St. Lawrence High School

A Jesuit Christian Minority Institution

Study Material – 1

Term : 1st

Class – XI Subject – Physics

Chapter – Physical world and measurement Date – 08.08.20

- Dimension of physical quantity
  - Seven fundamental quantities are – Length (L), Mass (M), Time (T), Electric current (I), Thermodynamic temperature (θ), Amount of substance(n) and Luminous Intensity (I_v)
  - Physical quantity being the ratio of two same kinds of quantities is dimensionless.
    For example refractive index of a medium = $\frac{speed\ \ of\ light\ in\ one\ medium}{speed\ \ of\ light\ in\ other\ medium}$
    The dimension of such quantities are considered to be 1 or $M^0L^0T^0$
  - For any equation of physics –
    Dimension of L.H.S = Dimension of R.H.S
  - For any equation $y = ax + bx^2 - \frac{c}{d}$
    $[y] = [ax] = [bx^2] = \left[\frac{c}{d}\right]$
  - The exponent of any number is always dimensionless. E.g in $10^{\frac{ax^2-b}{\sqrt{y}}}$
    $\left[\frac{ax^2-b}{\sqrt{y}}\right] = 1$
  - Angle being the ratio of arc and the radius, is always dimensionless and hence $\sin\theta$, $\cos\varphi$, $\tan\left(\frac{a}{x^2} - px - y^2\right)$, all the trigonometric functions are dimensionless.
    I.e $[\sin\theta]$=1

    $[\cos\varphi]$=1

    $\left[\tan\left(\frac{a}{x^2} - px - y^2\right)\right] = 1$

- Dimensional analysis
  - This is the method of predicting the dependency of some interrelated physical quantities.
  - This method is applicable, if the relation is such that, we will get only the product form of the physical quantities on both sides of the equation predicting the relation. E.g. $y = \frac{ax^3}{bz\sqrt{z}}$, this kind of equation can be predicted by dimensional analysis. But not the equation like $s = ut + \frac{1}{2}at^2$ although this equation is dimensionally correct.
  - If $a, b\ c\ and\ d$ are the known physical quantiy to us, and we are asked to find out the relation connecting them, then we can consider

    $$a = [b]^x.[c]^y.[d]^z$$

    Then, putting the dimensions for all physical quantities and then equating the exponents from both sides of the equation, we can predict the dependency.

❖ Error Analysis

- If the measurement of a single physical quantity is done by five different persons as $x_1, x_2, x_3, x_4\ and\ x_5$ then the true measurement or the true value of that physical quantity will be taken as the mean of those individual measurements. i.e $x = \frac{x_1+x_2+x_3+x_4+x_5}{5}$

  Then the individual errors are $\Delta x_1 = x - x_1$

$$\Delta x_2 = x - x_2$$

$$\Delta x_3 = x - x_3$$

$$\Delta x_4 = x - x_4$$

$$\Delta x_5 = x - x_5$$

  Note – individual error can be negative or positive, but when we say absolute error then it always the magnitude of an individual error. Hence absolute error is always positive.

  Hence mean absolute error will be the average of all the absolute error as –

$$\Delta x = \frac{|\Delta x_1| + |\Delta x_2| + |\Delta x_3| + |\Delta x_4| + |\Delta x_5|}{5}$$

  Relative error = $\frac{mean\ \ absolute\ \ error}{True\ \ value} = \frac{\Delta x}{x}$

  And finally percentage error = $Relative\ error\ \times 100\% = \frac{\Delta x}{x} \times 100\%$

❖ Laws of error estimation

- If Y = A+B

  Then maximum error in the measurement of Y is , $\Delta Y = \Delta A + \Delta B$
- If Y = A – B

  Then maximum error in the measurement of Y is , $\Delta Y = \Delta A + \Delta B$
- If $Y = A^x . \frac{B^y}{C^z}$

  Then, relative error in the measurement of Y is

$$\frac{\Delta Y}{Y} = x\frac{\Delta A}{A} + y\frac{\Delta B}{B} + z\frac{\Delta C}{C}$$