ATOMIC ENERGY EDUCATION SOCIETY

Distant Learning Programme

Class XI Subject: Physics

Hand out study Material

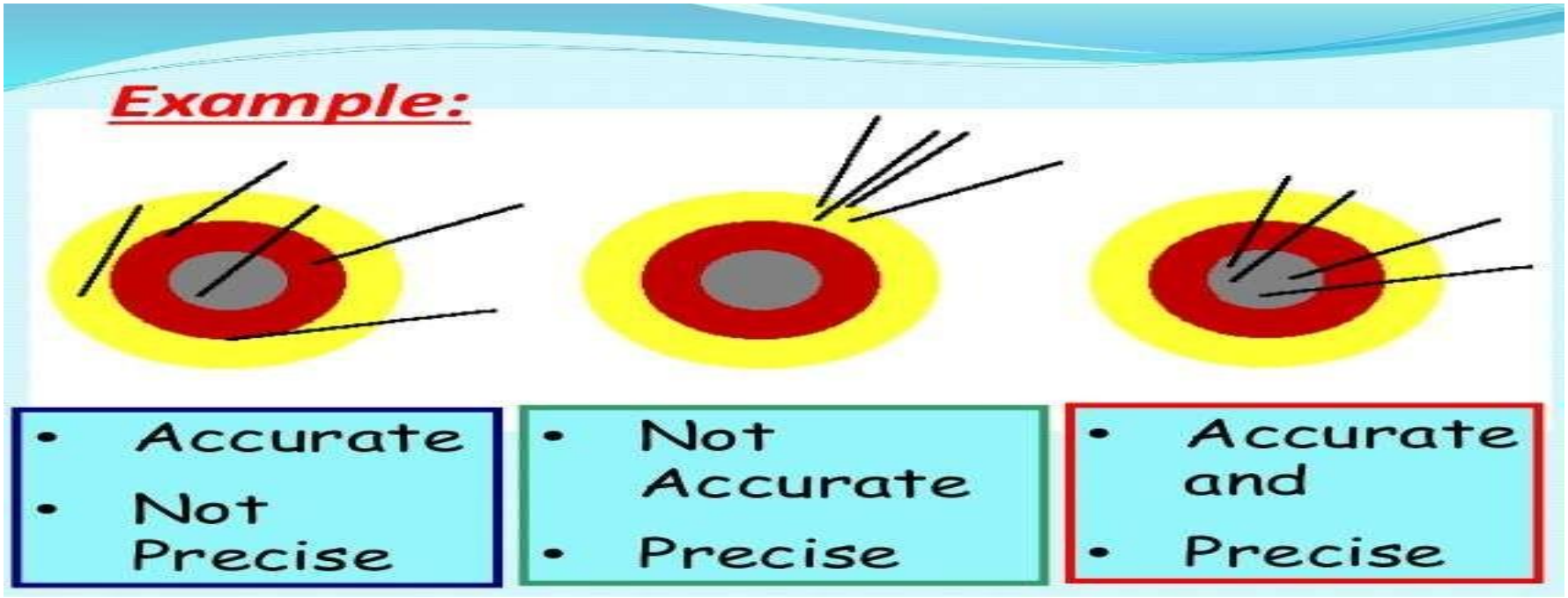
Chapter: Unit and Measurement (Module 2/4)

Contents

- Accuracy &Precision
- Errors and types of errors
- Systematic and Random errors
- Instrumental, Imperfection and personal errors
- Absolute, Relative error and Percentage errors.

Accuracy and Precision

- **Accuracy: Accuracy of a measurement is how close the measured value is to the true value.**
- **Precision: Precision is the resolution orcloseness of a series of measurements of a same quantity under similar conditions.**
- If the true value of a certain length is 3.678 cm and two instruments with different resolutions, up to 1 (less precise) and 2 (more precise) decimal places respectively, are used. If first measures the length as 3.5 and the second as 3.38 then the first has more accuracy but less precision while the second has less accuracy and more precision.



Errors and types of error

- **Error:** Any uncertainty resulting from measurement by a measuring instrument is called an **error.**
- **Systematic Errors:** Errors which reasons are known to us and they can be positive or negative both are called as systematic errors.
- **Instrumental errors:** These arise from imperfect design or calibration error in the instrument.Worn off scale, zero error in a weighing scale are some examples of instrument errors.
- **Imperfections in experimental techniques:** If the technique is not accurate (for example measuring temperature of human body by placing thermometer under armpit resulting in lower temperature than actual) and due to the external conditions like temperature, wind, humidity, these kinds of errors occur.

