

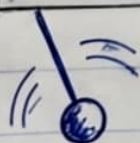


Introduction:

- What is motion? → Motion is the change in the position of an object with respect to its surroundings over time.
- Reference point:
 - A fixed place/object used to determine if something is moving. Motion is always described relative to a reference point.
- Example:
 - Our school is 2km north of the railway station.
 - Here, the railway station is the reference point to locate the school.
- Perception of Motion:
 - Motion can be felt differently depending on the observer.
 - Example: Passengers sitting inside a moving bus feel that trees, houses, and poles outside are moving backwards.
 - But in reality, the bus is moving forward! ★

Types of Motion:

Types of Motion	Definition	Example
Circular →	Object moves along a circular path	→ Movement of Earth around the Sun, ceiling fan blades
Linear →	Object moves along a straight line path	→ A car moving on a straight road, a soldier marching
Oscillatory →	Object moves to and fro about a fixed point	→ Swinging of pendulum, vibrating guitar string



pendulum → oscillatory

Note: Motion is relative!

Handwritten notes — Page 2

Distance and Displacement

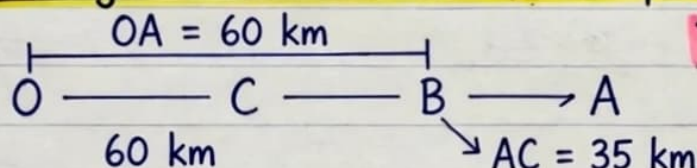
• Definition of Scalar and Vector

- Scalar $\rightarrow$ Quantity with magnitude only. (No direction)
- Vector $\rightarrow$ Quantity with magnitude + direction.

• Distance = actual path length $\rightarrow$ Scalar quantity

• Displacement = shortest straight line (from initial to final point) $\rightarrow$ Vector quantity

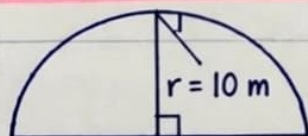
1. Straight Line Motion — Example



$$\text{Total Distance} = 60 \text{ km} + 35 \text{ km} = 95 \text{ km}$$

Displacement = 60 km from O to A
(straight line to the right) $\rightarrow$ 60 km East

2. Semicircle Motion — Example

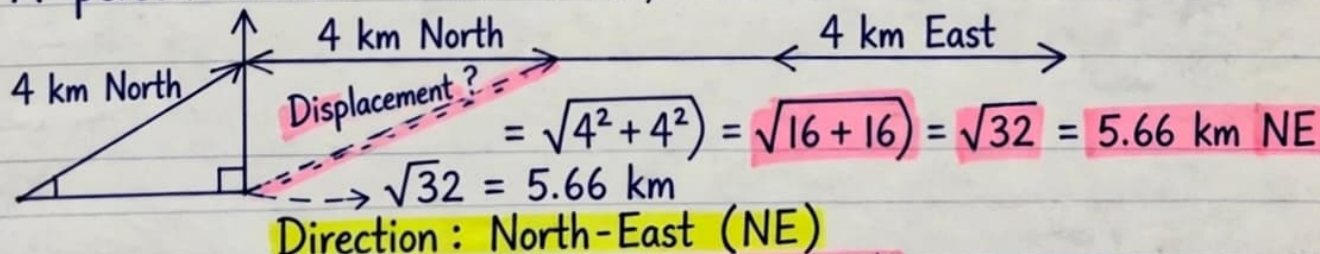


$$\text{Diameter} = 2r = 20 \text{ m}$$

- Distance = half the circumference = $\pi r = \pi \times 10 = 3.14 \times 10 = 31.4 \text{ m}$
- Displacement = Diameter = $2 \times 10 = 20 \text{ m}$ (straight line)
(from one end of semicircle to the other)

3. Example 2 — Right Triangle Motion

A person travels 4 km North, then 4 km East



Key Formula: Displacement = $\sqrt{\Delta x^2 + \Delta y^2}$ [Pythagoras]

★ Scalar = only magnitude | Vector = magnitude + direction ★

Page 3 - Speed and Velocity

• Speed = distance / time

• velocity = displacement / time

(Speed is scalar $\rightarrow$ only magnitude. Velocity is vector $\rightarrow$ magnitude + direction)

Uniform & Non-uniform Motion

- Uniform motion: Object moves with constant speed, travels equal distance in equal time intervals. Example: Car moving at 50 km/h in straight line.
- Non-uniform motion: Speed changes, object covers unequal distances in equal time intervals. Example: Car moving in traffic — speed increases/decreases.

