times 100 = 2, \frac{|\Delta L|}{L}\times 100 = 3, \frac{|\Delta T|}{T}\times 100 = 4$

From $X = M^{-1}L^3T^{-2}$

$\frac{|\Delta X|}{X}\times 100 = \frac{|\Delta M|}{M}\times 100 + 3\left(\frac{|\Delta L|}{L}\times 100\right) + 2\left(\frac{|\Delta T|}{T}\times 100\right)$ = 2+3(3) +2(4) = 19 %

3. **In Poiseuille's method of determination of coefficient of viscosity which physical quantity requires greater accuracy in measurement?**

Sol: $V = \frac{\pi pr^2}{8\eta l}$ .The accuracy in measurement is directly proportional to power of quantity.

Since the power of radius is highest, radius of capillary tube requires greater accuracy in measurement.

4. **In an experiment of simple pendulum the errors in the measurement of length of the pendulum L and time period T are 3 % and 2 % respectively. Find the maximum percentage error in the value of $\frac{L}{T^2}$.**

Sol: Maximum percentage error in $\frac{L}{T^2} = \left(\frac{\Delta L}{L}\times 100\right) + 2\left(\frac{\Delta T}{T}\times 100\right)$ = 3 + 2 (2) = 7 %

5. **The measured mass and volume of a body are 2.42 g and 4.7 cm^2 respectively with possible errors 0.01 g, and 0.1 cc. Find the maximum error in density.**

Sol: m = 2.42 gm , V = 4.7 cc

Maximum error is density = $\left(\frac{\Delta m}{m}+\frac{\Delta V}{V}\right)\times 100=\left(\frac{0.01}{2.42}+\frac{0.1}{4.7}\right)\times 100$ = 2%.

6. The heat generated in a circuit is dependent on the resistance, current and time of flow of electrical current. If the errors measured in the above are 1%, 2% ad 1% respectively. Find the maximum error in measuring the heat .(Heat developed = $\frac{I^2RT}{J}$ calories)

Sol: $Q=\frac{i^2RT}{J}=2\left(\frac{\Delta I}{I}\times 100\right)+\left(\frac{\Delta R}{R}\times 100\right)+\left(\frac{\Delta T}{T}\times 100\right)$ = 2(2) +1+1 = 6 %

7. We know density of a cube can be measured by measuring its mass and the length of its side. If the maximum errors in the measurement of mass and length are 3 % and 2% respectively, find the maximum error in the measurement of the density of the cube.

Sol: Maximum error is density = $\frac{m}{V}=\frac{m}{l^3}=\left(\frac{\Delta m}{m}+3\frac{\Delta l}{l}\right)\times 100=3+3\,(2)=9\,\%$

Given $\frac{\Delta r}{r}\times 100=1$

From $V=\frac{4}{3}\pi r^3 \Rightarrow \frac{\Delta V}{V}\times 100=3\left(\frac{\Delta r}{r}\times 100\right)$

$\Rightarrow \frac{\Delta V}{V}\times 100=3(1)=3\%$.

8. An experiment measures quantities a, b,c and then x is calculated as $x=\frac{ab^2}{c^3}$. If the percentage errors in a,b,c are $\pm 1\%, \pm 3\%$ *and* $\pm\ 2\%$ respectively, the percentage error in x can be

Sol: $x=\frac{ab^2}{c^3}$

$\Rightarrow \frac{\Delta x}{x}\times 100=\left(\frac{\Delta a}{a}\times 100\right)+2\left(\frac{\Delta b}{b}\times 100\right)+3\left(\frac{\Delta c}{c}\times 100\right)=1+2(3)+3(2)=13\,\%$.

9. The percentage error in the mass and speed are 2 % and 3 % respectively. How much will be the maximum error in kinetic energy calculated using mass and velocity?

Sol: K.E = $\frac{1}{2}m\upsilon^2 \Rightarrow \frac{\Delta K.E}{K.E}\times 100=\left(\frac{\Delta m}{m}\times 100\right)+2\left(\frac{\Delta \upsilon}{\upsilon}\times 100\right)=2+2(3)=8\%$

ASSESS YOURSELF

1. By taking precautions, can we minimize the random errors?

Ans: No. By taking precaution we can not minimize the random errors because these errors can not be predicted.

2. What is that for both very small as well as very large [in addition to ordinary] quantities, the physical measurements are usually expressed in scientific notations, with powers of ten?

Ans: To denote the precision of the measurement

3. **The Unit of length, metre was originally defines as the distance between two lines engraved on gold plugs near the ends of a bar of a platinum-iridium alloy that is kept at 0 ^{0}C . Then the unit was defined in October 1983 in terms of wavelength of Kr-86 radiation. Now, the present Unit is defined in terms of distance travelled by light.**

In your opinion, which of the two essential requirements for a standard Unit (1) availability, invailability played the key role in this modification?

Ans: Invariability

4. **Originally the 'foot' of the human being is taken as a unit of length. What condition prevents the use of human foot as a standard scientific fundamental (base) unit.**

Ans: Invariability