Motion in a straight-line class 11 formulas

- **Distance -** The total length that is travelled between different positions.
- **Displacement -** Distance between two points in a particular direction.
  - Formula :- $\Delta x = x_f - x_i$
  - $\Delta x \rightarrow$ Displacement
  - $x_f \rightarrow$ final position
  - $x_i \rightarrow$ initial position
- **Speed -** the total distance covered divided by the time taken to cover that distance.
  - Formula :- $\text{Speed} = \frac{\text{Total Distance Covered}}{\text{Time Taken}}$
  - Unit - m/s, Km/hr or mph(mile per hour)
  - Dimensions - $[M^0LT^{-1}]$
- **Velocity -** the displacement divided by the time it takes for the displacement
  - Formula :- $Velocity = \frac{Displacement}{Time}$
  - Unit - m/s, Km/hr or mph(mile per hour)
  - Dimensions - $[M^0LT^{-1}]$
- **Average Speed -** the total distance covered divided by the time taken to cover that distance
  - Formula :- $\text{Average Speed} = \frac{\text{Total Distance Covered}}{\text{Time Taken}} = \frac{\Delta x}{\Delta t}$
  - Body covering different distances with different speeds
    - $\bar{v} = \frac{s_1+s_2+s_3+....}{t_1+t_2+t_3+....} = \frac{s_1+s_2+s_3+....}{\frac{s_1}{v_1}+\frac{s_2}{v_2}+\frac{s_3}{v_3}+....}$

- If the body covers first half of the total distance with speed v_1 and second half with the speed v_2, then the average speed is given by
  - $\bar{v} = \frac{2v_1v_2}{v_1+v_2}$
  - In this case average speed is harmonic mean of individual speeds.
- Body is moving with different speeds in different time intervals then
  Total distance travelled $= v_1t_1 + v_2t_2 + v_3t_3 + \ldots$
  Total time taken $= t_1 + t_2 + t_3 + \ldots$
  - $\bar{v} = \frac{v_1t_1+v_2t_2+v_3t_3+\ldots}{t_1+t_2+t_3+\ldots}$
- If $t_1 = t_2 = t_3 = \ldots = t_n = t$ then,
  - $\bar{v} = \frac{(v_1+v_2+v_3+\ldots)t}{nt} = \frac{(v_1+v_2+v_3+\ldots)}{n}$
- In this case average speed is arithmetic mean of the individual speeds.

- **Average Velocity -** the total displacement covered divided by the time taken for that displacement
  - Formula :- Average Velocity $= \frac{\text{Displacement}}{\text{Time Taken}}$ $or,$ $\bar{v} = \frac{\Delta\vec{x}}{\Delta t}$
  - Finding position from velocity - $x = x_0 + \bar{v}t$
- **Instantaneous Velocity -** defined as velocity of an object at a particular instant of time.
  - Formula :- $v(t) = \frac{dx(t)}{dt}$
- **Instantaneous Speed -** defined as speed of an object at a particular instant of time. It is absolute value of instantaneous velocity.
  - Formula :- Instantaneous speed $= |v(t)|$
- **Acceleration -** The rate of change of velocity is called acceleration.
  - Formula :- $a = \frac{\Delta\vec{v}}{\Delta t} = \frac{v_f-v_i}{t_f-t_i}$
- **Instantaneous acceleration -** acceleration of a particle at a particular instant of time

- Formula :- $a = \lim_{\Delta \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$

- **Equations of motion with constant acceleration**
  - First Equation of motion - finding velocity from acceleration –
    - $v = v_0 + at$
  - Second Equation of motion - finding position from velocity and acceleration –
    - $x = x_0 + v_0 t + \frac{1}{2} a t^2$
  - Third Equation of motion - finding velocity from distance and acceleration –
    - $v^2 = v_0^2 + 2a(x - x_0)$
  - Equation for finding distance travelled in n^{th} second of object's journey –
    - $S_n = u + a\left(n - \frac{1}{2}\right)$

- **Motion under gravity**
  - Equations of motion for freely falling body
    - $v = u + gt$
    - $s = ut + \frac{1}{2} g t^2$
    - $v^2 - u^2 = 2gs$
  - For body falling freely under the action of gravity, g is taken as positive.
  - For body thrown vertically upwards, g is taken as negative.
  - When the body is just dropped, $u = 0$
  - For a body thrown vertically up with initial velocity u
  - Maximum height reached is, $h = \frac{u^2}{2g}$

- time of ascent = time of descent = $\frac{u}{g}$
- total time of flight = $\frac{2u}{g}$
- velocity of fall at point of projection = u
- velocity attained by a body dropped from height h, $v = \sqrt{2gh}$

- **Relative Velocity**
  - Relative velocity of object A w.r.t. object B is, $v_{AB} = v_A - v_B$
  - When two objects are moving in the same direction, $v_{AB} = v_A - v_B$
  - When two objects are moving in opposite direction, $v_{AB} = v_A + v_B$
  - When v_A and V_B are inclined to each other at an angle θ
    - $\vec{v}_{AB} = \sqrt{v_A^2 + v_B^2 - 2v_A v_B \cos\theta}$
  - If v_{AB} makes an angle β with v_A, then
    - $\tan\beta = \frac{v_B \sin\theta}{v_A - v_B \cos\theta}$