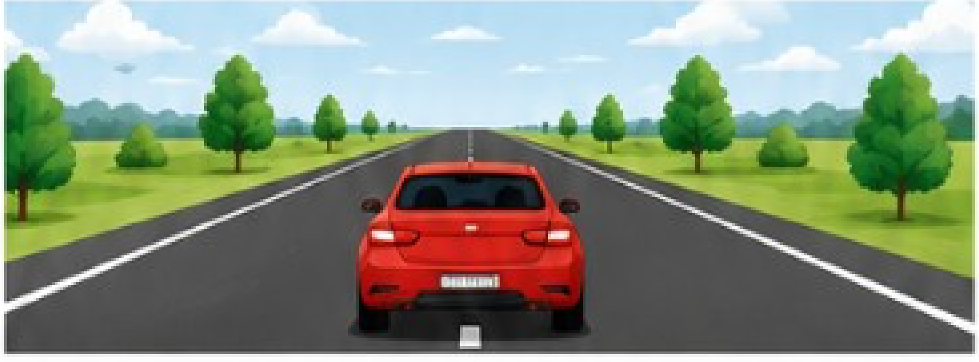
MOTION IN A STRAIGHT LINE – PART 1

Distance, Displacement, Speed & Velocity

1 WHAT IS MOTION IN A STRAIGHT LINE?

Motion along a single straight path is called **rectilinear motion.**



EXAMPLES:

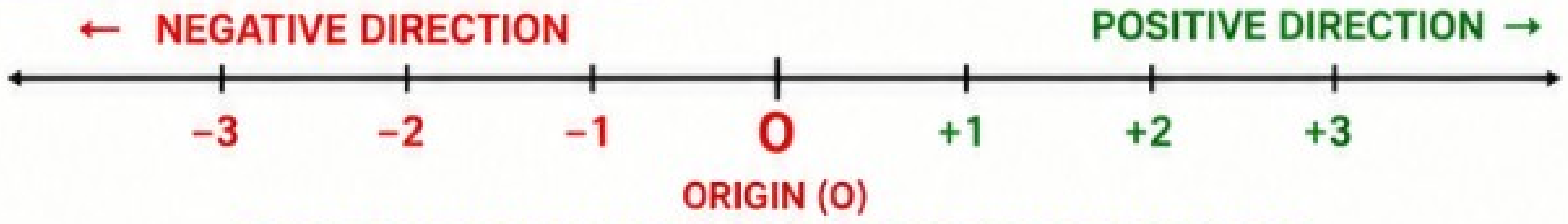
1. Train moving on a straight track

2. Lift moving upward or downward

3. Car moving on a straight road

4. Ball falling vertically downward

2 DIRECTION AND SIGN CONVENTION

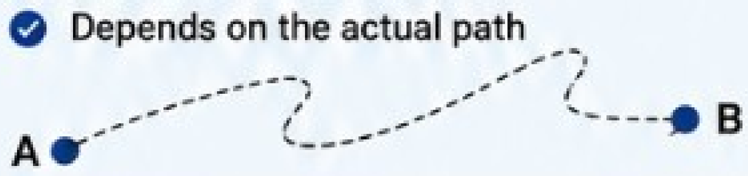


In one-dimensional motion, direction is represented using positive (+) and negative (−) signs.

3 DISTANCE VS DISPLACEMENT

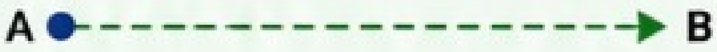
DISTANCE

- Total path length travelled
- Scalar quantity
- Always positive or zero
- Depends on the actual path



DISPLACEMENT

- Change in position
- Vector quantity
- Can be positive, negative or zero
- Depends only on initial and final positions



EXAMPLE:
Walk 4 m east and then 4 m west.

