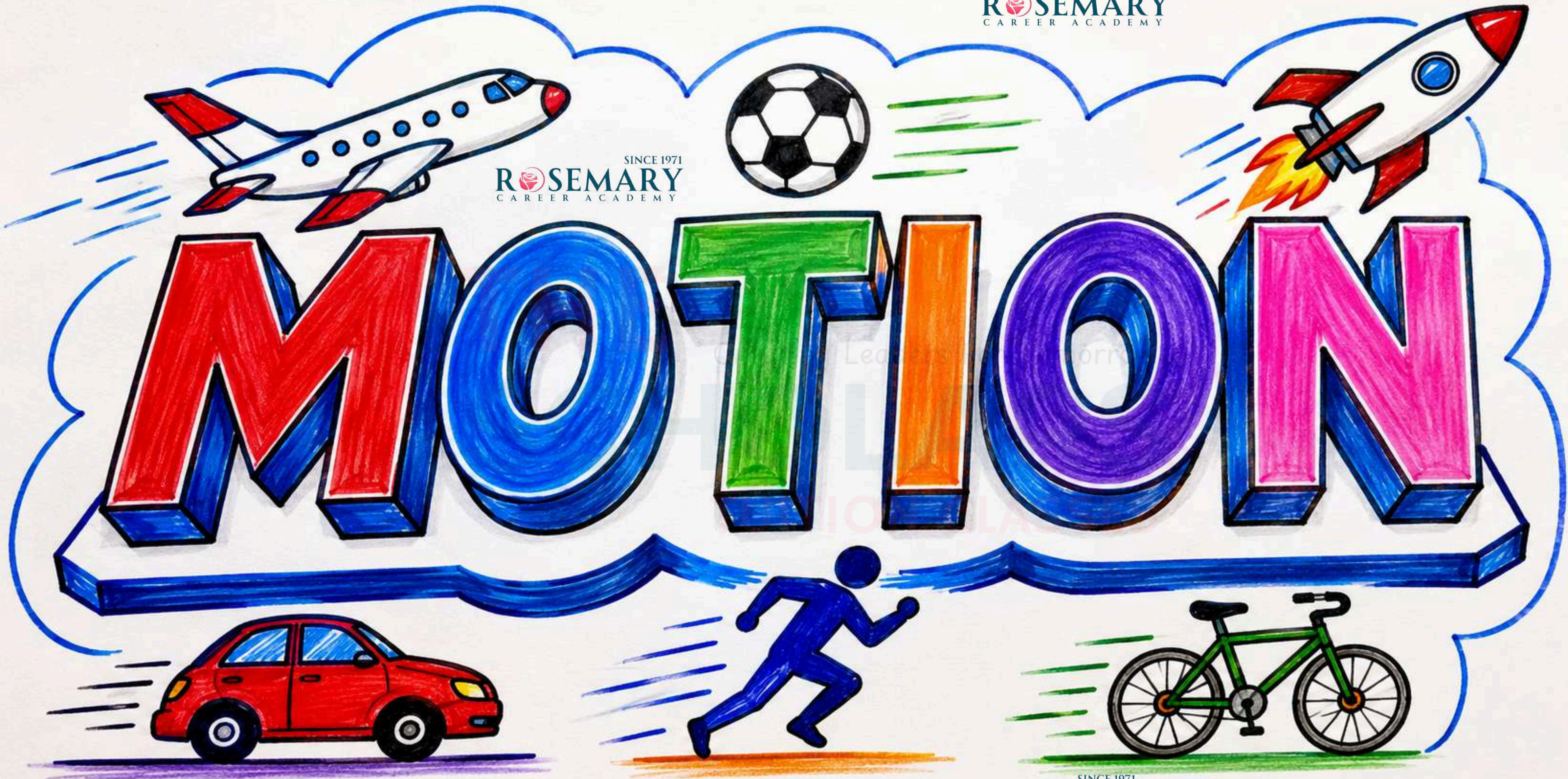
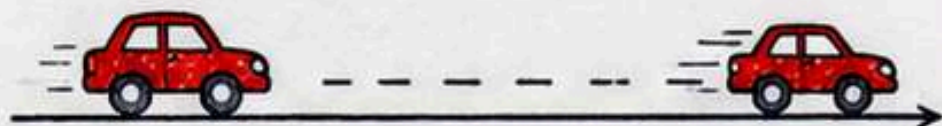
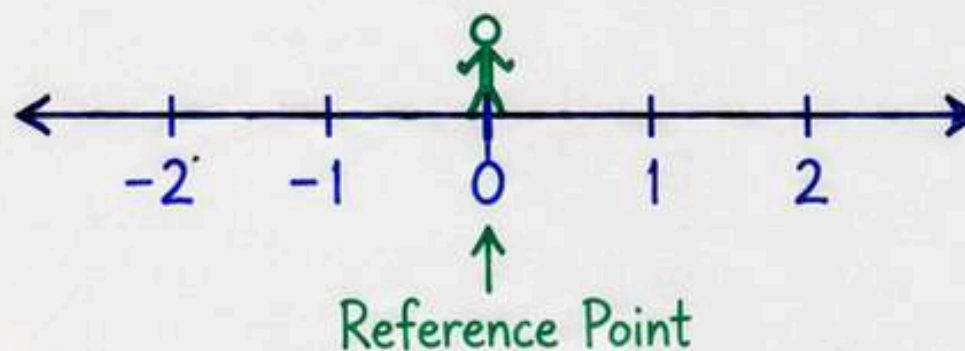




Motion in a Straight Line



Position and Reference Point



Distance and Displacement



Distance = Length of path

Displacement = Shortest distance

Speed and Velocity

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$



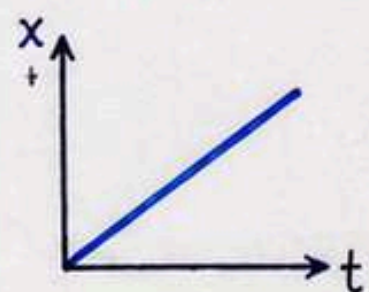
CHAPTER OVERVIEW

Acceleration

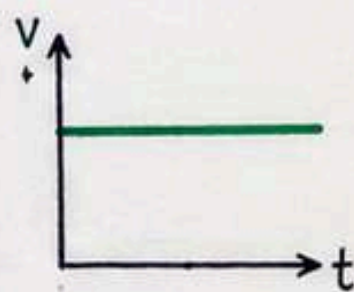
$$\text{Acceleration} = \frac{\text{Change in Velocity}}{\text{Time}}$$



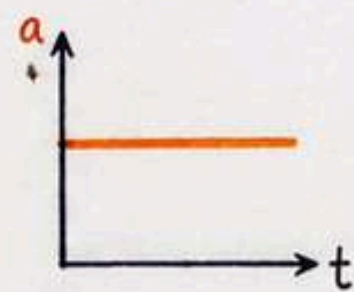
Graphical Representation of Motion



Position-Time



Velocity-Time



Acceleration-Time

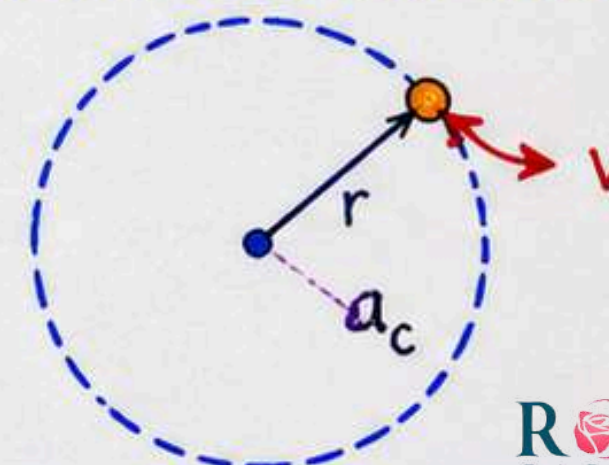
Kinematic Equations

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Uniform Circular Motion



1. MOTION

Definition

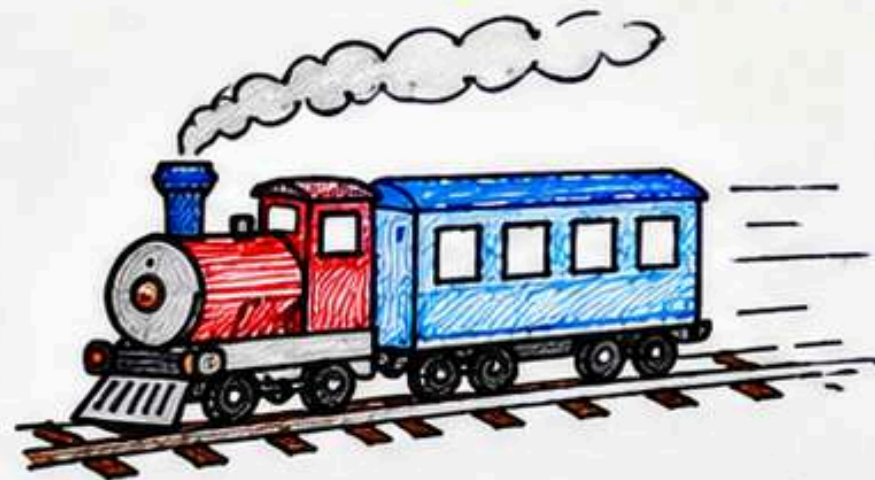
An object is said to be in motion if its position changes with time with respect to a reference point.

