Atomic Energy Education Society, Mumbai

Class XI Chapter- 3
Module- 2

Motion in a straight line

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Motion in a Straight Line

Topics Covered in Module - 2

1) Path length and Displacement
2) Position time graph
3) Speed and velocity
4) Acceleration
5) Velocity time graph

Total Path Length (Distance)

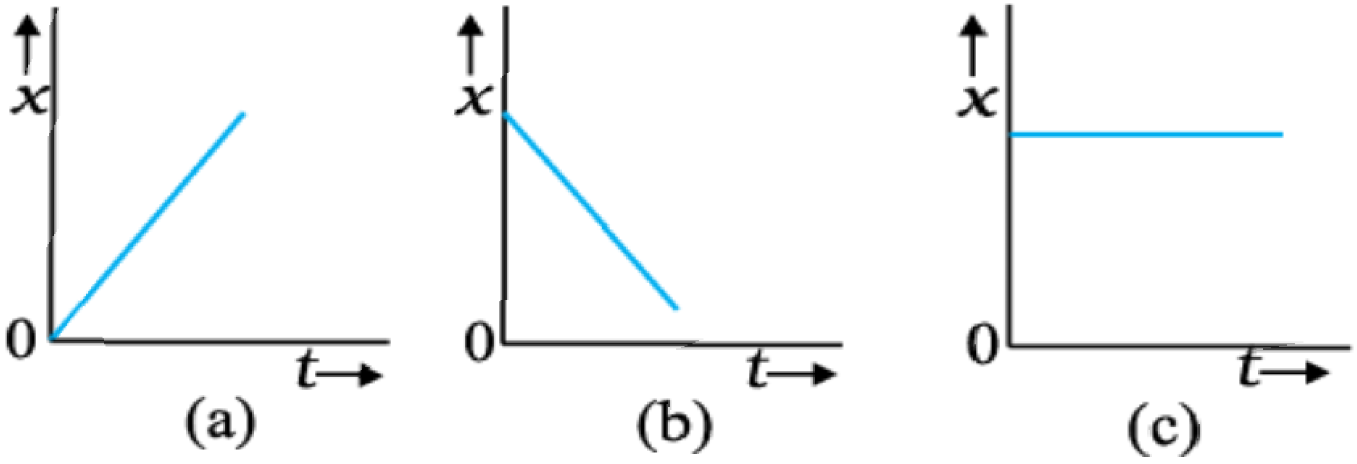
For a particle in motion the total length of the actual path traversed between initial and final positions of the particle is known as the ‘total path length’ or distance covered by it.

Displacement

Displacement of a particle in a given time is defined as the change in the position of particle in a particular direction during that time. It is given by a vector drawn from its initial position to its final position

Distance	Displacement
The actual path covered by a body is called its distance.	The shortest path possible by the body is called displacement.
It can not be less than displacement.	It is equal to or less than distance.
When it is divided by time, we get speed of the body.	When it is divided by time, we get the velocity of the body.
It can not be equal to zero.	It can be equal to zero.
It's a scalar quantity.	It's a vector quantity

Position time graph



Position-time graph for an object (a) moving with positive velocity, (b) moving with negative velocity, and (c) at rest.

Uniform Speed and Uniform Velocity

Uniform Speed: An object is said to move with uniform speed if it covers equal distances in equal intervals of time, howsoever small these intervals of time may be.

Uniform Velocity: An object is said to move with uniform velocity if it covers equal displacements in equal intervals of time, howsoever small these intervals of time may be.

Variable Speed and Variable Velocity

Variable Speed: An object is said to move with variable speed if it covers unequal distances in equal intervals of time, howsoever small these intervals of time may be.

Variable Velocity: An object is said to move with variable velocity if it covers unequal displacements in equal intervals of time, howsoever small these intervals of time may be.

Average Speed and Average Velocity

Average Speed: **It is the ratio of total path length traversed and the corresponding time interval.**

The distance covered in unit time is called average speed.

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Total time taken}}$$

$$V_{av} = \Delta x / \Delta t$$

Average Speed: **It is the ratio of total path length traversed and the corresponding time interval.**

Or

It is that single velocity with which the object can travel the same length in the same time as it generally does with varying velocity.

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time taken}}$$

$$\vec{V}_{av} = \Delta \vec{x} / \Delta t$$

The average speed of an object is greater than or equal to the magnitude of the average velocity over a given time interval.

The ratio of the total distance travelled by the object to the total time taken is called average speed of the object.

Average speed = Total distanced travelled / Total time taken

If a particle travels distances s_1, s_2, s_3, … with speeds v_1, v_2, v_3, …, then

Average speed = $s_1 + s_2 + s_3 + \ldots .. / (s_1 / v_1 + s_2 / v_2 + s_3 / v_3 + \ldots ..)$

If particle travels equal distances ($s_1 = s_2 = s$) with velocities v_1 and v_2, then

Average speed = $2\, v_1 v_2 / (v_1 + v_2)$

If a particle travels with speeds v_1, v_2, v_3, …, during time intervals t_1, t_2, t_3,…, then

Average speed = $v_1t_1 + v_2t_2 + v_3t_3 + \ldots / t_1 + t_2 + t_3 + \ldots.$

If particle travels with speeds v_1 and v_2 for equal time intervals, i.e., $t_1 = t_2 = t_3$, then

Average speed = $v_1 + v_2 / 2$

When a body travels equal distance with speeds V_1 and V_2, the average speed (v) is the harmonic mean of two speeds.

