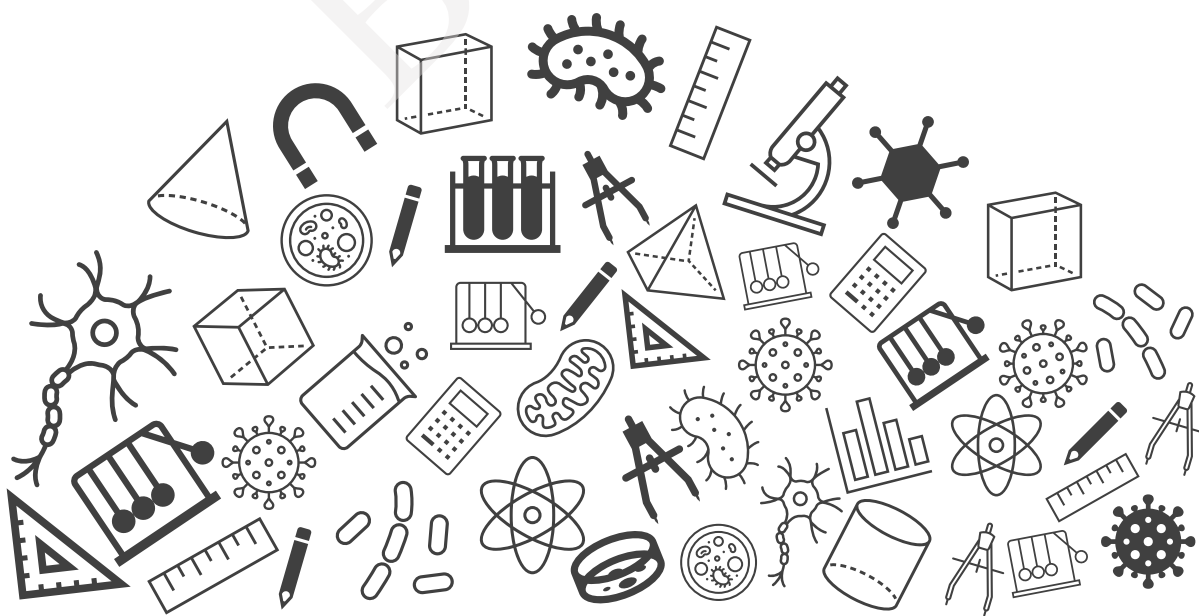




# Grade 09

## Science Chapter Notes



# BYJU'S Classes

## Chapter Notes



# Motion

## Class 9



# Motion

## 1. Understanding motion

- Rest and motion
- Distance & displacement