Examples

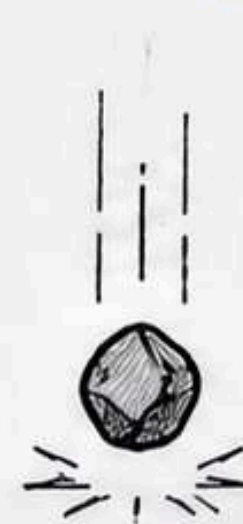
- Running athlete



- Moving train



- Falling stone



- Flying bird



2. REFERENCE POINT

Before describing motion, we must choose a fixed point called a reference point.

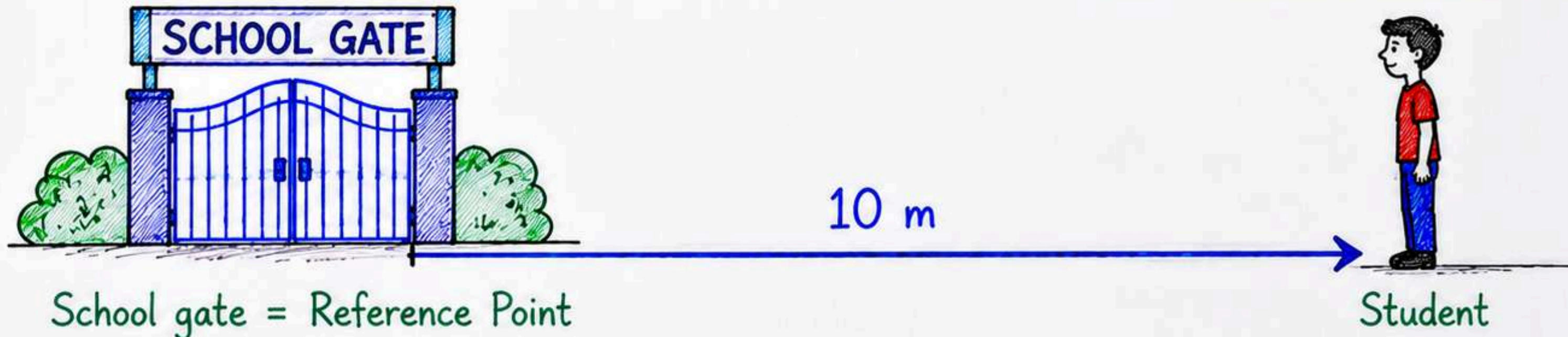
Definition

The distance and direction of an object from a fixed point describe its position.

Example

If a student stands:

- 10 m east of school gate
 - School gate = Reference Point
- Position = 10 m east



3. REST AND MOTION

At Rest

Position does not change with time.

In Motion

Position changes with time.

Important Example

A passenger sitting in a moving train:

- At rest with respect to train
- In motion with respect to ground



Conclusion: Motion is relative.

4. DISTANCE TRAVELLED

Definition

Total length of actual path covered by an object.

Properties

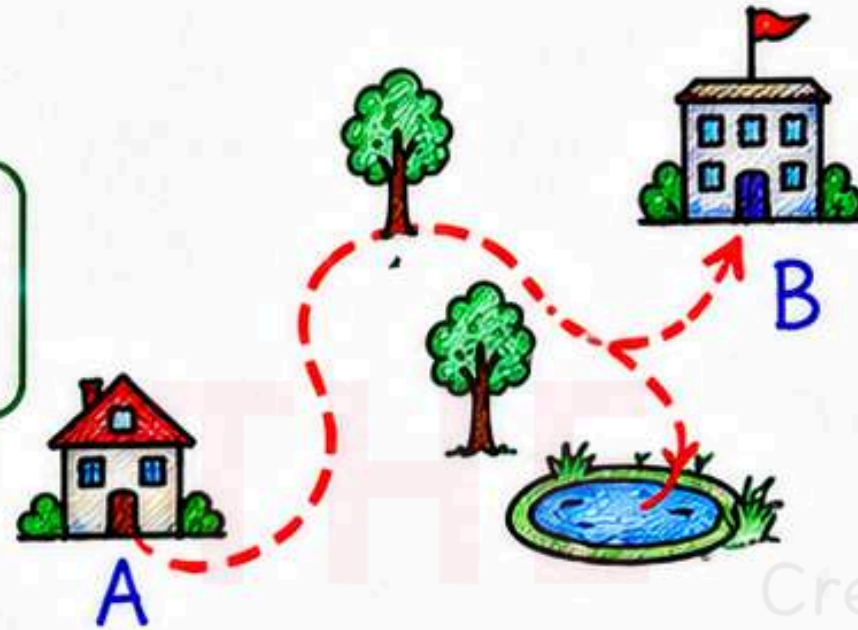
- ✓ Scalar quantity
- ✓ Always positive
- ✓ SI Unit = metre (m)

Formula

Distance =
Total Path Length

Example

If an object moves from A to B along a curved path, distance is the total length of the path.



5. DISPLACEMENT

Definition

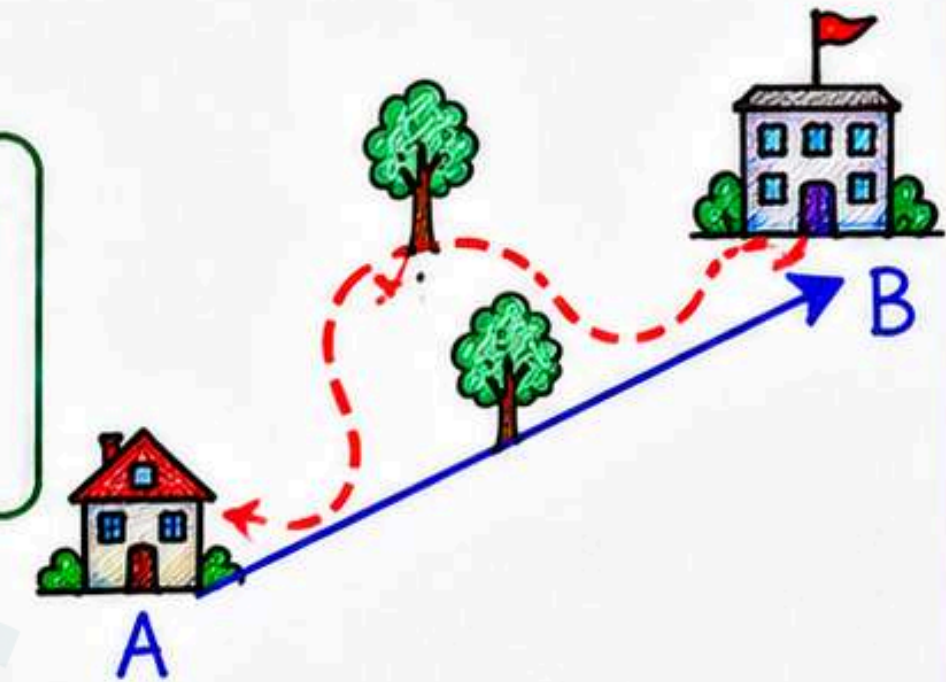
Shortest distance between initial and final positions in a specified direction.

Properties

- ✓ Vector quantity
- ✓ Has magnitude and direction
- ✓ SI Unit = metre (m)

Example

Displacement is the straight line distance from initial position (A) to final position (B) in a given direction.



Difference Between Distance and Displacement

Distance	Displacement
Actual path length	Shortest path
Scalar	Vector
No direction	Has direction
Always positive	Can be positive, negative or zero
$\geq$ Displacement	$\leq$ Distance

Important Result

When are Distance and Displacement Equal?

Distance and Displacement are equal when an object moves in a **straight line in one direction**.

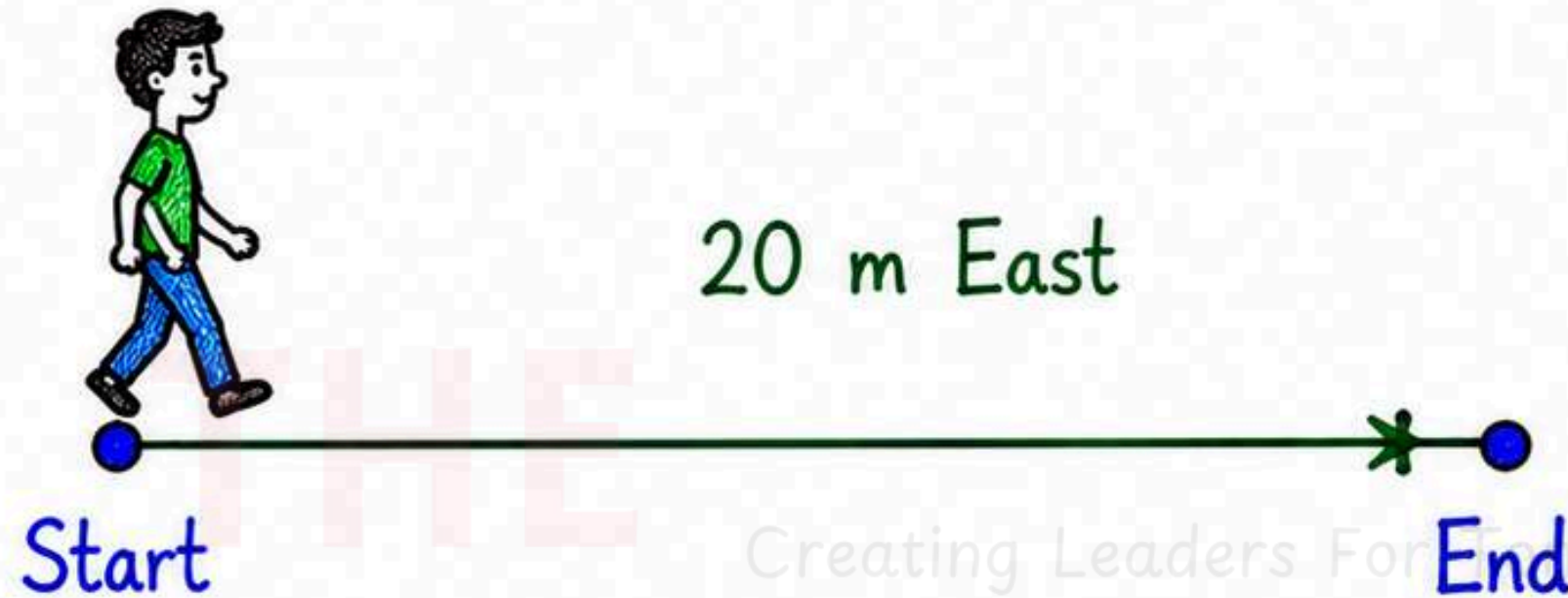


In this case:
Distance = Displacement

When an object moves in only one direction without turning back.