Average Speed = total distance / total time

Used when object moves at different speeds over journey.

Conversion: km/hr $\rightarrow$ m/s

To convert km/hr to m/s, multiply by $\frac{5}{18}$ $\times \frac{5}{18} *$

* Reason: 1 km = 1000 m, 1 hr = 3600 s $\rightarrow 1000/3600 = \frac{5}{18}$

Solved Examples

1) 40 km in 5 hrs = ? km/hr = ? m/s

$\rightarrow$ Speed = $\frac{40 \text{ km}}{5 \text{ hrs}} = 8 \text{ km/hr}$

Now convert to m/s: $8 \times \frac{5}{18} = \frac{40}{18} = 2.22 \text{ m/s}$

2) Two equal distances: speed 40 km/hr & 20 km/hr $\rightarrow$ find average speed

Formula for equal distances: avg speed = $2v_1v_2$

$= 2 \times 40 \times 20 \div (40 + 20) = \frac{1600}{60} = 26.67 \text{ km/hr}$

3) 20 km + 40 km + 30 km in 3 hrs $\rightarrow$ average speed?

Total distance = 20 + 40 + 30 = 90 km

Total time = 3 hrs

Avg speed = $\frac{90}{3} = 30 \text{ km/hr}$

Vector vs Scalar — Comparison Table

Property	Scalar	Vector
Definition	Only magnitude	Magnitude + direction
Example	Speed, Distance, Time	Velocity, Displacement, Acceleration
Follows	Normal algebra	Vector addition (direction matters)

* Note: Velocity can be zero even if speed is not, if displacement is zero (e.g., round trip). ★

Heading: Acceleration and Retardation

• Definition: $a = (v - u) / t$

(where a = acceleration, v = final velocity, u = initial velocity, t = time)

► **Positive Acceleration** → when $v > u$

Example: Car accelerates from 40 to 60 km/hr in 5 sec = 1.11 m/s^2

Steps:

Step 1: Convert km/h → m/s

$$40 \text{ km/h} = \frac{40 \times 1000}{3600} = 11.11 \text{ m/s}$$

$$60 \text{ km/h} = \frac{60 \times 1000}{3600} = 16.67 \text{ m/s}$$

$$\text{Change in velocity, } v - u = 16.67 - 11.11 = 5.56 \text{ m/s}$$

$$\text{Time, } t = 5 \text{ sec}$$

$$a = \frac{5.56}{5} = 1.11 \text{ m/s}^2 \quad \checkmark \rightarrow$$

► **Retardation (Deceleration)** → when $v < u$ → **negative**

Example: Car slows from 20 km/hr to rest in 0.5 hr = -40 km/hr^2

Steps:

$$\text{Change in velocity, } v - u = 0 - 20 = -40 \text{ km/hr}^2$$

$$\text{Time, } t = 0.5 \text{ hr}$$

(negative sign shows slowing down / retardation)

► **Types of Non-Uniform Motion:**

• **Accelerated Motion** — speed increases with time

→ positive acceleration

• **Decelerated Motion** — speed decreases with time

→ negative acceleration (retardation)



Tip: Always check units!
Convert to m/s for SI
unit calculation ☆

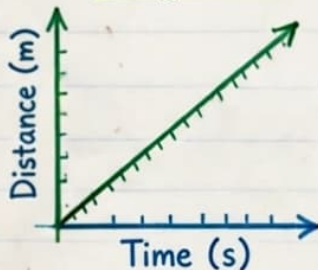
Note: Uniform motion → constant velocity → $a = 0$

Graphical Representation of Motion

A. Distance-Time Graphs

- Plots Distance (y-axis) vs Time (x-axis)