Distance = 8 m

Displacement = 0 m

4 SPEED VS VELOCITY

SPEED = Distance ÷ Time

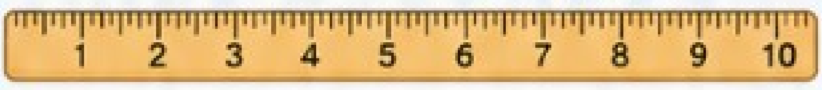
- Scalar quantity
- No direction
- Always positive or zero

VELOCITY = Displacement ÷ Time

- Vector quantity
- Has direction
- Can be positive, negative or zero

5 AVERAGE SPEED

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



6 AVERAGE VELOCITY

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

COMMON MISTAKE: Speed and velocity are NOT the same.

7 IMPORTANT EXAMPLE

A car completes a circular path and returns to its starting point.

Distance ≠ 0

Displacement = 0

EXAM TIP: Always check whether the question asks for DISTANCE or DISPLACEMENT.

MOTION IN A STRAIGHT LINE – PART 2

Acceleration & Equations of Motion

1 ACCELERATION

Acceleration = **Rate of change of velocity**

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

Where:

- u = Initial velocity
- v = Final velocity
- a = Acceleration
- t = Time

t = 0 s	t = 1 s	t = 2 s	t = 3 s
u = 0 m/s	v = 5 m/s	v = 10 m/s	v = 15 m/s

Velocity increases with time →

2 TYPES OF ACCELERATION

POSITIVE ACCELERATION

Velocity increases with time.

0 m/s → 5 m/s → 10 m/s → 15 m/s

Time →

NEGATIVE ACCELERATION (RETARDATION)

Velocity decreases with time.

15 m/s → 10 m/s → 5 m/s → 0 m/s

Time →

ZERO ACCELERATION

Velocity remains constant.

10 m/s → 10 m/s → 10 m/s → 10 m/s

Time →

UNIFORM MOTION

An object covers equal displacements in equal intervals of time.

NON-UNIFORM MOTION

Velocity changes with time.

UNIFORM ACCELERATION

Acceleration remains constant.

⚠ The three equations of motion are valid only for **CONSTANT ACCELERATION.**

3 THREE EQUATIONS OF MOTION

EQUATION 1

$$v = u + at$$

Used when final velocity is required.

EQUATION 2

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

Used when displacement and time are involved.

EQUATION 3

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

Useful when time is not given.

SYMBOLS

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

4 SOLVED NUMERICAL EXAMPLE

QUESTION:

A car starts from rest and accelerates at 2 m/s² for 5 seconds. Find:

1. Final velocity
2. Distance travelled

SOLUTION:

Initial velocity:	$u = 0$ m/s
Acceleration:	$a = 2$ m/s²
Time:	$t = 5$ s

FINAL VELOCITY

$v = u + at$

$v = 0 + (2 \times 5)$

$\boxed{v = 10 \text{ m/s}}$

DISTANCE

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

$s = 0 + \frac{1}{2} \times 2 \times 5^2$

$\boxed{s = 25 \text{ m}}$

FINAL ANSWER:

🏆 Final Velocity = 10 m/s

🏆 Distance Travelled = 25 m

5 COMMON MISTAKES

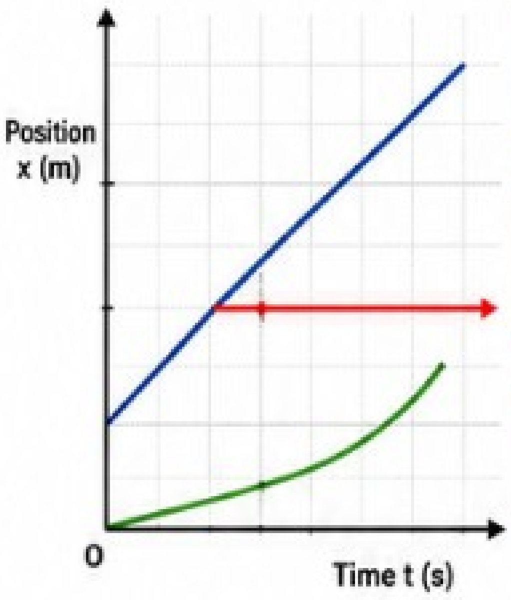
- ✖ Using equations when acceleration is not constant.
- ✖ −1; −10, −5, 0, 5, 10 — Forgetting that displacement can be negative.
- ✖ u → v — Confusing initial velocity u with final velocity v.
- ✖ $\frac{1}{2}at^2$ — Forgetting square on t in $+\frac{1}{2}at^2$.