- **Personal errors:** Errors occurring due to human carelessness, lack of proper setting, taking down incorrect reading are called personal errors. These errors can be removed by:
- Taking proper instrument and calibrating it properly.
- Removing human bias as far as possible Experimenting under proper atmospheric conditions and techniques. Removing human bias as far as possible

Random Error:

- Those errors which reasons are not known to us are called as random errors.
- Any factors that randomly affect measurement of the variable across the sample.
- For instance, each person's mood can inflate or deflate performance on any occasion.
- Random error adds variability to the data but does not affect average performance for the group.

Least Count Error

Smallest value that can be measured by the measuring instrument is called its **least count. Least count error is the error associated with the resolution or the least count of the instrument.**

- Least count errors can be minimized by using instruments of higher precision/resolution and improving experimental techniques (taking several readings of a measurement and then taking a mean).

Absolute Error:

- Mean of n measurements

$$a_{mean} = \frac{a_1 + a_2 + a_3 + \cdots\ldots + a_n}{n}$$

- Absolute error (Δa) = a_{mean} - a_1

- Absolute error is simply the amount of physical error in a measurement.

$$E_{absolute} = | x_{measured} - x_{accepted} |$$

- Absolute error is positive , negative or zero.
  In plain English: The absolute error is the difference between the measured value and the actual value. (The absolute error will have the same unit label as the measured quantity.)

Relative Error:

- Relative error is the ratio of the absolute error of the measurement to the accepted measurement. The relative error expresses the "relative size of the error" of the measurement in relation to the measurement itself.
- When the accepted or true measurement isknown, the relative error is found using

  which is considered to be a measure of accuracy.

$$E_{relative} = \frac{E_{absolute}}{x_{accepted}}$$

Percentage Error

- It is the relative error measured in percentage.
  So,
  Percentage Error =
  mean absolute value/mean value X 100
  $= \Delta a_{mean} / a_m X 100$

$$\text{Percent of Error} = \frac{|\text{measured value - actual value}|}{\text{actual value}} \cdot 100\%$$

Sample Question

- We measure the period of oscillation of a simple pendulum. In successive measurements, the readings turn out to be 2.63 s, 2.56 s, 2.42 s, 2.71s and 2.80 s. Calculate the absolute errors, relative error or percentage error.

Sol. The mean period of oscillation of the Pendulum T = (2.63 + 2.56 + 2.42 + 2.71+2.80)/5

T = 13.12/5 = 2.62 sec.

As the periods are measured to a resolution of 0.01 s, all times are to the second decimal; it is proper to put this mean period also to the second decimal. The absolute errors in the measurements are

2.63 s – 2.62 s =0.01 s
2.56 s – 2.62 s = – 0.06 s
2.42 s – 2.62 s = – 0.20 s
2.71 s – 2.62 s = 0.09 s
2.80 s – 2.62 s = 0.18 s

Note that the errors have the same units as the quantity to be measured. The arithmetic mean of all the absolute errors (for arithmetic mean, we take only the magnitudes) is

$\Delta T_{mean} = [(0.01 + 0.06 + 0.20 + 0.09 + 0.18)s]/5$ = 0.54 s/5 = 0.11 s

That means, the period of oscillation of the simple pendulum is (2.62 ± 0.11) s i.e. it lies between (2.62 + 0.11) s and (2.62 – 0.11) s or between 2.73 s and 2.51 s. As the arithmetic mean of all the absolute errors is 0.11 s, there is already an error in the tenth of a second. Hence there is no point in giving the period to a hundredth. A more correct way will be to write $T = (2.6 \pm 0.1)\ s$

Note that the last numeral 6 is unreliable, since it may be anything between 5 and 7. We indicate this by saying that the measurement has two significant figures. In this case, the two significant figures are 2, which is reliable and 6, which has an error associated with it. You will learn more about the significant figures

For this example, the relative error or the percentage error is = (0.1/2.6)×100 = 4%

REFERNECES :

NCERT XI CLASS WIKIPEDIA

CONCEPT OF PHYSICS BY H C VERMA

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