(i) Uniform Motion — Straight Line

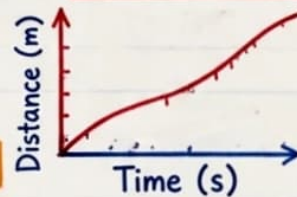


Straight line $\Rightarrow$ constant slope
 $\Rightarrow$ constant velocity

$$\text{Velocity} = \text{slope} = \frac{\Delta \text{Distance}}{\Delta \text{Time}} = \text{constant}$$

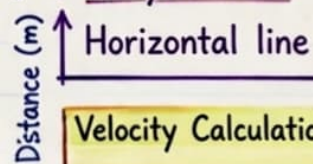
Example: slope = $\frac{10 \text{ m}}{5 \text{ s}} = 2 \text{ m/s}$
 (constant)

(ii) Non-Uniform Motion — Curved Line



Curved Line
 $\Rightarrow$ slope increases
 $\Rightarrow$ velocity increases
 $\Rightarrow$ acceleration
 Not constant velocity - speed changes

(iii) Body at Rest — Horizontal Line



Horizontal line $\Rightarrow$ slope = 0
 $\Rightarrow$ velocity = 0

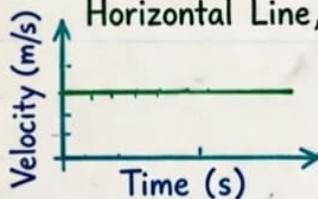
$$\text{Velocity Calculation: } v = \frac{\text{distance}}{\text{time}} = \frac{0}{t} = 0 \text{ m/s}$$

$\therefore$ Body is at rest, no motion

B. Velocity-Time Graphs

- Plots Velocity (y-axis) vs Time (x-axis)

(i) Uniform Motion — Horizontal Line, $a = 0$



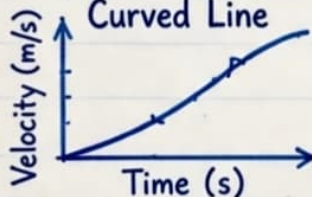
Horizontal line
 $\Rightarrow$ constant velocity
 $\Rightarrow$ acceleration = 0

(ii) Uniformly Accelerated — Straight Inclined Line



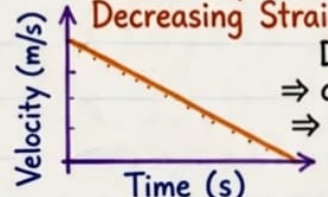
Straight inclined line
 $\Rightarrow$ constant slope
 $\Rightarrow$ constant acceleration
 $a = \text{slope} = \text{constant} > 0$

(iii) Non-Uniformly Accelerated — Curved Line



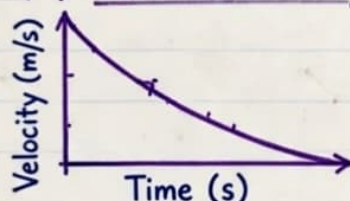
Curved line
 $\Rightarrow$ slope increasing
 $\Rightarrow$ acceleration increasing

(iv) Uniformly Decelerated — Decreasing Straight Line



Downward straight line
 $\Rightarrow$ constant negative slope
 $\Rightarrow$ constant deceleration
 $a = \text{constant} < 0$

(v) Non-Uniformly Decelerated — Curved Decreasing



Curved downward $\Rightarrow$ slope decreasing
 $\Rightarrow$ deceleration decreasing $\Rightarrow$ deceleration

★ **Key Point:** Area under the v-t graph = Displacement

= Area of Trapezium = $\frac{1}{2} \times (v_1 + v_2) \times t$
 where v_1 = initial velocity, v_2 = final velocity, t = time

Example: If $v_1 = 2 \text{ m/s}$, $v_2 = 8 \text{ m/s}$, $t = 4 \text{ s}$
 $\rightarrow$ Area = $\frac{1}{2} \times (2 + 8) \times 4 = \frac{1}{2} \times 10 \times 4 = 20 \text{ m} = 20 \text{ m}$ ✓

Remember:

- ✓ Slope of Distance-Time graph = Velocity
- ✓ Slope of Velocity-Time graph = Acceleration
- ✓ Area under Velocity-Time graph = Displacement