Class 11 Physics

Motion in a straight line – Chapter Summary

1. **Path length** : The length of the total path covered by a body during its motion is called path length or distance. It is a scalar quantity. Its SI unit is m and it can only be positive or zero
2. **Displacement :** The minimum distance between the starting and finishing point of a body in motion is called displacement. It os a vector quantity. Its SI unit is m. It can be positive, negative or even zero
3. Average speed $\frac{\text{Total distance (path length)}}{\text{Total time}}$;
4. Average Velocity = $\frac{\text{Total displacement}}{\text{Total time}}$ The SI unit for both is ms^{-1}
5. If the position of an object at two different times t_1 and t_2 are x_1 and x_2 then the **average velocity** for the given time interval is $\bar{v}_{av}\frac{x_2-x_1}{t_2-t_1}=\frac{\Delta x}{\Delta t}$. **I**

   Hence if suppose in any question you are given that the position x of a particle varies with time as $x = 6t^2 - 5t + 9$,(x is in m) find the average velocity of the particle between t = 2s and t = 4s, then we proceed as follows

   $x_2 = 6(4)^2 - 5(4) + 9 = 85m$, $x_1 = 6(2)^2 - 5(2) + 9 = 33m$

   $$\therefore \bar{v}_{av} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{85-33}{4-2} = \frac{52}{2} = 26ms^{-1}$$

6. The average velocity tells us how fast an object has been moving over a given time interval but does not tell us how fast it moves at different instants of time during that interval. For this, we define **instantaneous velocity** or simply velocity *v* at an instant *t*. The velocity at an instant is defined as the limit of the average velocity as the time interval Δt becomes infinitesimally small. In other words,

$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$, where $\frac{dx}{dt}$ gives the rate of change of position with respect to time, at that instant.

Thus in the above example where $x = 6t^2 - 5t + 9$, the velocity or instantaneous velocity is given by $v = \frac{dx}{dt} = \frac{d(6t^2 - 5t + 9)}{dt} = 6(2t^{2-1}) - 5(1.t^{1-1}) + 0 = 12t - 5$

$\therefore$ velocity at any instant, for example at $t = 2s$ may be obtained as

$v = 12(2) - 5 = 19ms^{-1}$

7. Kinematic equations for uniformly accelerated motion, Their derivation by graphical and by calculus method is important

$$v = u + at \text{ or } v = v_0 + at$$

$$s = ut + \frac{1}{2}at^2 \text{ or } x = x_0 + v_0 t + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as \text{ or } v^2 = v_0{}^2 + 2a(x - x_0)$$

8. Free fall: The object is released from rest at *y* = 0. Therefore, *v0* = 0 and the equations of motion become:
    a. $v = 0 - g\,t = -9.8\,t\ m\ s^{-1}$
    b. $y = 0 - ½\,g\,t^2 = -4.9\,t^2\ m$
    c. $v^2 = 0 - 2\,g\,y = -19.6\,y\ m^2\ s^{-2}$

    These equations give the velocity and the distance travelled as a function of time and also the variation of velocity with distance.

9. **Relative velocity:** Consider two objects *A* and *B* moving uniformly with average velocities v_A and v_B in one dimension, say along *x*-axis. As seen from object *A*, object *B* has a velocity $v_B - v_A$ because the displacement from *A* to *B* changes steadily by the amount $v_B - v_A$ in each unit of time.
    a. We say that the **velocity of object B relative to object A** is $v_{BA} = v_B - v_A$
    b. Similarly, **velocity of object A relative to object B** is $v_{AB} = v_A - v_B$