- Speed & Velocity
- Acceleration

## 2. Visualizing motion

- Distance-time graph
- Velocity-time graph

## 3. Equations of motion

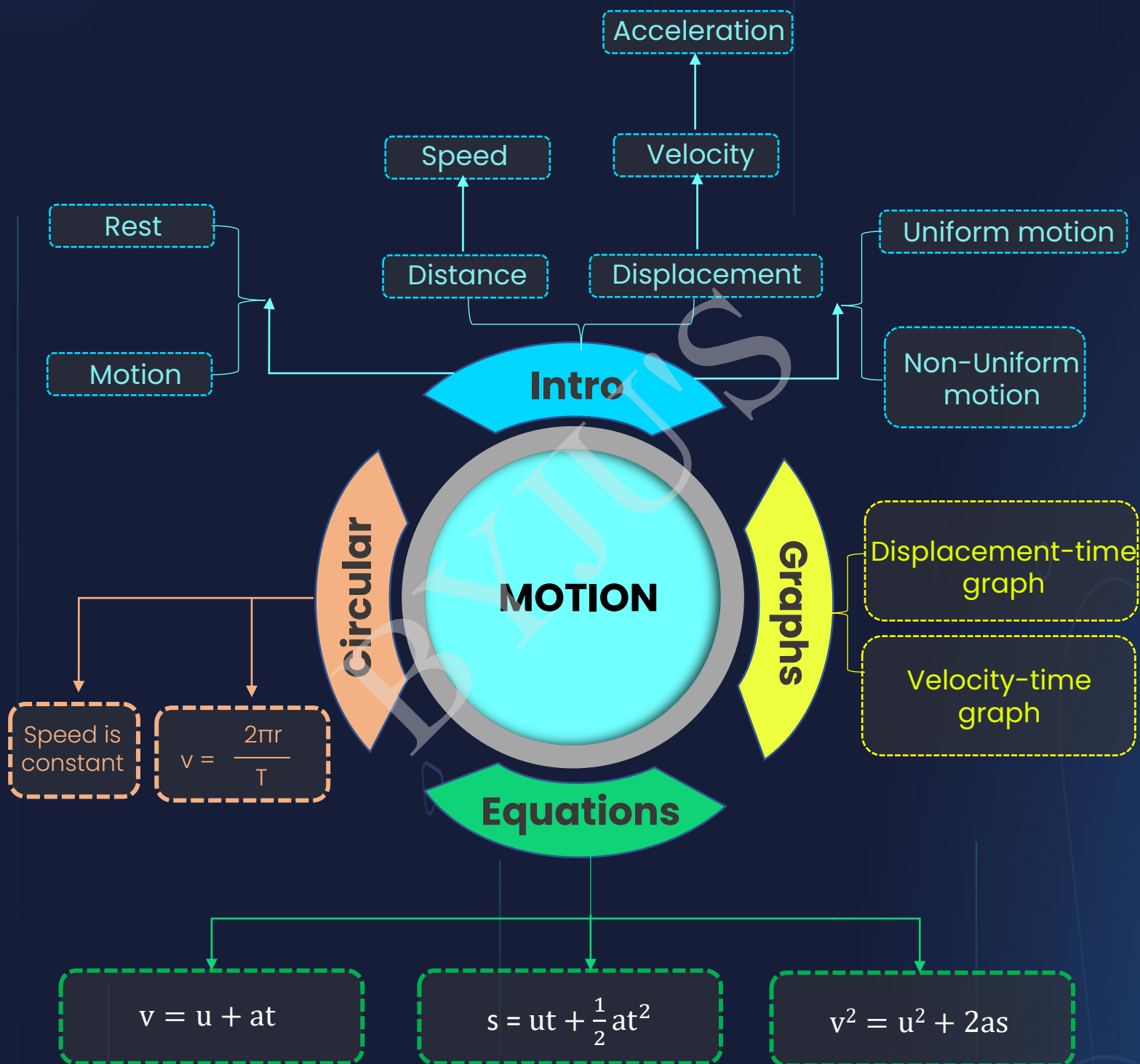
- First equation
- Second equation
- Third equation