Example

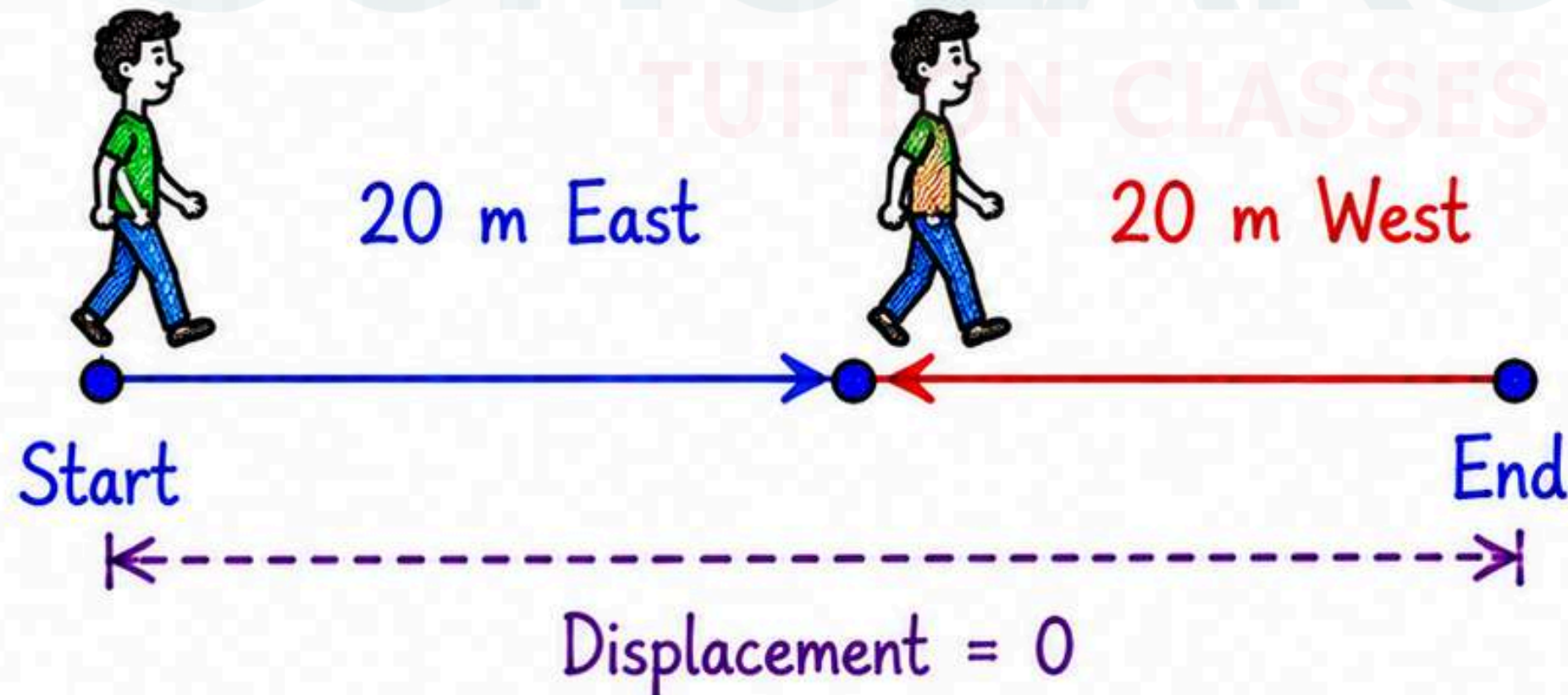
- A person moves:
- 20 m East



Distance = 20 m
Displacement = 20 m East
Both are equal.

Example

- A person walks:
- 20 m East
then 20 m West



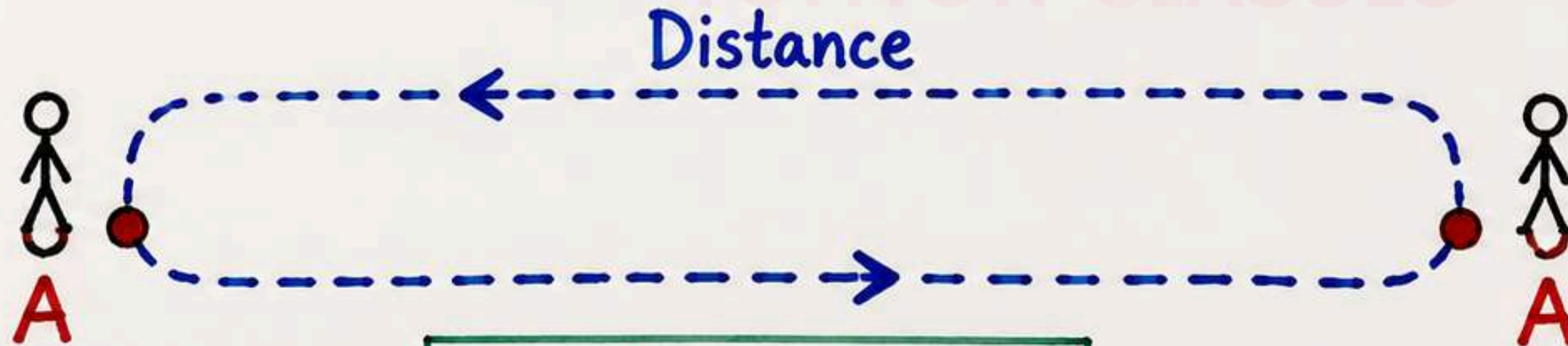
Distance = 40 m
Displacement = 0

EXAM TIP

**** Distance can never be zero during motion. ****



**** Displacement can be zero even when distance is not zero. ****



Displacement = 0

6. SPEED

Definition

Speed tells how fast an object moves.



SI Unit

m/s

Formula

Speed = $\frac{\text{Distance}}{\text{Time}}$

$$v = \frac{d}{t}$$

$$v = \frac{d}{t}$$

Other Unit

km/h

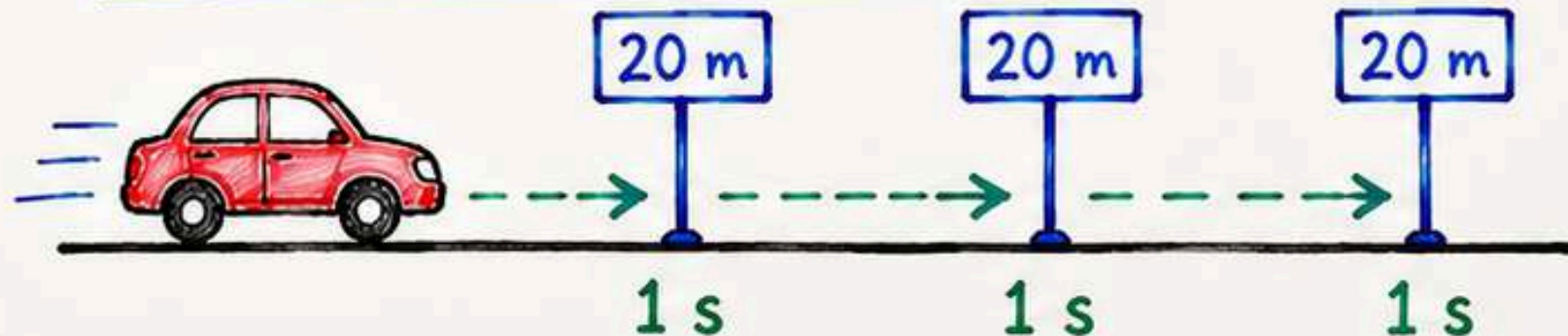
TYPES OF SPEED

Uniform Speed

Equal distances in equal intervals of time.

Example

20 m every second



Non-Uniform Speed

Unequal distances in equal intervals of time.

Example

Car in city traffic



7. VELOCITY

Definition

Velocity is displacement per unit time.