2 / v = 1 / v1 + 1 / v2

Instantaneous Speed and Instantaneous Velocity

Instantaneous Speed: The speed of an object at an instant of time is called instantaneous speed.

Or

Instantaneous velocity: is the limit of the average speed as the time interval becomes infinitesimally small.

$$V = \lim_{\Delta t \to 0} \Delta \vec{x} / \Delta t = dx/dt$$

Acceleration

The rate at which velocity changes is called acceleration.

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time taken}}$$

$$a = \frac{v-u}{t}$$

Where v and u are final and initial velocity respectively. It is a vector quantity with SI unit of m/s^2 and has dimensions of $[LT^{-2}]$

If acceleration is –ve (negative), then it is called retardation or deceleration.

Uniform Acceleration

If an object undergoes equal changes in velocity in equal time intervals it is called uniform acceleration.

Average and Instantaneous Acceleration

Average Acceleration: It is the change in the velocity divided by the time-interval during which the change occurs.

$$\vec{a} = \Delta\vec{v}/\Delta t$$

Instantaneous Acceleration: It is defined as the limit of the average acceleration as the time-interval Δt goes to zero

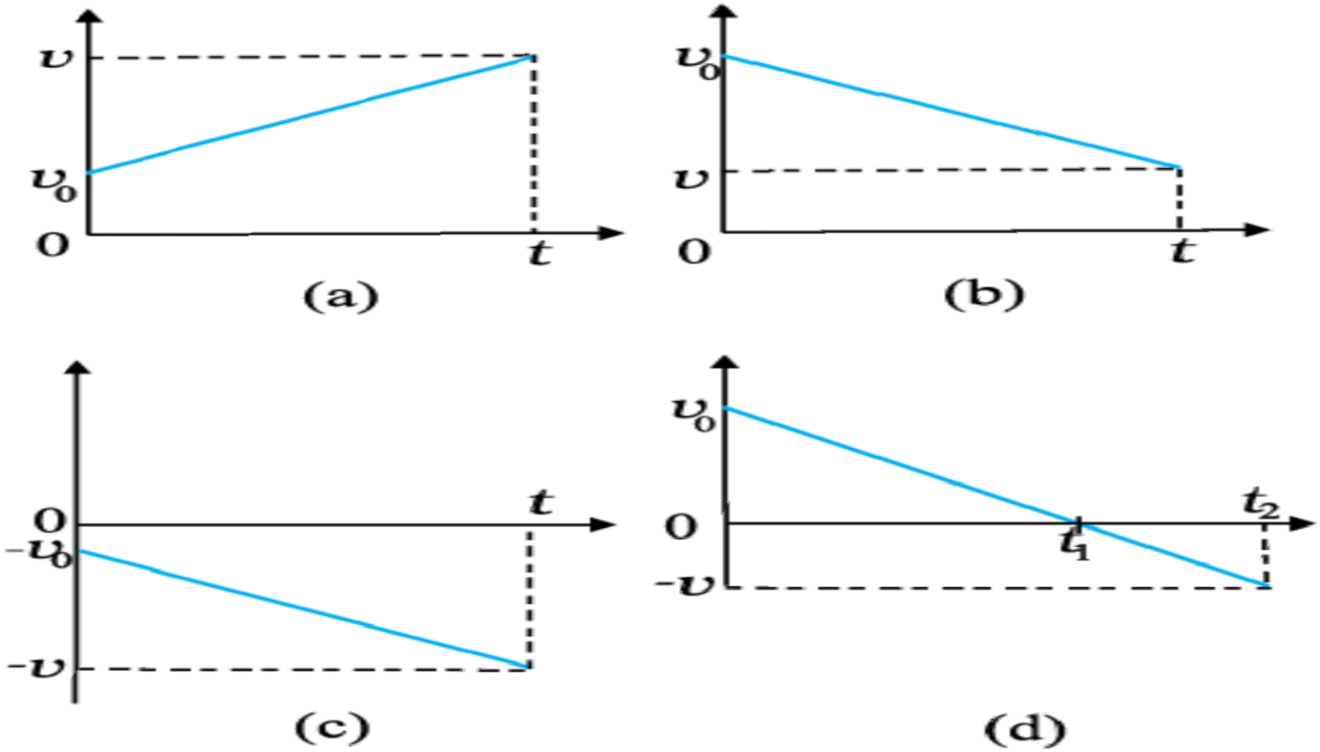
$$\vec{a} = \lim_{\Delta t \to 0} \Delta\vec{v}/\Delta t = dv/dt$$

Position time graph for acceleration

Position-time graph for motion with

(a) positive acceleration, (b) negative acceleration, and (c) zero acceleration.

Velocity time graph for acceleration



Velocity–time graph for motions with constant acceleration. (a) Motion in positive direction with positive acceleration, b) Motion in positive direction with negative acceleration, (c) Motion in negative direction with negative acceleration, (d) Motion of an object with negative acceleration that changes direction at time t_1. Between times 0 to t_1, it moves in positive x - direction and between t_1 and t_2 it moves in the opposite direction.