## 4. Motion in 2D

- Uniform Circular Motion



# MIND MAP



# 1. Understanding Motion

## 1.1 Rest and Motion



Rest



- Rest is when position of an object **doesn't change** w.r.t the observer



Motion

- Motion is when position of an object **changes** w.r.t the observer



Frame of reference

- State of motion or rest **depends on the observer**

Outside view



- Passengers are in motion

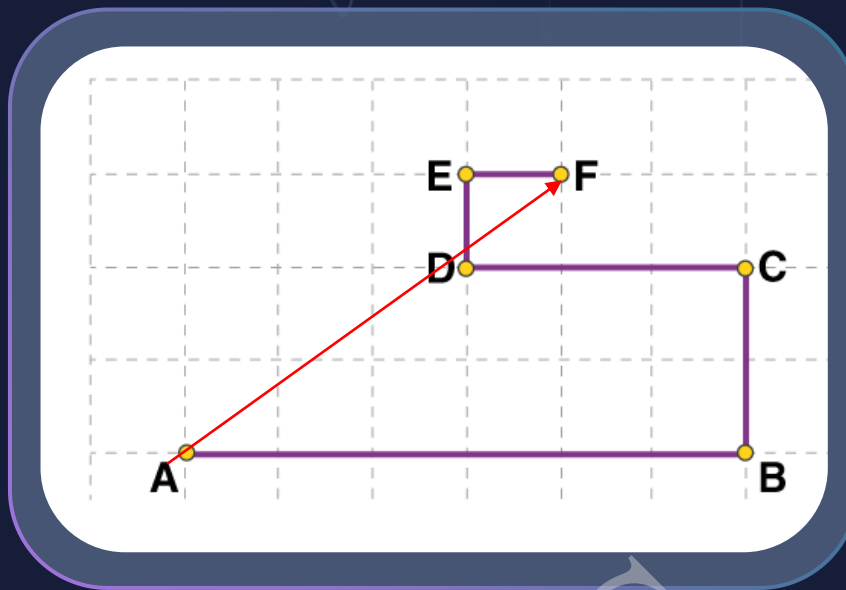
Inside view



- Passengers are at rest



## 1.2 Distance and Displacement



### Distance

- The complete length of the path between any two points is called **distance**

$$AB + BC + CD + DE + EF$$

- Distance has magnitude but no direction

Scalar quantity

- Distance can be only positive

### Displacement

- Displacement** is the shortest/minimum length between any two points

AF

- Displacement has both magnitude and direction

Vector quantity

- Displacement can be positive, negative, zero



## 1.3 Speed and Velocity



### Speed

- Speed is the **rate of change of distance**.
- SI unit: **m/s**



$$\text{Average Speed} = \frac{\text{Total distance}}{\text{Total time}}$$

- Scalar quantity – Only magnitude



### Velocity

- Velocity is **rate of change of displacement**
- SI unit: **m/s**



$$\text{Average Velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

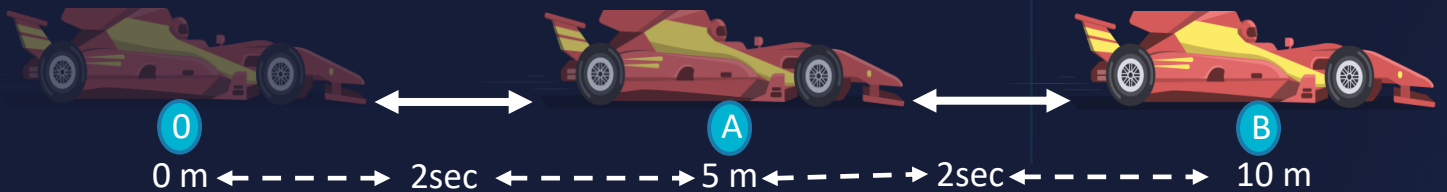
- Vector quantity – Both magnitude and direction



## 1.4 Uniform and Non-uniform motion



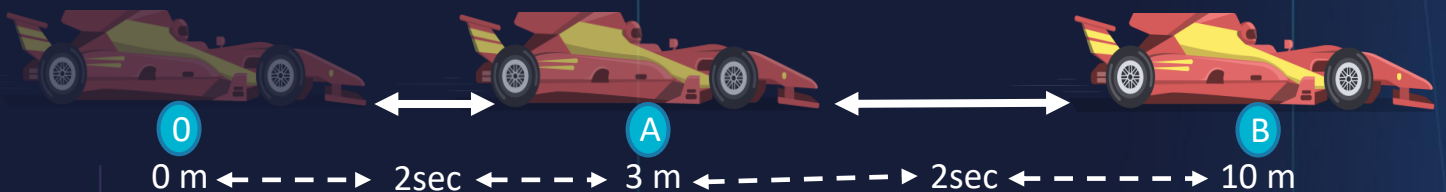
### Uniform Motion



- When object travels equal distances in equal intervals of time
- Speed is constant



### Non-uniform Motion



- When object travels unequal distances in equal intervals of time
- Speed is changing



## 1.5 Acceleration



### Acceleration



- Acceleration is rate of change of velocity
- SI unit:  $ms^{-2}$
- Acceleration =  $\frac{\text{Change in velocity}}{\text{Time}}$