SI Unit

m/s

Formula

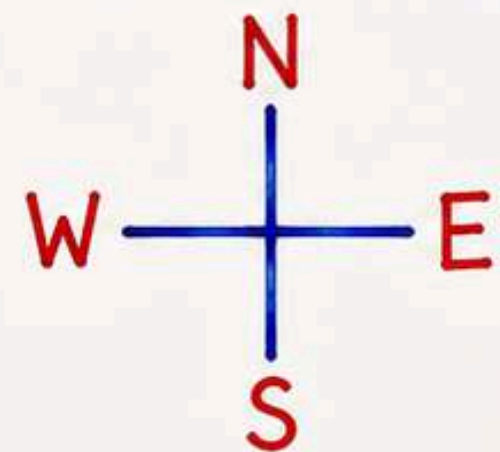
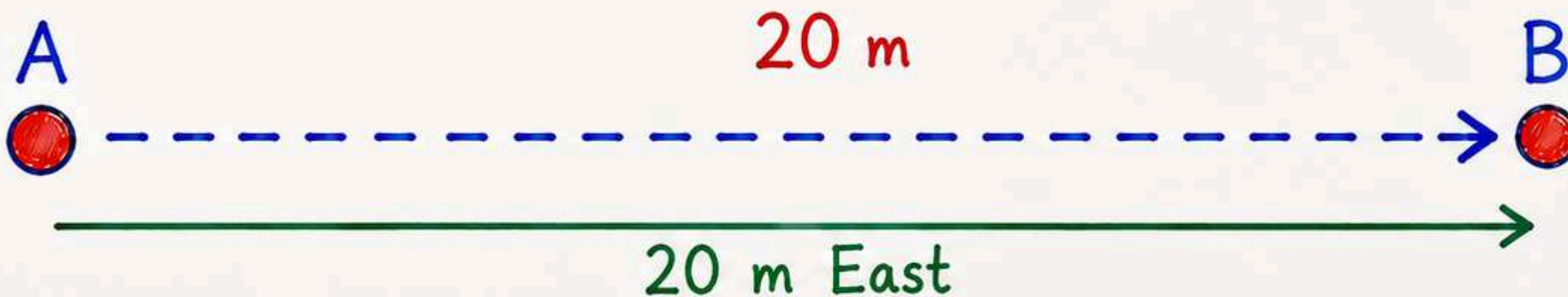
$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}} \quad v = \frac{s}{t} \quad v = \frac{s}{t}$$

Key Point

Velocity has direction.

Example:

20 m/s East



SPEED VS VELOCITY

SPEED	VELOCITY
• Scalar 	• Vector 
• Uses distance 	• Uses displacement 
• No direction 	• Has direction 

8. AVERAGE SPEED

Formula

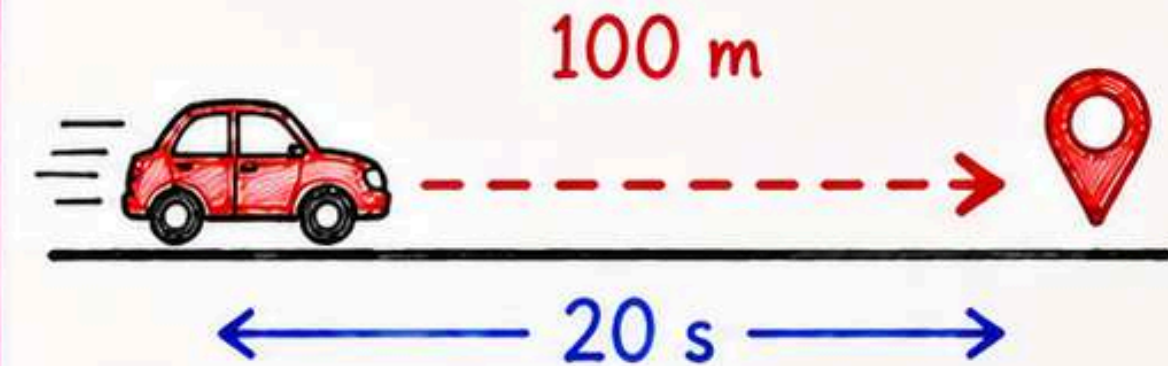
$$\text{Average Speed} = \frac{\text{Total Distance}}{\text{Total Time}}$$

Example

$$\text{Distance} = 100 \text{ m}$$

$$\text{Time} = 20 \text{ s}$$

$$\text{Average Speed} = 5 \text{ m/s}$$



9. AVERAGE VELOCITY

Formula

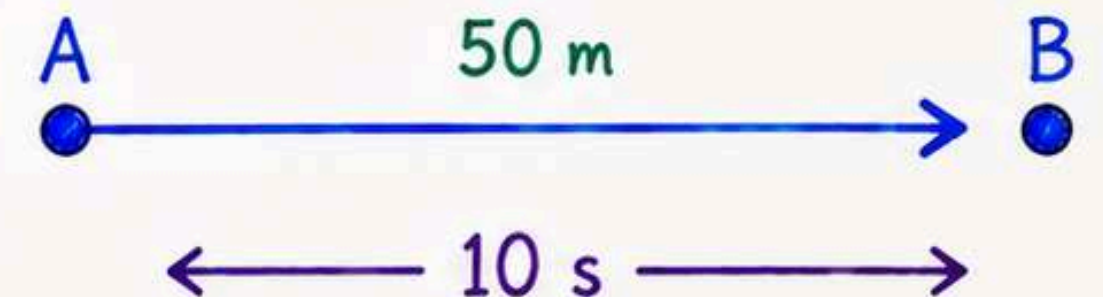
$$\text{Average Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

Example

$$\text{Displacement} = 50 \text{ m}$$

$$\text{Time} = 10 \text{ s}$$

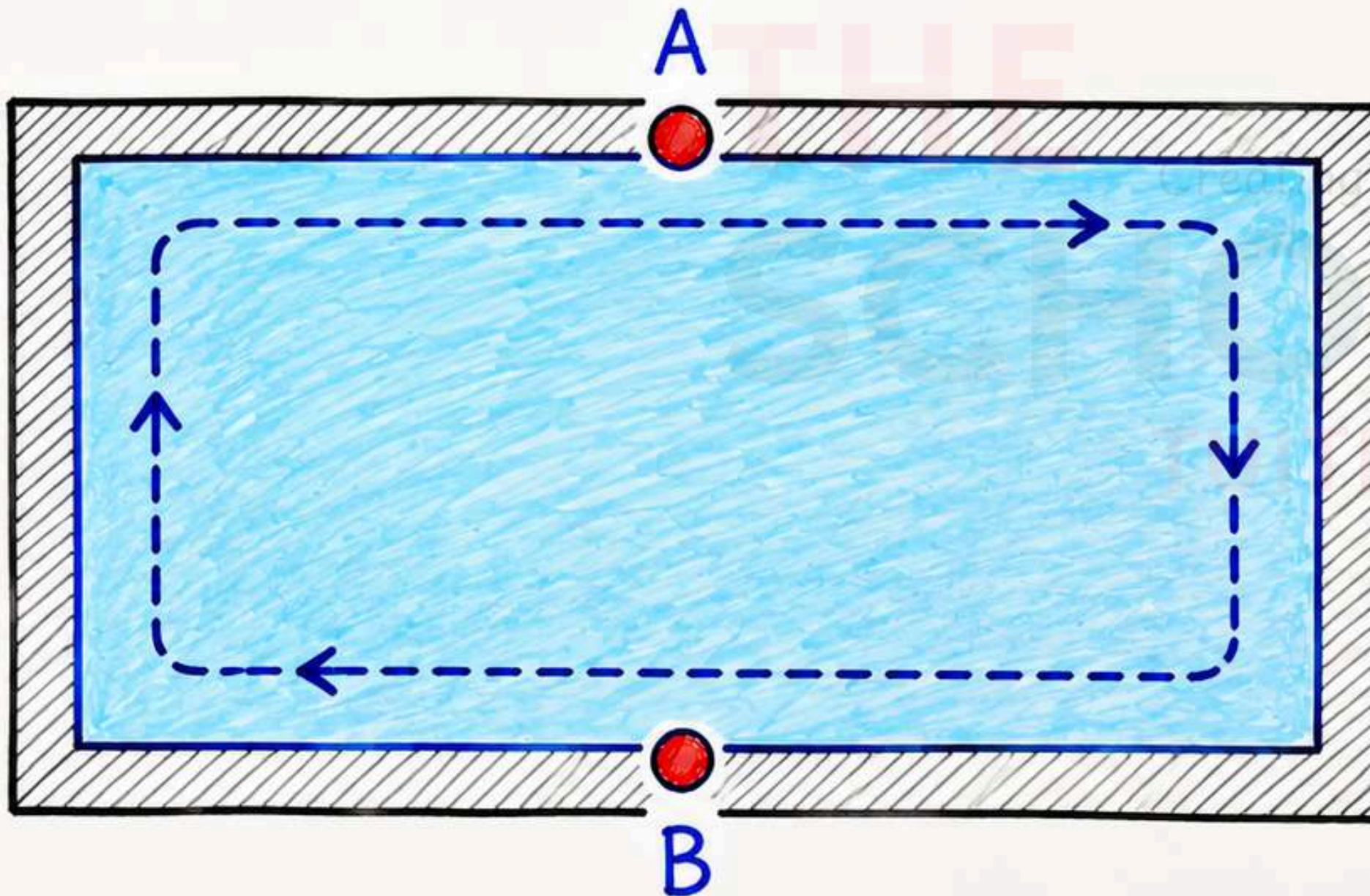
$$\text{Average Velocity} = 5 \text{ m/s}$$



IMPORTANT EXAM CONCEPT

Swimming Pool Example

SINCE 1971
ROSEMARY
CAREER ACADEMY



One round trip:

Distance = 50 m

Displacement = 0

Average Speed = 1 m/s

Average Velocity = 0 m/s

10. ACCELERATION

Definition

Rate of change of velocity.

