2

MOTION IN A STRAIGHT LINE

Speed and Velocity

- The total length of the path covered by a body is the distance travelled by it.
- The difference between the initial and final position vectors of a body is called its displacement.
- Displacement is the shortest distance between the two positions and has a certain direction.
- The rate of change of distance with time is called **speed**
- The rate of change of displacement is known as **velocity**.

Average Velocity

- The average velocity of an object is defined as the displacement per unit time

$$\bar{v} = \frac{displacement}{time\ taken} = \frac{x_2 - x_1}{t_2 - t_1}$$

- The average speed of an object is obtained by dividing the total distance travelled by the total time taken:

$$= \frac{Total\ distance\ travelled}{total\ time\ taken}$$

Relative Velocity

- The relative velocity of an object with respect to another object is the rate at which it changes its position relative to the object / point
- relative to the object / point taken as reference

- The rate of change of the relative position of an object with respect to the other object is known as the **relative velocity** of that object with respect to the other
- The relative velocity of B with respect to A will be $v_b - v_a$

Acceleration

- The acceleration is defined as time rate of change of velocity.
- Acceleration is a vector quantity and its SI unit is ms^{-2}.

Average acceleration

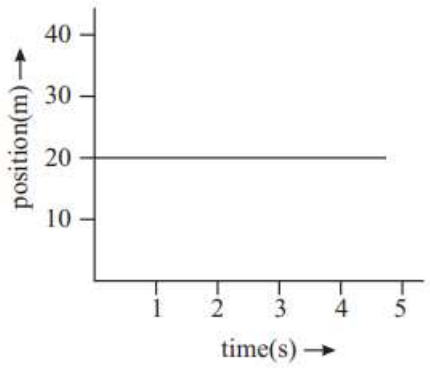
$$(\bar{a}) = \frac{\text{Final velocity – Initial velocity}}{\text{time taken}} = \frac{v_2 - v_1}{t_2 - t_1}$$

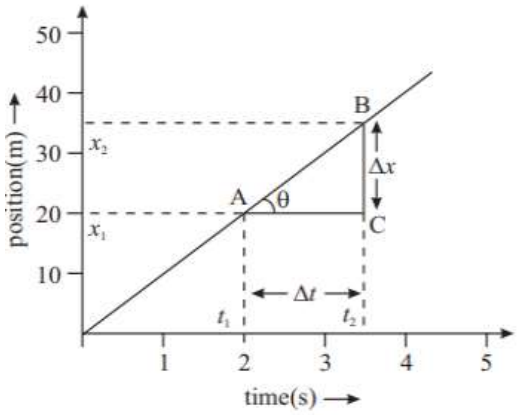
The decrease in the rate of change of velocity is **retardation**

Position - Time Graph

- The different positions and corresponding times can be plotted on a graph giving us a certain curve. Such a curve is known as position-time curve.
- The time is represented along x-axis whereas the position of the body is represented along y-axis.

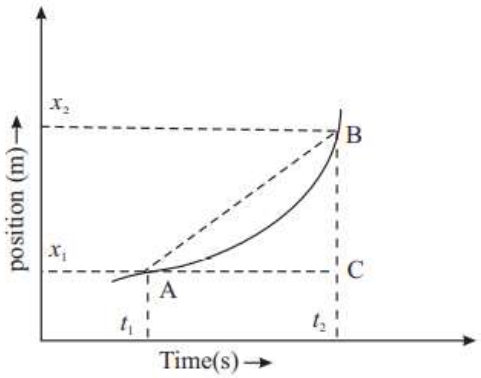
- A motion in which the velocity of the moving object is constant is known as uniform motion.





Position-Time Graph for Non-Uniform Motion

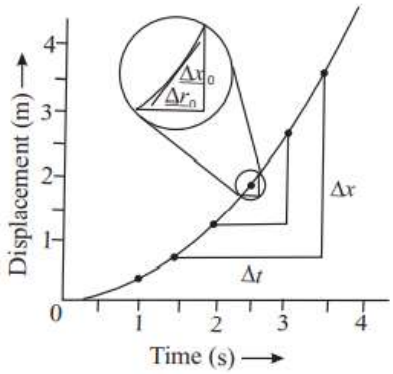
- The distances covered in equal intervals of time are not equal. Such a motion is said to be non-uniform motion.
- If the distances covered in successive intervals are increasing, the motion is said to be accelerated motion.



Velocity from position - time graph

Instantaneous velocity

- The velocity of the particle at any instant of time or at some point of its path is called its instantaneous velocity.
- $\overline{v} = \frac{\Delta x}{\Delta t}$
- The slope ($\Delta x/\Delta t$) of a line tangent to the curve at that point gives the instantaneous velocity.