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



### Positive Acceleration

- Increase in velocity with time



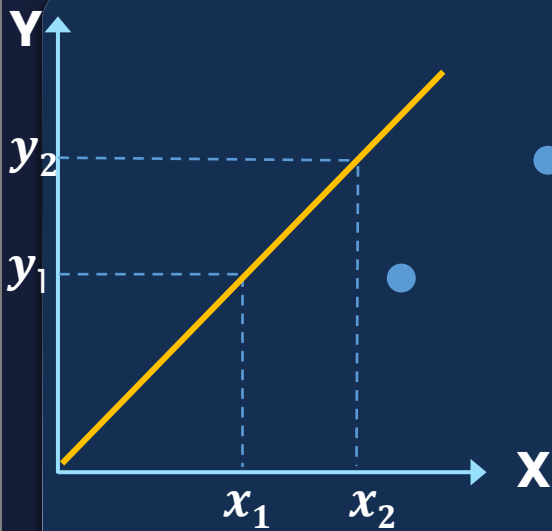
### Negative Acceleration

- Decrease in velocity with time



## 2. Visualizing Motion

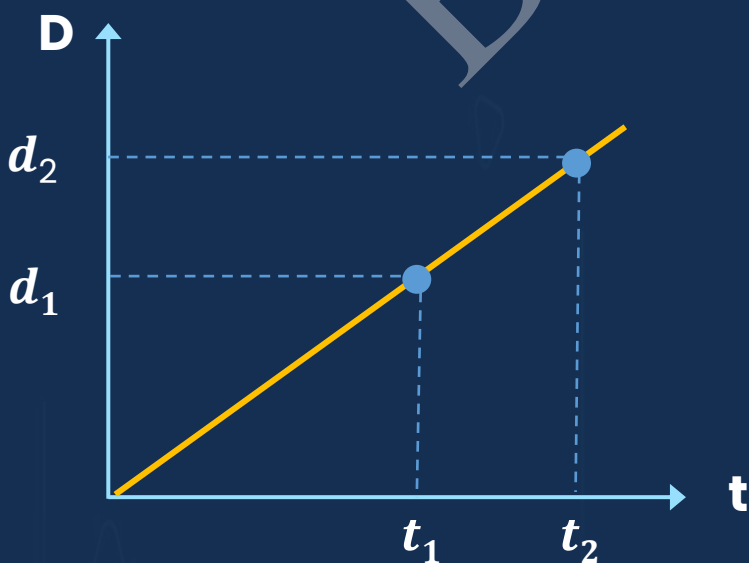
### 2.1 Slope of a Graph



$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1}$$



### Distance – Time Graph



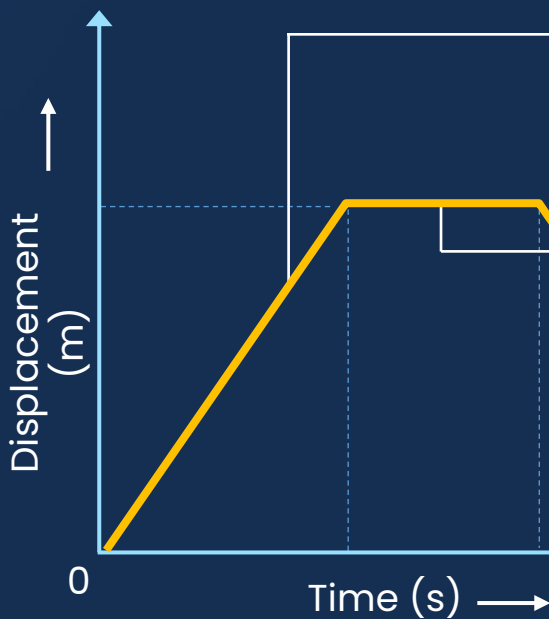
$$\text{Slope} = \frac{d_2 - d_1}{t_2 - t_1}$$

$$\text{Slope} = \frac{\text{distance}}{\text{time}}$$

Slope (m) of the distance – time graph gives **speed**.



## 2.2 Displacement-Time Graph



• Slope is **positive**:  
Velocity is constant and **increasing**

• Slope is **zero**:  
Velocity is **zero**

• Slope is **negative**:  
Velocity is constant and **decreasing**.