Where

u = Initial Velocity

v = Final Velocity

t = Time

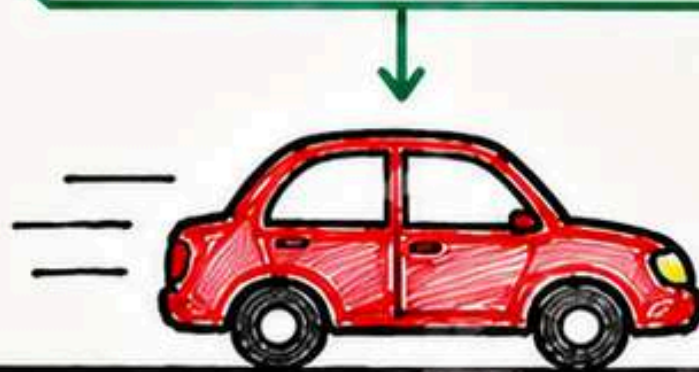
Formula

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

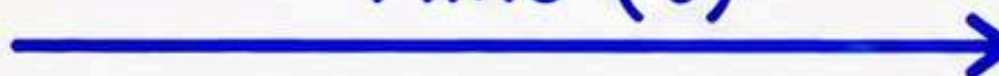
SI Unit

$$\text{m/s}^2$$

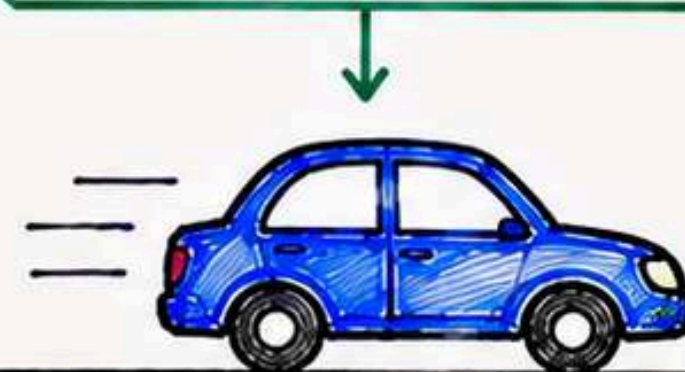
u = Initial Velocity



Time (t)



v = Final Velocity



TYPES OF ACCELERATION

★ Positive Acceleration

Velocity increases.

Example:

Bike speeding up.



Velocity increases →

★ Negative Acceleration

Velocity decreases.

Also called Retardation.

Example:

Applying brakes.



Velocity decreases →

★ Zero Acceleration

Velocity remains constant.

Example:

Car moving at constant speed on highway.



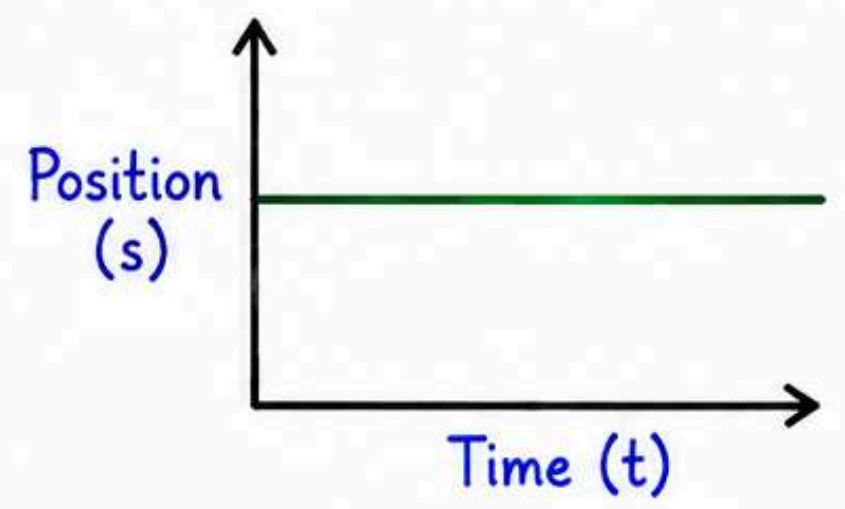
Velocity remains constant →

11. GRAPHICAL REPRESENTATION OF MOTION

Graphs help to understand motion visually.

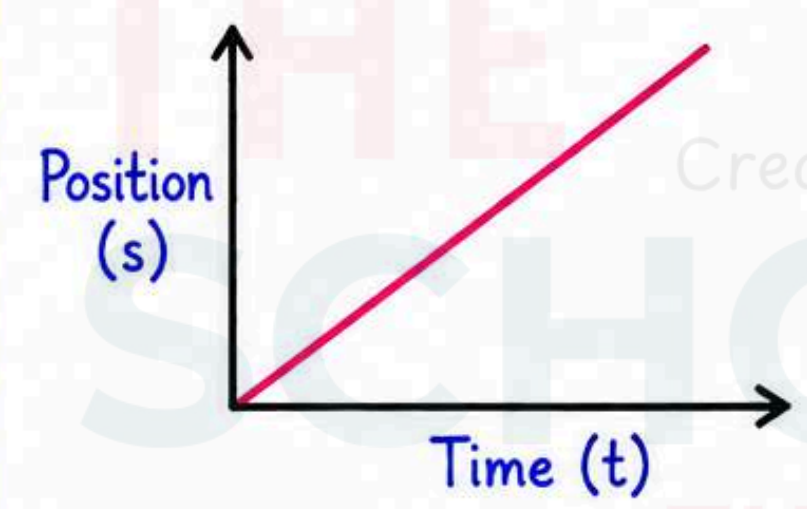
POSITION-TIME GRAPH

Case 1: Object at Rest



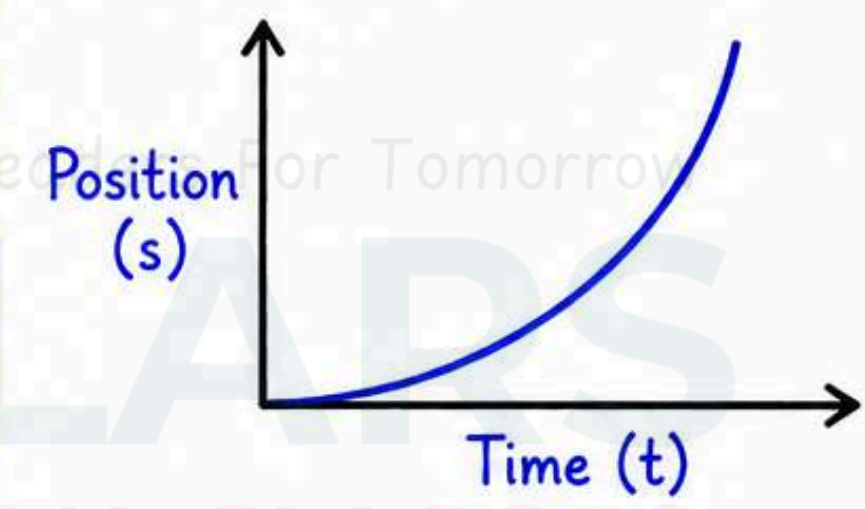
- Horizontal straight line.
- Position remains **constant**.

Case 2: Constant Velocity



- Straight inclined line.
- Slope remains **constant**.

Case 3: Accelerated Motion



- Curved graph.
- Velocity changes **continuously**.

SLOPE OF POSITION-TIME GRAPH

Slope = Velocity



$$\text{Slope} = \frac{\Delta s}{\Delta t}$$

ACCELERATION-TIME (a-t) GRAPH

An **Acceleration-Time Graph** shows how the acceleration of an object changes with time.

X-axis → Time (t)

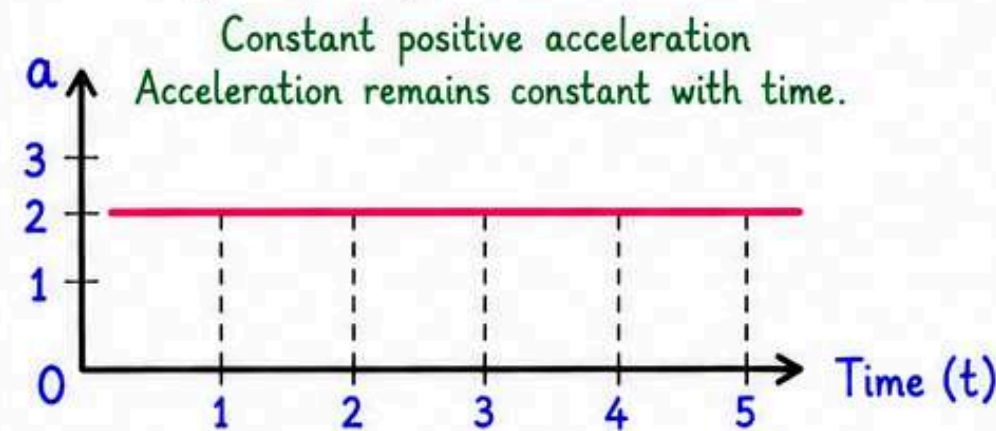
Y-axis → Acceleration (a)

① Constant Positive Acceleration

When acceleration remains constant and positive.

Example:

- A car increases its velocity uniformly.



