Motion in a Straight Line

Motion

- Motion refers to the change in position of an object with respect to time. When an object changes its position with respect to a reference point, it is said to be in motion.
- Motion can be described in terms of its speed, direction, and acceleration.

Position, Distance and Displacement:

- Position: An object's position is always expressed in relation to some reference point, known as the origin. We take into account two physical quantities to express the change in position.
- Distance: This is the actual path that an object travels while in motion. Its dimensions are [L] and its S.I. unit is 'm'.
- Displacement: This term describes the variation between the final and initial positions of an object during motion.

Differences Between Distance and Displacement:

*aasan bhasha me kahu tho coaching se chutne ke baad tum sidhe ghar gaye tho displacment hua
or agar tum coaching se chutne ke baad pehle chai ki tapari pe gaye and then ghar gaye tho distance

Distance	Displacement
It describes the actual path taken by an object while in motion.	It denotes the difference between the starting and ending positions.
It is a scalar quantity	It is a vector quantity
When an object is moving, the distance it covers is always positive and never negative or zero.	An object's displacement during motion can be positive, negative or even zero.
The distance travelled is always more than, or equal to the size of the displacement	The amount of displacement is negligible or equal to the distance covered during motion.
The distance depends on the path taken by the object.	The magnitude of displacement is independent of the path travelled by an object during motion.

Difference Between Speed and Velocity :

Speed	Velocity
It is defined as the total distance travelled divided by the amount of time that the motion has occurred.	It describes the division of the time intervals during which a change in location or displacement takes place.
It is a scalar quantity.	It is a vector quantity
Throughout motion, it is always positive.	During motion, it may be positive, negative or zero.

It is more than or equal to the magnitude of the velocity	It is equal to or less than the speed.

Note

- The amount of displacement is equal to the length of the entire path when an object is moving in a straight line and in the same direction.

- In this instance, the average speed and average velocity are of equal magnitude. This isn't always the case, though.

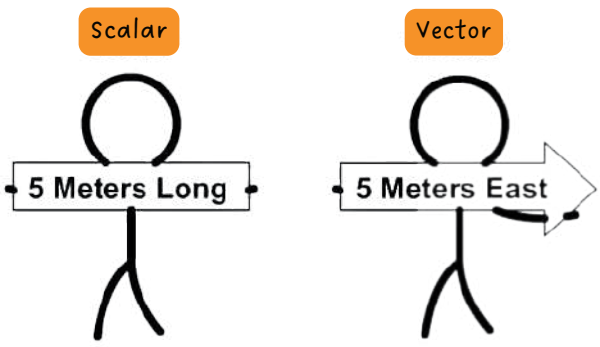
Scalar and Vector Quantities

Scalar Quantities

- Scalar quantities are used to describe physical quantities that only have magnitude and no direction.
- Scalars include things like mass, length, time, distance, speed, work and temperature, to name a few.

Vector Quantities

- The term "vector quantity" refers to a physical quantity that has both magnitude and direction.
- It includes displacement, velocity, acceleration, force, momentum and torque.



Average Velocity and Average Speed:

Average Velocity

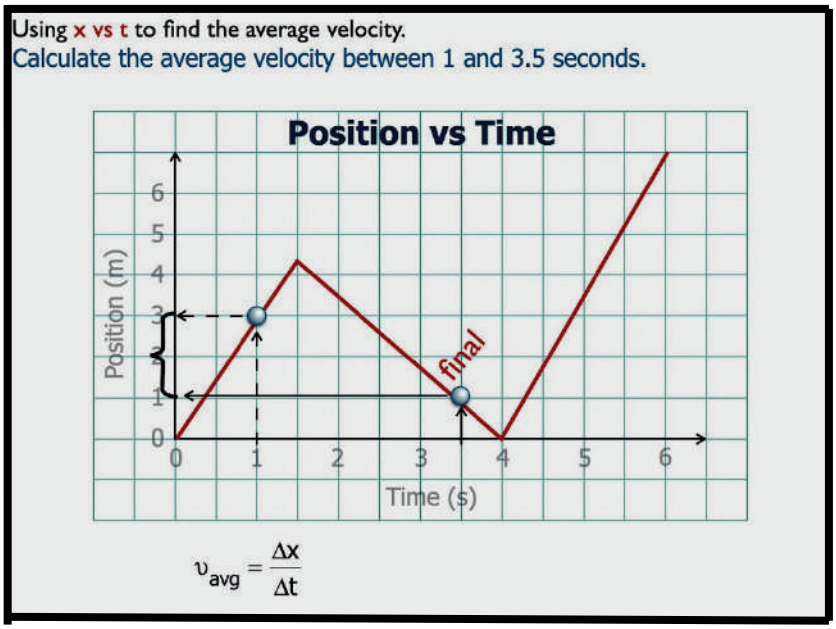
- Average velocity is the total displacement of an object over a certain period of time, divided by the time interval. In other words, it is the change in position of an object divided by the time taken for that change to occur.
- Average Velocity =
  (Final Position - Initial Position) / Time taken

$$\bar{v} = \frac{\Delta x}{\Delta t}$$

$\bar{v}$ = average velocity
Δx = displacement
Δt = change in time

Average Speed

- Average speed is the distance traveled by an object over a certain period of time, divided by the time interval. It is the total distance traveled by an object divided by the time taken for that journey.
- Average Speed = Total Distance Traveled / Time Taken