### NOTE:

Slope of distance-time graph can never be negative. During motion, distance covered will either be constant or will increase but it never decreases.



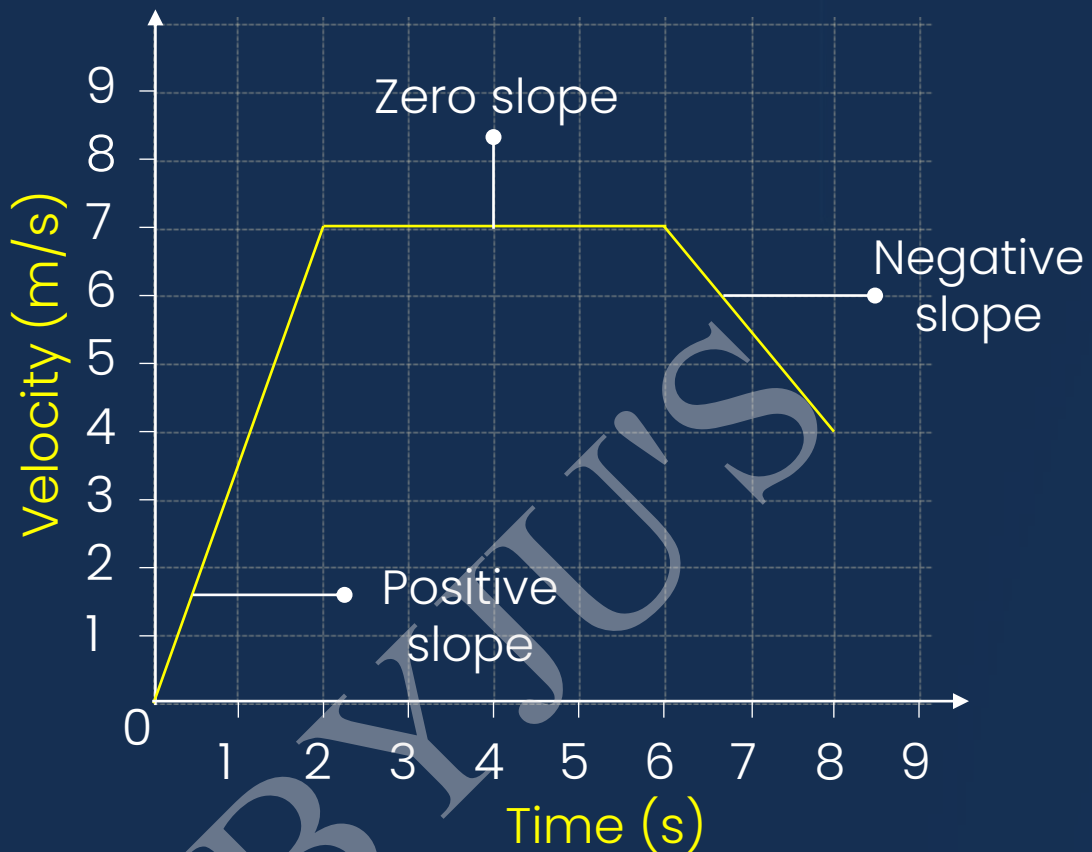
The slope of the displacement – time graph represents \_\_\_\_\_ of an object.



The slope of the displacement – time graph represents velocity of an object since velocity is change in displacement per unit time.