Important Point

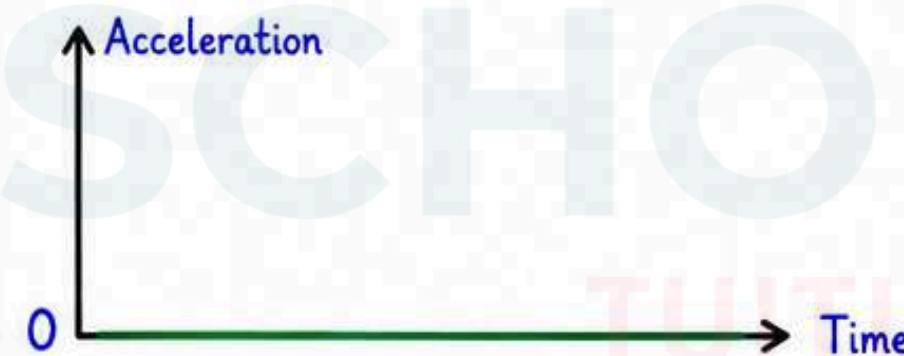
- Graph is a horizontal line above the time axis.
- Velocity **increases** uniformly.

② Zero Acceleration

When acceleration is zero.

Example:

- Car moving with constant velocity.



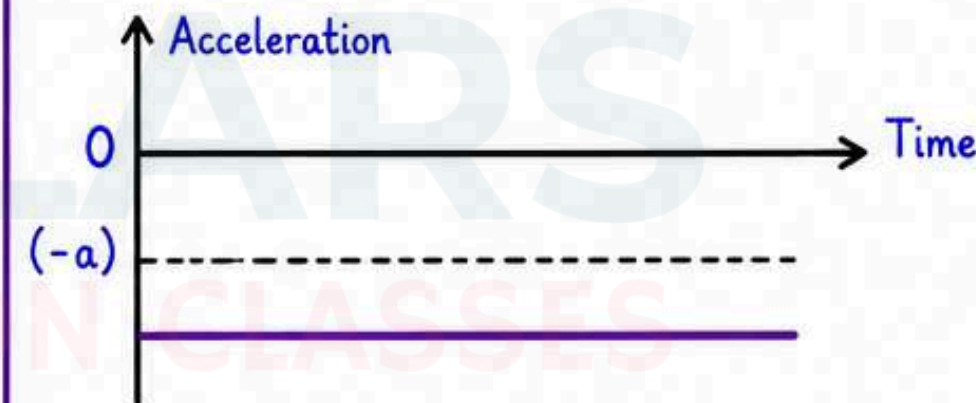
Important Point

- Graph lies on the time axis.
- Velocity **remains** constant.

③ Constant Negative Acceleration (Retardation)

Example:

- Applying brakes to a moving car.



Important Point

- Horizontal line below time axis.
- Velocity **decreases** uniformly.

SLOPE OF ACCELERATION-TIME GRAPH

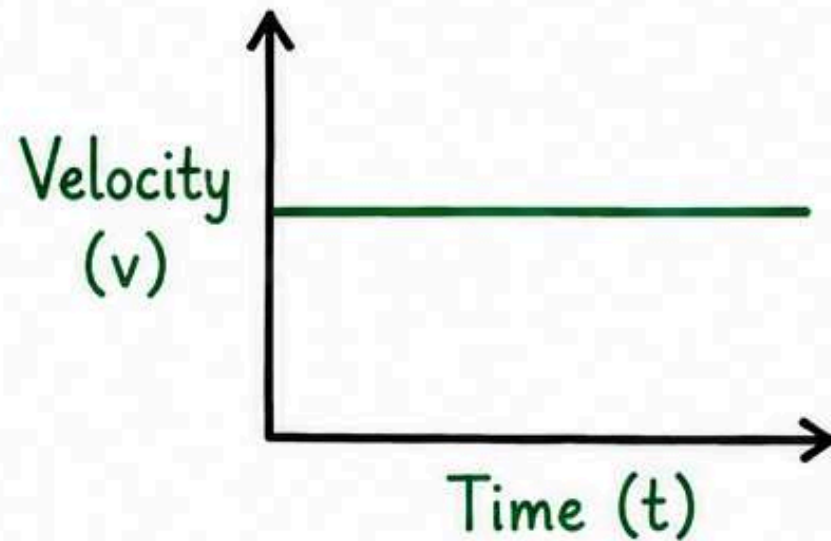
$$\Rightarrow \text{Slope} = \frac{\Delta a}{\Delta t} \Leftarrow$$



VELOCITY-TIME GRAPH

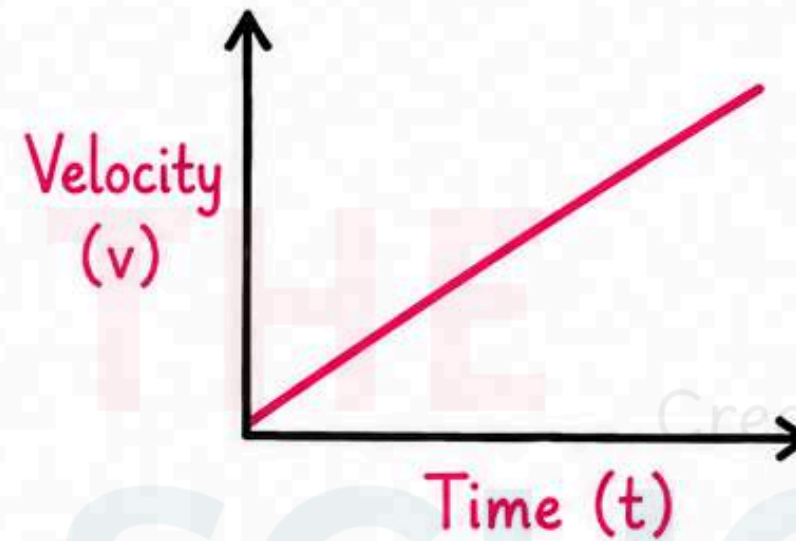


Constant Velocity



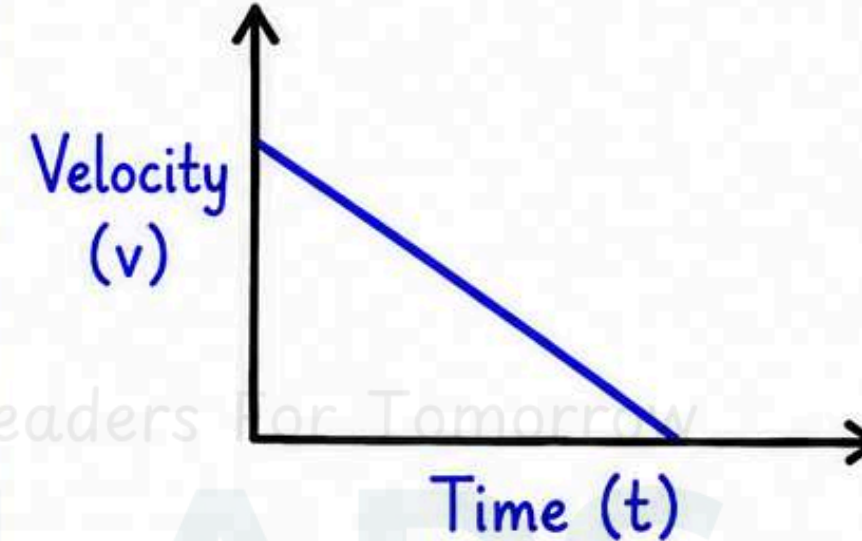
- Horizontal line.
- Acceleration = 0

Uniform Acceleration



- Straight line sloping upward.

Uniform Retardation



- Straight line sloping downward.

