

ACCURACY

PRECISION

ERRORS

[Units and dimensions]

SUBJECT: *Physics*

CLASS LEVEL: *XI*

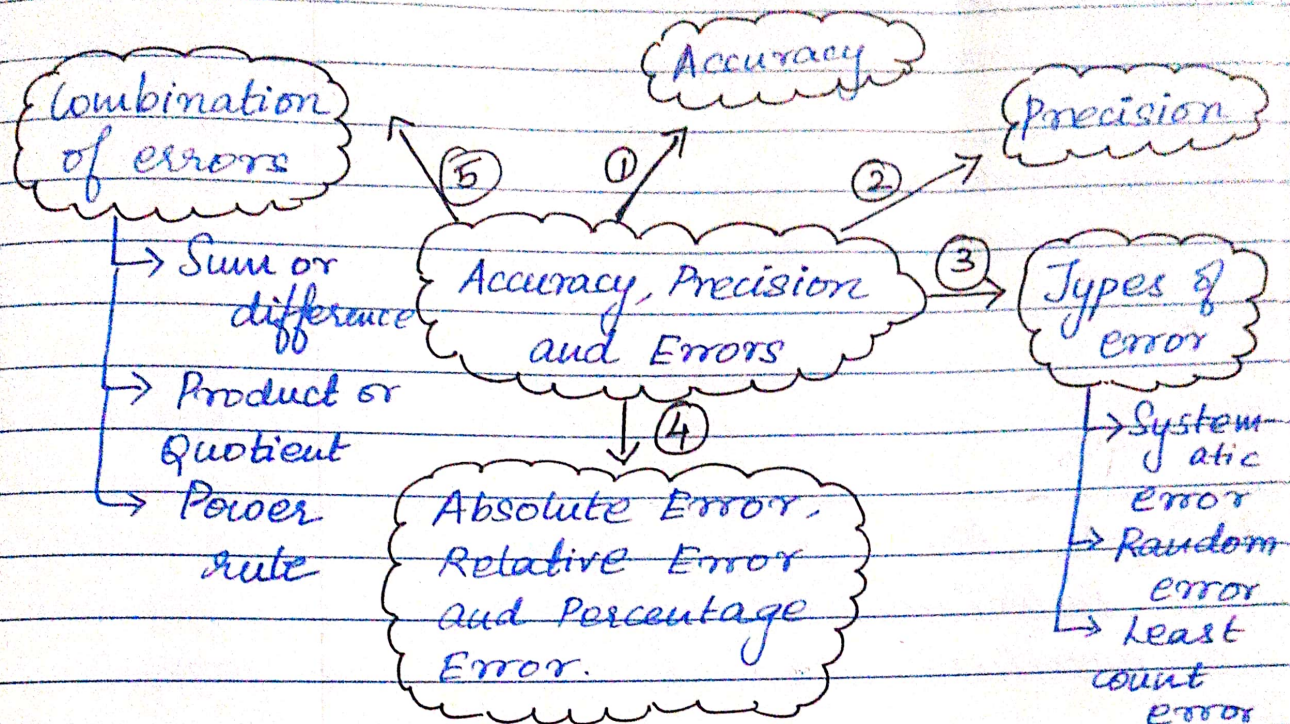
CONCEPT ABSTRACT: *In this nugget we are going to see about the accuracy and precision of instruments and types of errors in measurement.*

CONCEPT AUTHOR: *S. Pavani*

REFERENCE:

- *NCERT TEXT BOOK*

- *SAITECH NOTES*



TERMS, DEFINITIONS AND SYMBOLS

① Errors.

The result of every measurement by any measuring instruments contain some uncertainty. Uncertainty is error.

② Accuracy

Measure of how close the measured value is to the true value of the quantity.

③ Precision

It tells us to what resolution or limit the quantity is measured.