## 2.3. Velocity-Time Graph



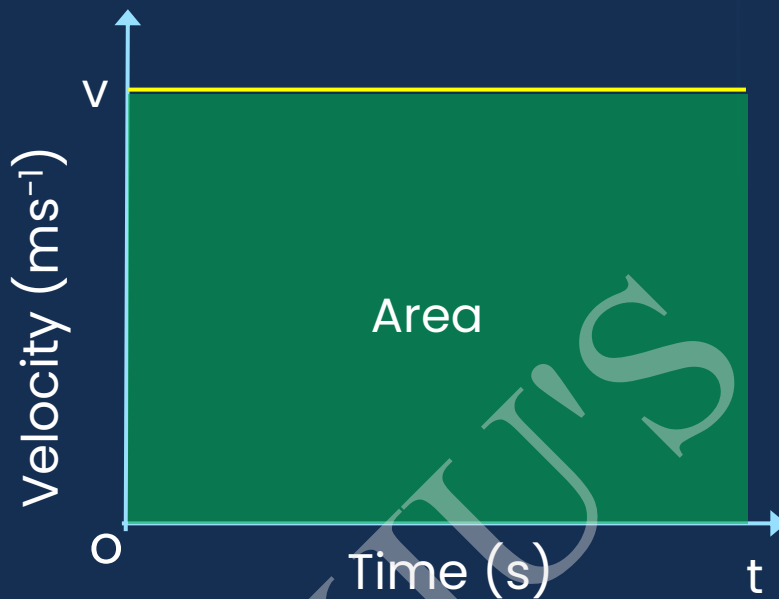
$$\text{Slope} = \frac{\text{change in velocity } (\Delta v)}{\text{change in time } (\Delta t)} = \text{acceleration } (\text{m/s}^2)$$

Slope is **zero** → zero acceleration

Slope is **negative** → Negative acceleration

Slope is **positive** → Positive acceleration

## 2.4. Area under Velocity-Time Graph



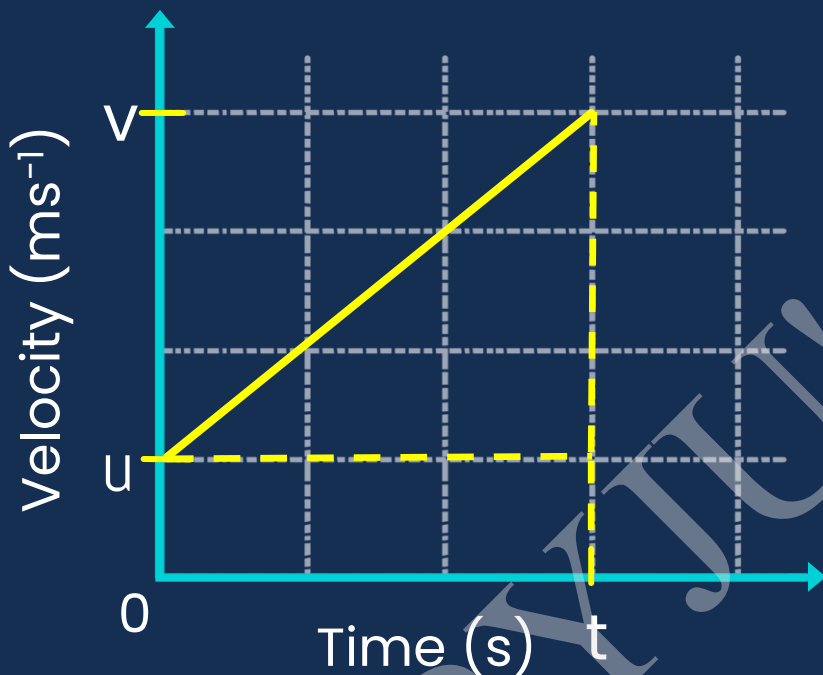
- Area under v-t graph gives **displacement**
- $\text{Velocity}(v) = \frac{\text{Displacement}}{\text{time}}$

$$\text{Displacement}(s) = (v) \times (t)$$



### 3. Equations of Motion

#### 3.1 First Equation of Motion



- $v$  Final velocity
- $u$  Initial velocity
- $a$  Acceleration
- $t$  Time taken