SLOPE OF VELOCITY-TIME GRAPH

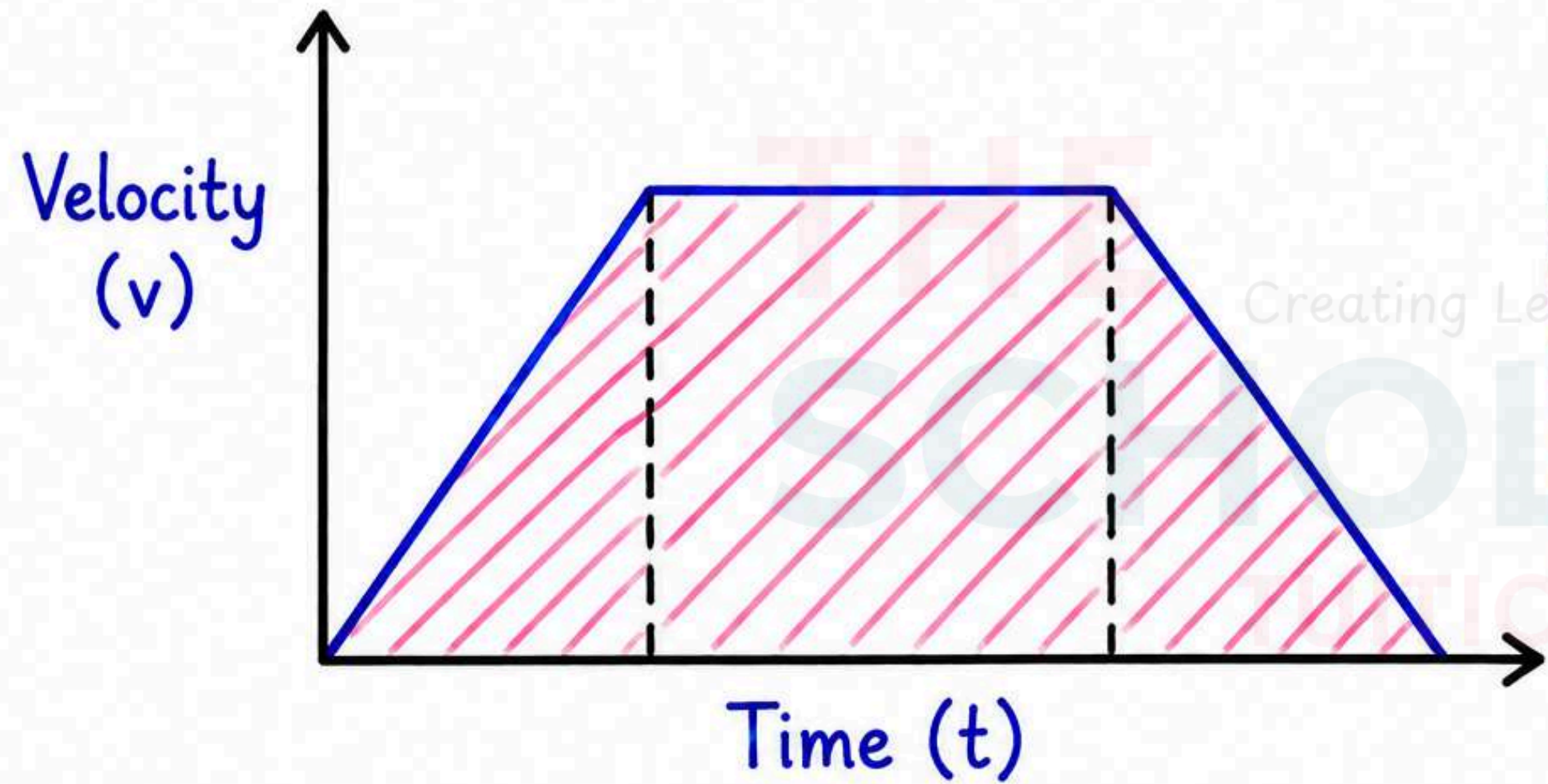
Slope = Acceleration



$$\text{Slope} = \frac{\Delta v}{\Delta t}$$

AREA UNDER VELOCITY-TIME GRAPH

MOST IMPORTANT BOARD QUESTION



Area under V-T graph gives displacement.

$$\text{Displacement} = \text{Area under graph}$$

EQUATION SELECTION TRICK

Given

Use

u, a, t



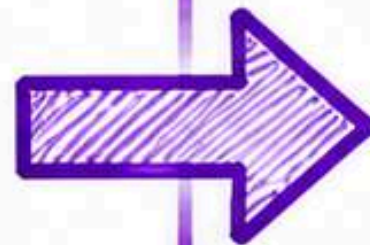
$$v = u + at$$

u, a, t



$$s = ut + \frac{1}{2}at^2$$

u, v, a



$$v^2 = u^2 + 2as$$

13. MOTION IN A PLANE

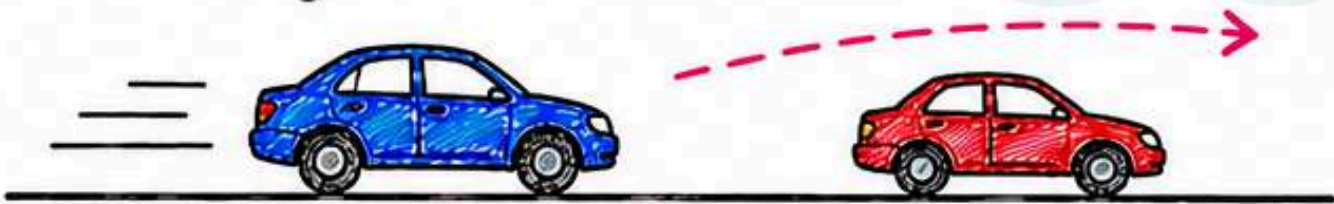
Motion occurring in **two dimensions**.

Examples

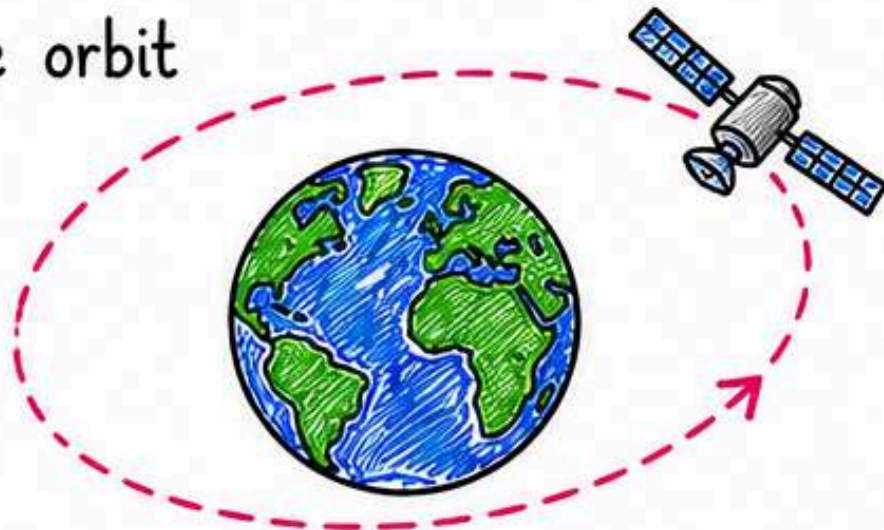
- Kicked football



- Overtaking vehicle



- Satellite orbit



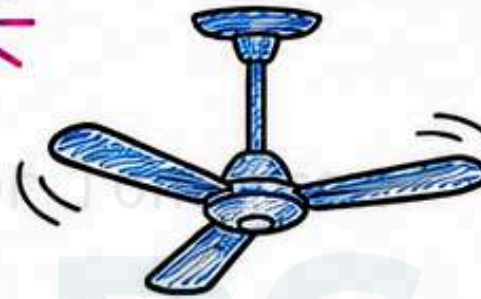
14. UNIFORM CIRCULAR MOTION

Definition

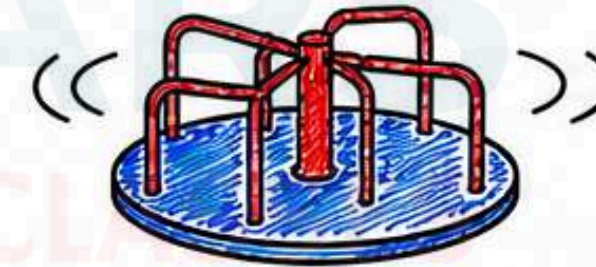
Motion in a circular path with **constant speed**.

Examples

- Ceiling fan



- Merry-go-round



- Earth around Sun



- Satellite around Earth



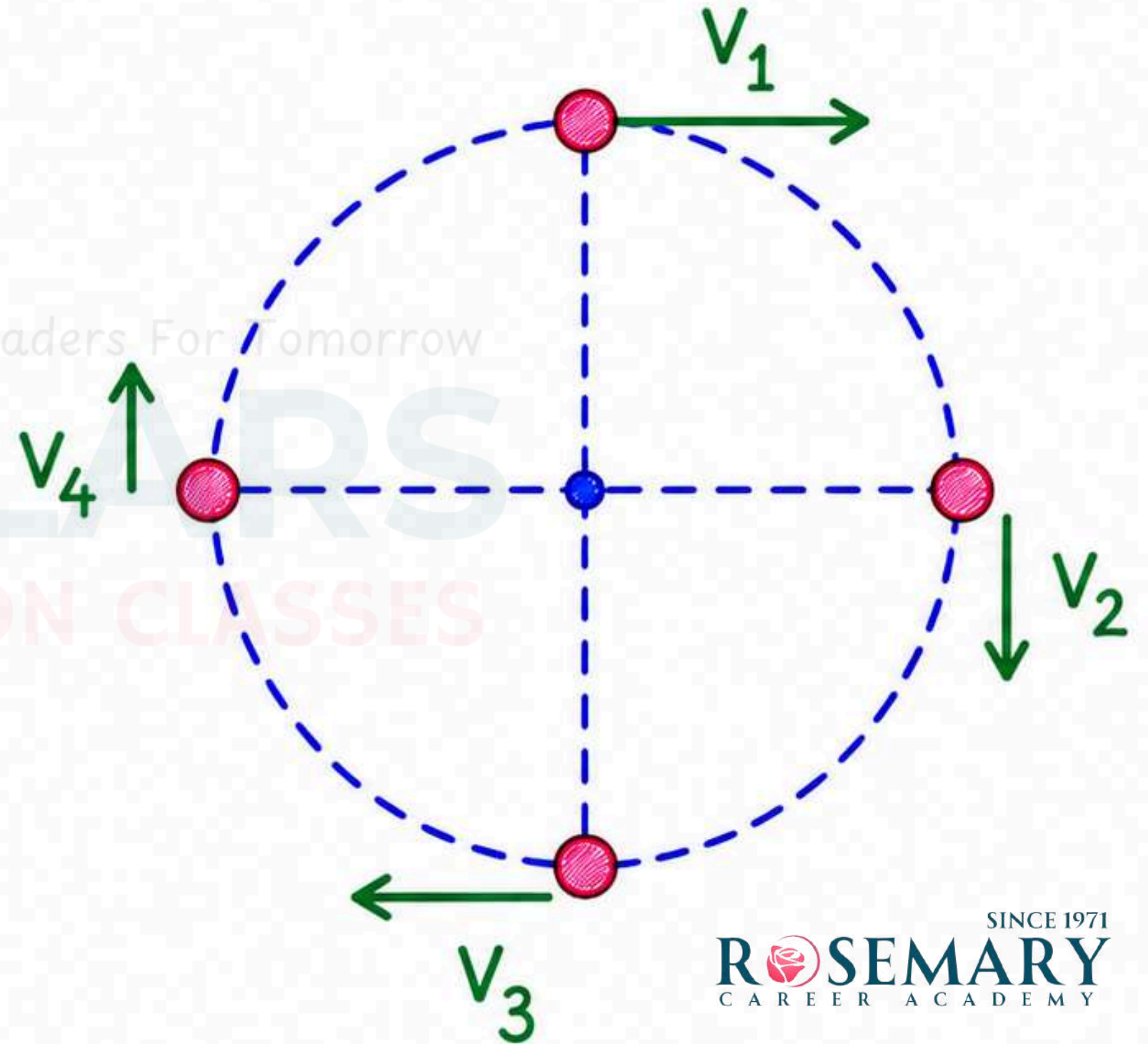
IMPORTANT FACT

- Speed remains constant.
- Velocity changes continuously because direction changes.