⭐ **MEMORY TRICK:** If time is missing, try $v^2 = u^2 + 2as$

MOTION IN A STRAIGHT LINE – PART 3

Motion Graphs, Relative Velocity & Exam Questions

1 POSITION–TIME GRAPH



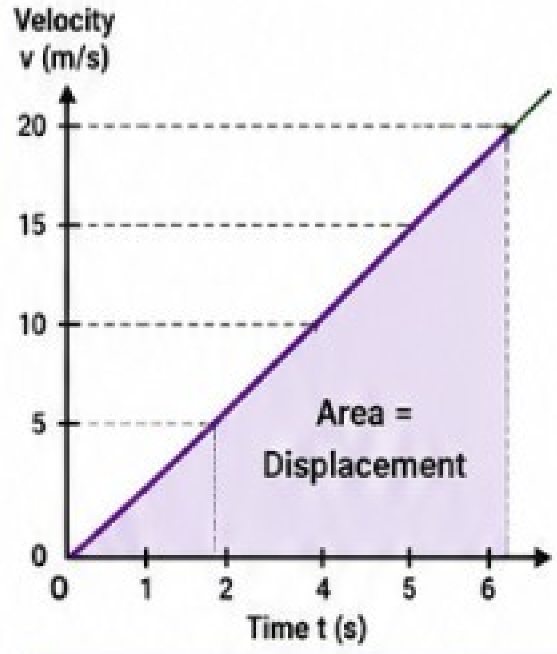
Straight Line
➡ Uniform velocity

Horizontal Line
➡ Object is at rest

Curved Line
➡ Velocity is changing

IMPORTANT FORMULA
Slope of Position–Time Graph = Velocity

2 VELOCITY–TIME GRAPH



Slope of v–t Graph = Acceleration

Area Under v–t Graph = Displacement

Horizontal Line (Constant velocity) = Zero acceleration

A steeper velocity-time graph means **greater acceleration**, not automatically greater velocity.

3 RELATIVE VELOCITY IN A STRAIGHT LINE

$$v_{A\,(\text{relative to } B)} = v_A - v_B$$

SAME DIRECTION

Train A = 60 km/h

Train B = 40 km/h

Relative velocity of A wrt B
= 60 – 40 = 20 km/h

OPPOSITE DIRECTIONS

Train A = 60 km/h

Train B = 40 km/h

Relative velocity of A wrt B
= 60 + 40 = 100 km/h

Always use the correct sign convention for direction.

4 IMPORTANT NCERT-STYLE QUESTION

A body has:
Initial velocity = 5 m/s
Acceleration = 3 m/s²
Time = 4 s
Find distance travelled.

FORMULA

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

CALCULATION

$$s = (5 \times 4) + \frac{1}{2} \times 3 \times 4^2$$
$$s = 20 + 24$$
$$s = 44 \text{ m}$$

Distance = 44 m

5 IMPORTANT EXAM QUESTIONS

1. Derive the three equations of motion using a velocity-time graph.
2. Explain the difference between distance and displacement.
3. Why can displacement be zero when distance is not zero?
4. Explain the slope of a position-time graph.
5. What does the area under a velocity-time graph represent?
6. Define relative velocity.
7. Solve numerical problems based on v = u + at.
8. Explain positive and negative acceleration.

6 FINAL CHAPTER SUMMARY – QUICK REVISION MAP


POSITION →

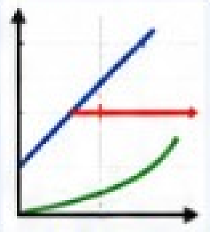
DISPLACEMENT →


VELOCITY →


ACCELERATION →

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

EQUATIONS OF MOTION →


MOTION GRAPHS →


RELATIVE VELOCITY

MASTER THE CONCEPTS + PRACTICE NUMERICALS = HIGHER PHYSICS MARKS

MOST IMPORTANT: Understand signs, graphs and constant acceleration before solving formulas.