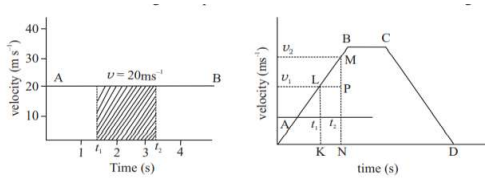


Velocity - Time Graph

Velocity-Time Graph for Uniform Motion

- In uniform motion the velocity of the body remains constant, i.e., there is no

change in the velocity with time.

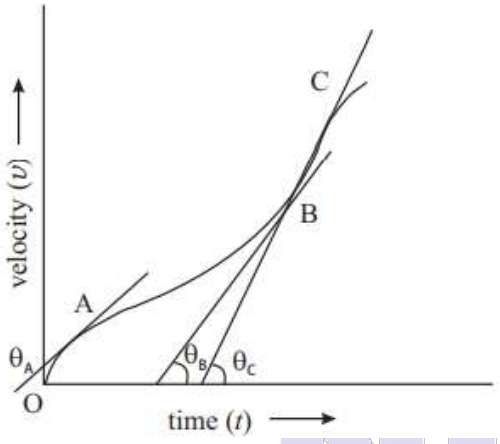


Velocity-Time Graph for Non-Uniform Motion

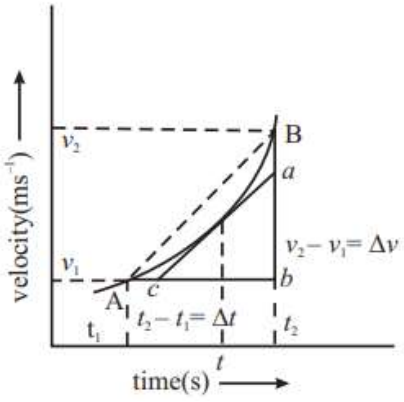
The average acceleration of the body is given by

$$\overline{a} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

$$= \textit{slope of the straight line}$$



Determination of the distance travelled by the body



S= area of trapezium

= (1/2) × (v_1+v_2) × (t_2-t_1)

Determination of the acceleration of the body

Average acceleration $= \frac{\Delta v}{\Delta t}$ = slope of the tangent

Equations of Motion

First Equation of Uniformly Accelerated Motion

$$(\bar{a}) = \frac{\text{Final velocity} - \text{Initial velocity}}{\text{time taken}}$$

$$= \frac{v_2 - v_1}{t_2 - t_1}$$

$$a = \frac{v - v_0}{t}$$

$$\mathbf{V} = \boldsymbol{v_0 + at}$$

Second Equation of Uniformly Accelerated Motion

Distance travelled = area under v-t graph

= Area of trapezium

$$x - x_0 = \frac{1}{2}(v + v_0)t$$

Since $V = v_0 + at$

$$\boldsymbol{x = x_0 + v_0 t + 1/2\ at^2}$$

Third Equation of Uniformly Accelerated Motion

$$x - x_0 = \frac{1}{2}(v + v_0)t$$

$$x - x_0 = \frac{1}{2}(v + v_0)(v - v_0)$$

$$\mathbf{V^2} = \boldsymbol{v_0^2 + 2a(x - x_0)}$$

Motion under Gravity

The free fall of a body towards the earth is one of the most common examples of motion with constant acceleration.

$$V = v_0 + gt$$

$$x = x_0 + v_0 t + 1/2\ gt^2$$

$$V^2 = v_0^2 + 2g(x - x_0)$$

CHECK YOURSELF

1. Slope of position time graph represents for uniform motion.
   A. Uniform Velocity
   B. Distance
   C. Acceleration
   D. None of these
2. A car runs at a constant speed of a circular track of radius 200 meter. Taking 62.8 second on each lap. Find the average velocity
   A. 0
   B. $20ms^{-1}$
   C. $10ms^{-1}$
   D. $30ms^{-1}$
3. The area under v-t graph gives the
   A. Displacement
   B. Velocity
   C. Acceleration
   D. Time
4. The ratio of the displacement of an object to the time interval is known as
   A. Average velocity
   B. Speed
   C. Acceleration
   D. Distance
5. Slope of velocity time graph represents
   A. Speed
   B. Distance
   C. Acceleration
   D. None of above

STRETCH YOURSELF

1. Which speed is measured by the speedometer of your scooter?
2. What is the numerical ratio of velocity to speed of an object?
3. Derive expression for equation of Motion by v-t graph.
4. Give the difference between distance and displacement.
5. A bus travels a distance A to B at a speed of 40 km/h and returns to A at a speed of 30km/h.
   I. What is the average speed for the whole journey?
   II. What is average velocity?

Answer to Check yourself

1A) 2A) 3A) 4A) 5C)