Hence,

Acceleration $\neq 0$

Even when speed is constant.

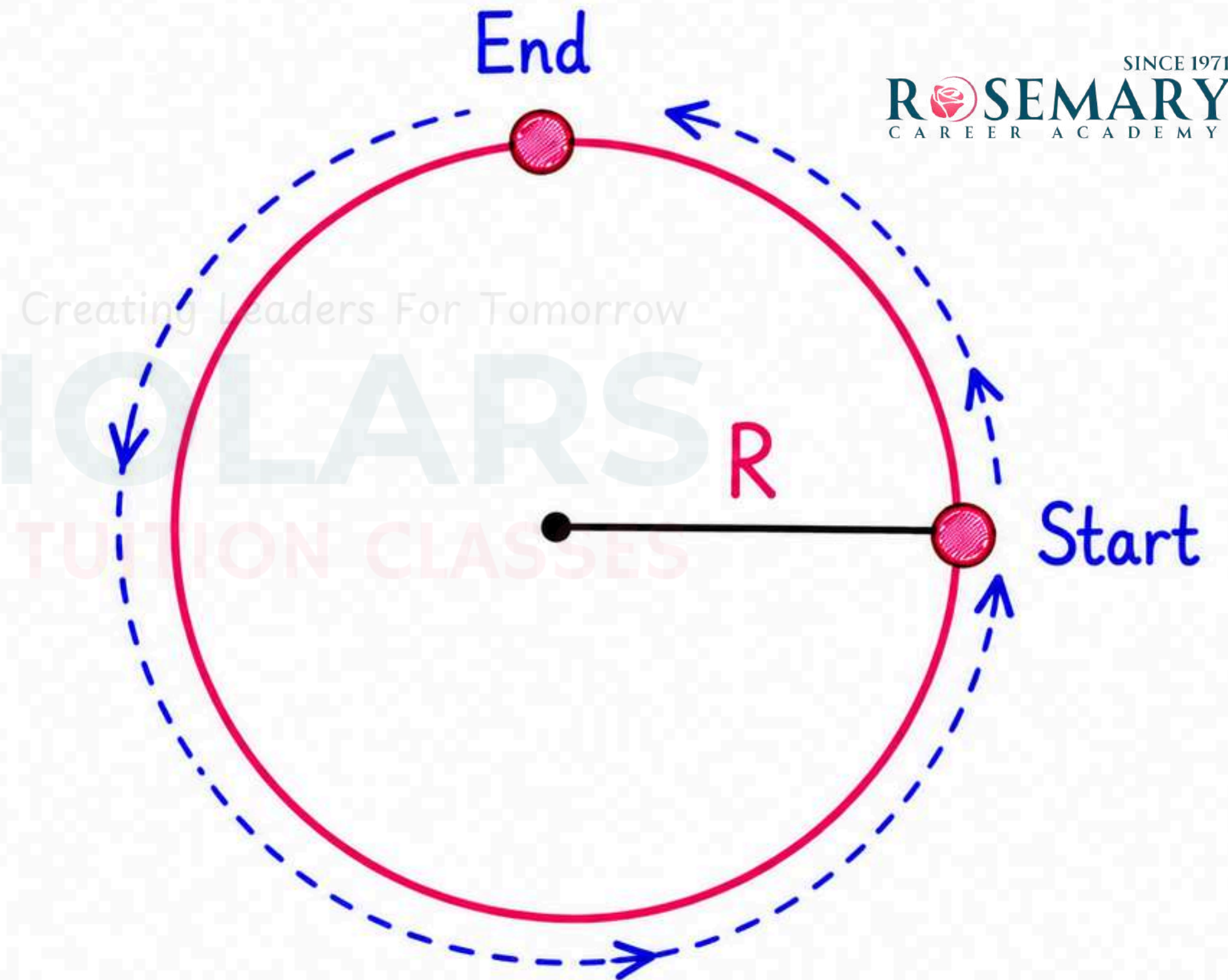


ONE REVOLUTION

Distance travelled:

$$2\pi R$$

Displacement = 0
after one complete
revolution.



1. POSITION & REFERENCE POINT

Position

- Location of an object
- Measured from a reference point



Reference Point

- Fixed point for comparison
- Helps determine motion

Motion

- Change in position with time
- Relative in nature

2. DISTANCE & DISPLACEMENT

Distance

- Total path travelled
- Scalar quantity
- Always positive
- SI Unit → metre (m)



Displacement

- Shortest path between two points
- Vector quantity
- Has direction
- Can be zero
- SI Unit → metre (m)



Key Facts

- Distance ≥ Displacement
- Equal in straight-line motion
- Round trip → Displacement = 0

3. SPEED

Definition

- Distance travelled per unit time

Formula

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Unit

- m/s
- km/h



Uniform Speed

- Equal distances in equal intervals



Non-uniform Speed

- Unequal distances in equal intervals



4. VELOCITY

Definition

- Displacement per unit time

Formula

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

Vector Quantity

Average Velocity

$$\text{Average Velocity} = \frac{\text{Total Displacement}}{\text{Total Time}}$$

Difference from Speed

- Speed → Scalar
- Velocity → Vector

5. ACCELERATION

Definition

- Rate of change of velocity

Formula

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

Unit

- m/s²

Types

Positive Acceleration

- Velocity increases



Negative Acceleration

- Retardation
- Velocity decreases



Zero Acceleration

- Constant velocity



Free Fall

- $g = 9.8 \text{ m/s}^2$



SUPER REVISION BOX

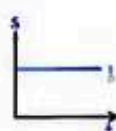
- MOTION
- Distance
- Displacement
- Speed
- Velocity
- Acceleration
- Position-Time Graph
- Velocity-Time Graph
- Acceleration-Time Graph
- Equations of Motion
- Motion in a Plane
- Uniform Circular Motion
- Distance = $2\pi R$
- Displacement = 0 (One Revolution)
- Slope of P-T Graph = Velocity
- Slope of V-T Graph = Acceleration
- Area under V-T Graph = Displacement
- Area under A-T Graph = Change in Velocity
- $v = u + at$
- $s = ut + \frac{1}{2}at^2$
- $v^2 = u^2 + 2as$

MOTION

6. GRAPHICAL REPRESENTATION OF MOTION

Position-Time Graph

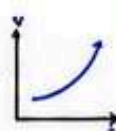
- Horizontal Line
 - Object at rest



- Straight Line
 - Uniform velocity



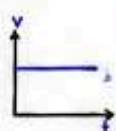
- Curved Line
 - Accelerated motion



- Slope = Velocity

Velocity-Time Graph

- Horizontal Line
 - Constant velocity



- Upward Slope
 - Positive acceleration



- Downward Slope
 - Negative acceleration



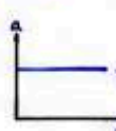
- Slope = Acceleration

- Area Under Graph
 - Displacement

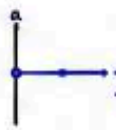


Acceleration-Time Graph

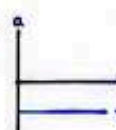
- Horizontal Above Axis
 - Constant positive acceleration



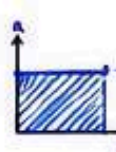
- On X-axis
 - Zero acceleration



- Horizontal Below Axis
 - Retardation



- Area Under Graph
 - Change in velocity



7. EQUATIONS OF MOTION

First Equation

$$v = u + at$$

Second Equation

$$s = ut + \frac{1}{2}at^2$$

Third Equation

$$v^2 = u^2 + 2as$$

Variables

- u = Initial Velocity
- v = Final Velocity
- a = Acceleration
- t = Time
- s = Displacement

Condition

- Applicable only for constant acceleration

8. MOTION IN A PLANE

Two-dimensional Motion

Examples

- Football trajectory
- Satellite motion
- Overtaking vehicle
- Projectile motion

9. UNIFORM CIRCULAR MOTION

Definition

- Motion in a circular path with constant speed

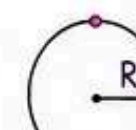
Examples

- Ceiling fan
- Merry-go-round
- Earth around Sun
- Satellite around Earth



One Revolution

- Distance = $2\pi R$
- Displacement = 0



Average Speed

$$2\pi R / T$$

Average Velocity

- Zero (for one complete revolution)

Important Concept

- Speed remains constant
- Direction changes continuously
- Velocity changes continuously
- Acceleration is always present