Instantaneous Velocity and Instantaneous Speed

Instantaneous velocity

- Instantaneous velocity is the velocity of an object at a specific instant in time.
- It is the rate of change of an object's position with respect to time at that specific moment.
- Instantaneous Velocity = $\lim (\Delta t \frown 0)\ \Delta x / \Delta t$
- Its dimensions are $[M^0 LT^{-1}]$ and its S.I. unit is m/s.

Instantaneous Speed

- Instantaneous speed is the speed of an object at a specific instant in time. It is the magnitude of the instantaneous velocity of the object
- Instantaneous Speed = |Instantaneous Velocity|
- Its dimensions are $[M^0 L\ T^{-1}]$ and its S.I. unit is m/s.

Acceleration

*vroom...vrooom

- Acceleration is the rate of change of an object's velocity with respect to time. It is the rate at which an object's velocity is changing in magnitude or direction, or both.

$$a = \frac{V_f - V_i}{t} \qquad a = v\frac{dv}{dx}$$

For example, if a car is initially traveling at a velocity of 30 km/h to the east and after 5 seconds it is traveling at a velocity of 60 km/h to the east, its acceleration can be calculated as:

Acceleration = (60 km/h - 30 km/h) / 5 s = 6 km/h/s to the east

This means that the car's velocity is increasing at a rate of 6 kilometers per hour every second to the east.

Average Acceleration

- The average acceleration during a period of time is defined as the change in velocity divided by the time interval.
- The average change in velocity per unit of time is hence known as average acceleration.
- a=(v2-v1)/(t2-t1), where v2 and v1 are the velocities at time t2 and t1, respectively.
- Its dimensions are $[M^0L\ T^{-2}]$ and its S.I. unit is m/s2.

Instantaneous Acceleration

- Instantaneous acceleration is the acceleration of an object at a specific instant in time. It is the rate of change of an object's velocity with respect to time at that specific moment.
- Mathematically, instantaneous acceleration is defined as:

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

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

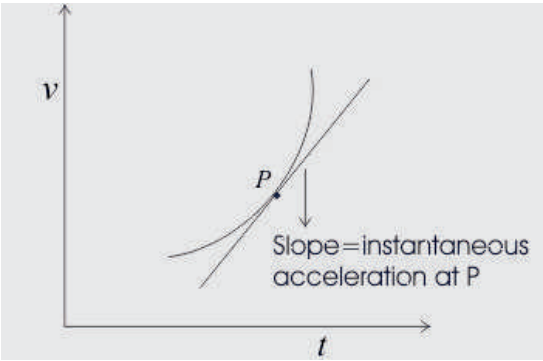
$$v=\frac{dx}{dt}$$

$$a=\frac{d}{dt}\left(\frac{dx}{dt}\right)=\frac{d^2x}{dt^2}$$

- Its dimensions are $[M^0L\ T^{-2}]$ and its S.I. unit is m/s2.

Note

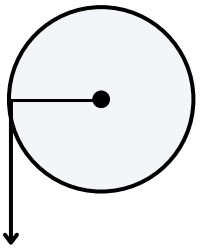
- Instantaneous acceleration is a vector quantity, meaning it has both magnitude and direction. Its direction is the same as the direction of the change in velocity. If the velocity is increasing, the acceleration is in the same direction as the velocity, and if the velocity is decreasing, the acceleration is in the opposite direction as the velocity.



Uniform Circular Motion

	Units	UCM	NUCM
θ : Angular Displacement	rad	ω=constant	$\omega \neq 0$
ω : Angular Velocity	rad/s	$\alpha = 0$	$\alpha \neq 0$
α : Angular Acceleration	rad/s^2	$a_t = 0$	
		$a_s = \frac{v^2}{r}$	

$\omega = \frac{d\theta}{dt}$ $\quad \alpha = \frac{d\omega}{dt} = \omega\frac{d\omega}{dt}$ $\quad \left[\text{like 1D } a = \frac{v dv}{dx}\right]$



V (Tangential Velocity)

Tangential Acceleration

$$a_t = \frac{dv}{dt} = \left[\frac{R d\omega}{dt}\right] \Rightarrow a_T = R\alpha$$