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|---|--|
| ④ Systematic errors. | It tends to be in one direction, either positive or negative. |
| ⑤ Instrumental errors. | The error due to imperfect design or calibration of the measuring instrument, zero error in the instrument, etc.
eg. Temperature graduation of a thermometer. |
| ⑥ Imperfection in technique or procedure. | • To determine the temperature of a human body, a thermometer placed under the armpit will always give a temperature lower than actual value. |
| ⑦ Personal errors. | • Due to individual's bias, lack of proper setting of the apparatus or individual's carelessness. |
| ⑧ Parallax | • Introduces an error due to parallel. Apparent shift in the position of the object with respect of background. |
| ⑨ Random errors | occur irregularly and hence are random with respect of sign and size. |

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|---------------------------------------|---|
| 10.) Least count
error | The smallest value that can be measured by the measuring instrument. |
| 11.) Least count error. | The error associated with resolution of the instrument. |
| 12.) arithmetic mean
(\bar{x}) | True value of the error |
| 13.) absolute error | It is the difference between measured individual value and true value
• Sign is not taken. |
| 14.) Relative error | It is the ratio of absolute error mean to arithmetic mean. |
| 15.) Percentage error | Relative error expressed in percent. |
| 16.) combination of errors. | <ul style="list-style-type: none"> • when ever two quantities are added and subtracted the resultant absolute error = sum of the absolute error in the individual quantities. • multiplied or divided the resultant relative error = sum of relative errors in the individual quantities. |

DATA, EQUATIONS, FORMULAE AND DERIVATION

Arithmetic
mean.

Let the measured values be $a_1, a_2,$
& a_3

• It is denoted by a_{mean}

$$a_{\text{mean}} = \frac{a_1 + a_2 + a_3}{3}$$

Absolute
error

• It is denoted by $|\Delta a_n| = |\Delta a_n|$

$$|\Delta a_1| = |a_{\text{mean}} - a_1|$$

$$|\Delta a_2| = |a_{\text{mean}} - a_2|$$

$$|\Delta a_3| = |a_{\text{mean}} - a_3|$$

Absolute error mean :-

$$\Delta a_{\text{mean}} = \frac{|\Delta a_1| + |\Delta a_2| + |\Delta a_3|}{3}$$

Relative
error.
(R.E)

$$R.E = \frac{\Delta a_{\text{mean}}}{a_{\text{mean}}}$$

Percentage
error
(P.E) (R.E)

$$P.E = R.E \times 100$$

Addition of errors.

$A, B =$ Physical quantities
 $\Delta A, \Delta B =$ Absolute error.

Both the quantities are represented with error.

$$(A \pm \Delta A), (B \pm \Delta B)$$

Here

$$Z = A + B$$

$$\Delta Z = \Delta A + \Delta B$$

Adding:-

$$(Z \pm \Delta Z) = (A \pm \Delta A) + (B \pm \Delta B)$$

$$(Z \pm \Delta Z) = (A + B) \pm \Delta A \pm \Delta B$$

$$\pm \Delta Z = \pm \Delta A \pm \Delta B$$

$$\boxed{\Delta Z = \Delta A + \Delta B}$$

Subtraction of errors.

Subtraction:-

$$Z = A - B$$

$$\Delta Z = \Delta A + \Delta B$$

$$Z \pm \Delta Z = (A \pm \Delta A) - (B \pm \Delta B)$$

$$(\cancel{Z} \pm \Delta Z) = \cancel{A} - \cancel{B} + \Delta A \pm \Delta B$$

$$\pm \Delta Z = \pm \Delta A + \Delta B$$

$$\boxed{\Delta Z = \Delta A + \Delta B}$$

Multiplication
and Division

resultant error is ΔZ whether it
is multiplication / division

$$Z = AB$$

$$Z = A/B$$

$$\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$

Power rule

The error of the given quantity
is raised to its power.

$$Z = A^2$$

$$Z = A \cdot A$$

$$\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta A}{A}$$

$$\frac{\Delta Z}{Z} = 2 \left(\frac{\Delta A}{A} \right)$$

MNEMONIC

A - Accuracy

P - Precision

E - Errors

A - Absolute errors

R - Relative errors

P - Percentage errors

C - Combination of errors

APEARPC