Slope of v-t graph gives us acceleration  $a$

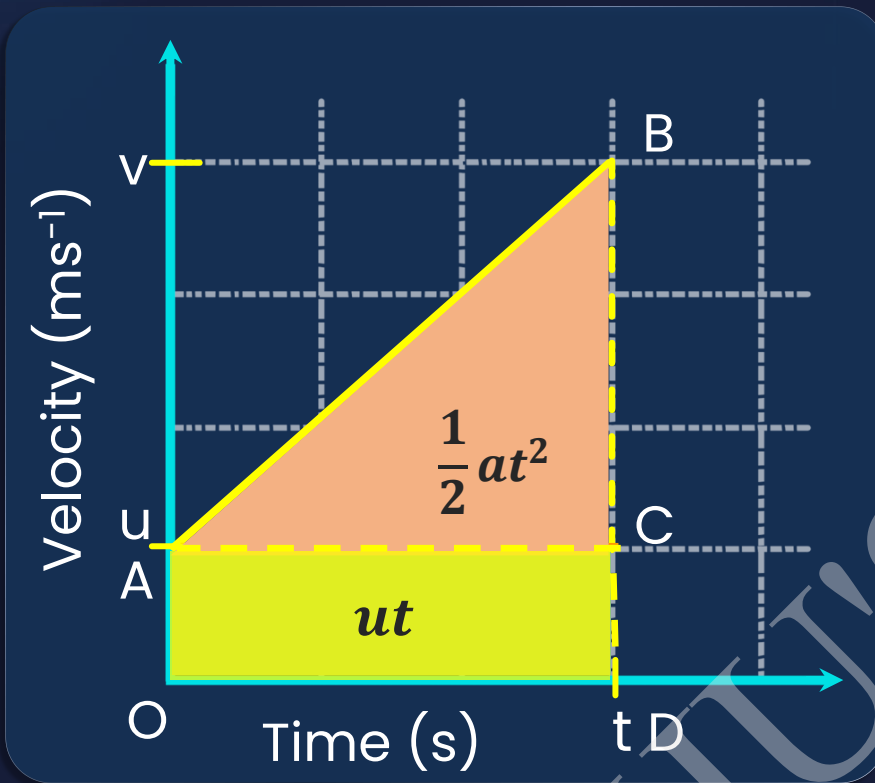
$$\text{Slope } (a) = \frac{\text{Change in velocity}}{\text{Time taken}}$$

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

$$v = u + at$$



## 3.2 Second Equation of Motion



- $v$  Final velocity
- $u$  Initial velocity
- $a$  Acceleration
- $s$  Displacement
- $t$  Time taken

$$\text{Area (s)} = (OD \times DC) + \left( \frac{1}{2} \times BC \times AC \right)$$

$$\text{Area (s)} = (u \times t) + \frac{1}{2} \times (v - u) \times t$$

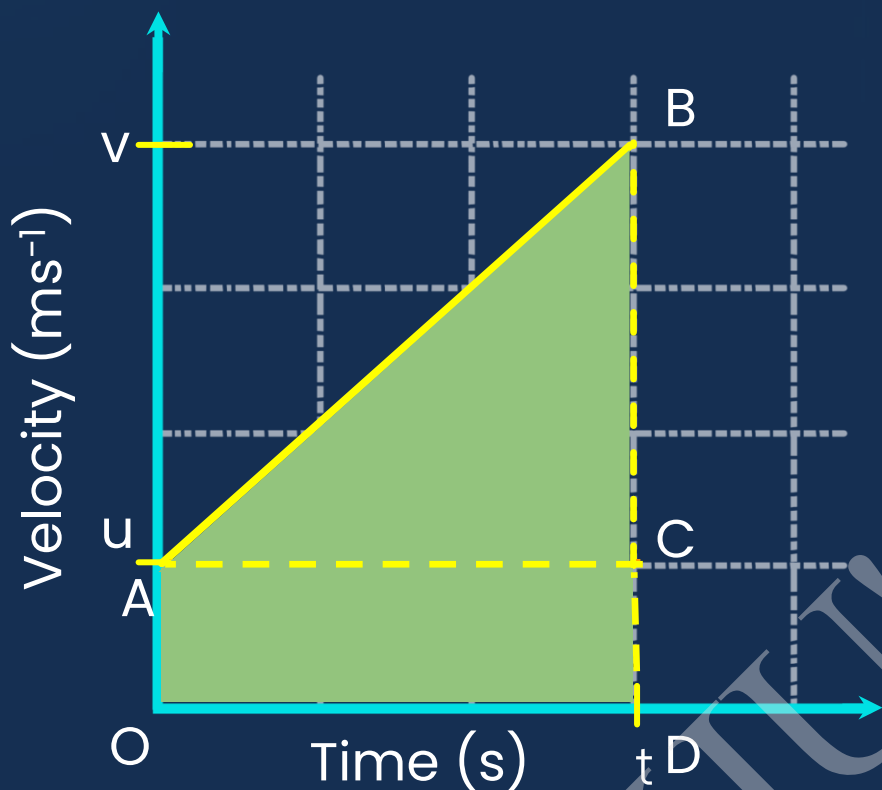
We know  $v = u + at$  or,  $v - u = at$