Total Acceleration = $a_{Total} = \sqrt{a_T^2 + a_N^2}$

Normal Acceleration

$$a_N = \frac{V^2}{r} = \omega^2 r$$

Review

Displacement

$$\Delta x = x_f - x_i$$

Average Velocity

$$\bar{v} = \frac{\Delta x}{\Delta t}$$

Average Acceleration

$$\bar{a} = \frac{\Delta v}{\Delta t}$$

Instantaneous velocity (acceleration) is the *slope* of the line *tangent* to the curve of the position (velocity) -time graph

For *constant* acceleration...

$$v = v_0 + at$$

$$\Delta x = v_0 t + \frac{1}{2} a t^2$$

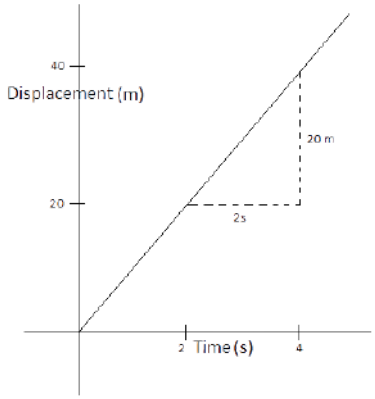
$$v^2 = v_0^2 + 2a\Delta x$$

Graphs

Uniform motion

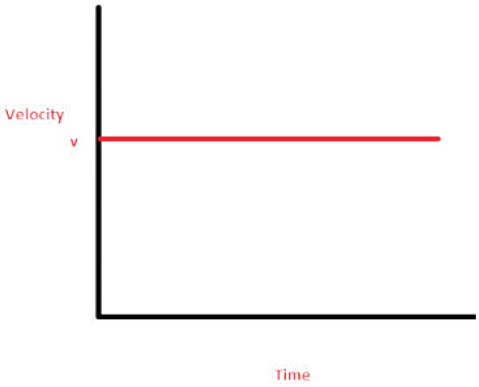
- When a body travels the same distances over the same periods of time, it is said to be in uniform motion.
- In this case, the speed remains constant throughout the movement
- In addition, during motion, there is no acceleration

Displacment - time graph



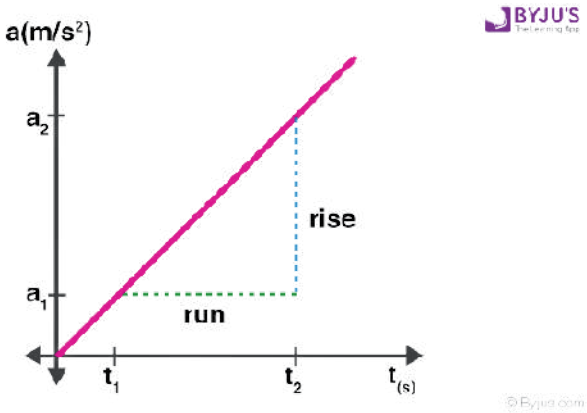
Nautre of slope : positive

Velocity - time graph



nature of slope : zero

acceleration time graph

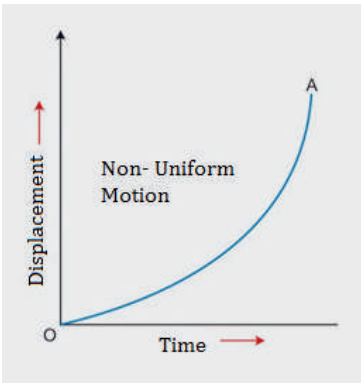


nature of slope of a - t

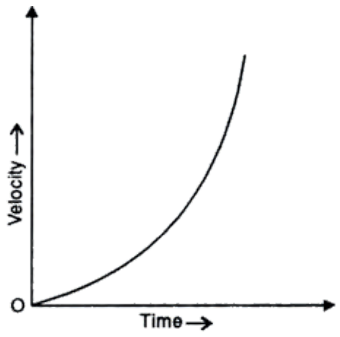
Non-Uniform motion

- Non-uniform motion refers to motion where an object's velocity (speed and direction) changes with respect to time.
- Magnitude of Velocity increases or decreases with time
- it moves with a constant speed in a straight line without changing its direction.

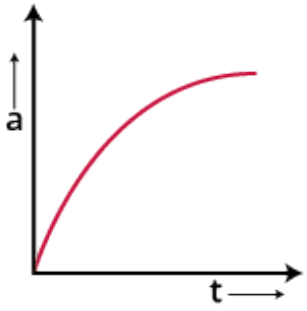
Displacment time graph



velocity time graph



acceleration - time graph



ye sare Graphs bhi taiyaar kar lena exam ke liye

"NCERT IN TEXT QUESTIONS AND BACK QUESTIONS ARE VERY IMPORTANT"