By substituting  $v - u = at$ ,

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



### 3.3 Third Equation of Motion



- $v$  Final velocity
- $u$  Initial velocity
- $a$  Acceleration
- $s$  Displacement
- $t$  Time taken

$s = \text{Area under trapezium } OABD$

$$s = \frac{1}{2} (\text{Sum of parallel sides})(\text{Height})$$

$$s = \frac{1}{2} (v + u)(t)$$

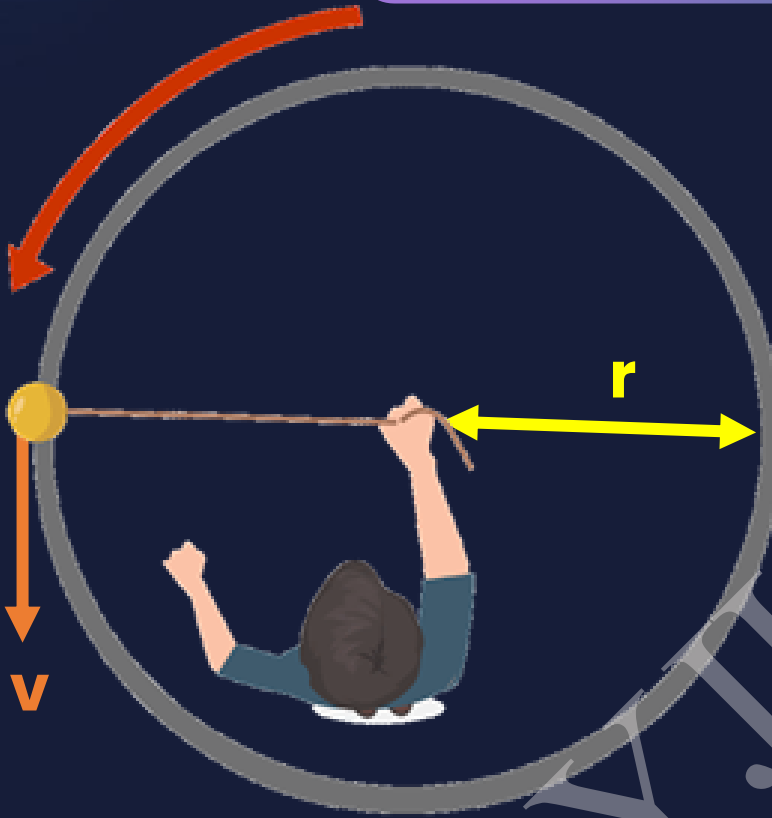
We know  $v = u + at$  or  $t = (v - u)/a$

$$s = \frac{1}{2} (v + u) \frac{(v - u)}{a} \Rightarrow 2as = v^2 - u^2$$

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

## 4. Motion in 2D

### 4.1 Uniform Circular Motion



- Speed is constant
- Velocity changes

- Uniform Circular motion is an accelerated motion.
- Velocity is directed tangentially at all points.

$$\text{Speed} = v = \frac{2\pi r}{T}$$

# Formula Sheet

1

SPEED

$$\text{Average Speed} = \frac{\text{Total distance}}{\text{Total time}}$$

2

VELOCITY

$$\text{Average Velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

3

ACCELERATION

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

4

EQUATIONS OF MOTION

$$v = u + at$$

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

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

