

Free Mini-Course: Motion in a Straight Line

Start your physics journey with the most important chapter of kinematics. Short lessons, clear notes, and exam-oriented numericals.

What You Will Learn

- Distance, displacement, speed, velocity
- Acceleration & retardation
- $x-t$ and $v-t$ graphs
- Equations of motion
- Solved numericals & MCQs

Course Content

1. Basics of Motion
2. Speed & Velocity
3. Acceleration
4. Graphs of Motion
5. Equations of Motion
6. Mini Test (MCQs + Numericals)

1. Basics of Motion

This section introduces the fundamental idea of motion—how and why objects change their position with time. Students learn the difference between rest and motion, how motion is always relative, and why choosing a proper reference frame is essential. Key terms like position, path, and distance travelled are explained with simple real-life examples. By the end of this part, students develop a clear intuition about how motion is described in physics and why straight-line motion (1D motion) is the simplest yet most important starting point.

2. Speed & Velocity

Here, students explore how fast an object moves and in which direction. The section begins with speed—a scalar quantity—and progresses to velocity, which includes direction and is therefore a vector. Concepts like average speed, instantaneous speed, average velocity, and uniform vs. non-uniform motion are explained with graphs and examples. Students learn how to interpret motion using position–time graphs and understand why velocity gives a deeper insight into motion than speed.

3. Acceleration

This part explains how motion changes over time. Students learn that acceleration is the rate at which velocity changes and can occur due to changes in speed, direction, or both. The section covers uniform acceleration, non-uniform acceleration, positive and negative acceleration, and retardation. Real-life examples—like a car speeding up, slowing down, or free fall—help students visualize acceleration. Velocity–time graphs are introduced to show how acceleration shapes motion.

4. Graphs of Motion

Students learn to represent motion visually using three essential graphs:

- Position–Time Graph ($x-t$)
- Velocity–Time Graph ($v-t$)
- Acceleration–Time Graph ($a-t$)

Each graph is explained with its shape, meaning, and interpretation. Students understand how to calculate slope, area under the curve, and how graphs reveal hidden details about motion—such as rest, uniform motion, acceleration, deceleration, and turning points. This section builds strong analytical skills needed for numericals and competitive exams.

5. Equations of Motion

This section introduces the three golden equations of uniformly accelerated motion:

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

Students learn when and how to apply these equations, along with their limitations. Each equation is derived conceptually and applied to real-world scenarios like free fall, vehicle motion, and projectile motion (1D). Step-by-step solved examples help students master these

1. Scalars & Vectors

Concept	Description	Examples
Scalar	Quantity with only magnitude	Distance, Speed, Time, Mass
Vector	Quantity with magnitude + direction	Displacement, Velocity, Acceleration
Sign Convention	+ (forward/right/up), – (backward/left/down)	Used in 1D motion

2. Position, Distance & Displacement

Term	Definition	Formula / Notes
Position (x)	Location of object on reference line	Measured from origin

Term	Definition	Formula / Notes
Distance (d)	Total path covered (scalar)	Always positive
Displacement (Δx)	Straight-line change in position (vector)	$\Delta x = x_2 - x_1$

3. Speed & Velocity

Quantity	Type	Formula	Notes
Speed	Scalar	Avg Speed = Total Distance / Total Time	No direction
Velocity	Vector	Avg Velocity = Displacement / Time	Can be + or -
Instantaneous Velocity	Vector	Slope of x-t graph	At a specific moment

4. Acceleration

Type	Definition	Formula	Notes
Acceleration (a)	Rate of change of velocity	$a = (v - u) / t$	Vector
Instantaneous a	Change at a moment	$a = dv/dt$	From calculus
Negative a	Retardation	Opposes motion	Slows object

5. Graphs of Motion

Graph	Slope Represents	Area Represents	Key Shapes
x-t (Position–Time)	Velocity	—	Straight line → uniform motion; Horizontal → rest
v-t (Velocity–Time)	Acceleration	Displacement	Area under curve = displacement
a-t (Acceleration–Time)	—	Change velocity in	Area under curve = Δv

6. Equations of Motion (Uniform Acceleration)

Equation	Meaning	Use Case
$v = u + at$	Velocity after time t	When time is known
$s = ut + \frac{1}{2}at^2$	Displacement in time t	When time is known
$v^2 = u^2 + 2as$	Relation without time	When time is missing

7. Free Fall

Quantity	Value	Notes
Acceleration due to gravity (g)	9.8 m/s ² downward	Take upward as negative
Free fall	Motion under gravity only	Use equations of motion with a = g

Facts about Graphs

1. Uniform motion — position–time graph

- Axes: x (position) vs t (time)
- Shape: Straight line with constant positive slope
- Concept: Object moving with constant velocity (no acceleration).
- Key point: Slope = velocity (same everywhere).

2. Body at rest — position–time graph

- Axes: x vs t
- Shape: Horizontal line ($x = \text{constant}$)
- Concept: Object is not changing position with time.
- Key point: Slope = 0 \rightarrow velocity = 0.

3. Uniform acceleration — velocity–time graph

- Axes: v (velocity) vs t
- Shape: Straight line with constant positive slope
- Concept: Object speeding up with constant acceleration.
- Key points:
 - Slope = acceleration (constant)
 - Area under graph = displacement.

4. Uniform retardation — velocity–time graph

- Axes: v vs t
- Shape: Straight line with negative slope (slanting down)
- Concept: Object slowing down at constant rate.
- Key point: When line hits $v = 0$, object comes to rest.

5. Constant acceleration — acceleration–time graph

- Axes: a (acceleration) vs t
- Shape: Horizontal line above time axis ($a = \text{constant}$)
- Concept: Motion under constant acceleration (e.g., free fall).
- Key point: Area under graph = change in velocity.

6. Non-uniform motion — curved position–time graph

- Axes: x vs t
- Shape: Curve (slope increasing with time)
- Concept: Speed is increasing \rightarrow acceleration present.
- Key point: Slope gets steeper \rightarrow velocity increasing.

7. Changing acceleration — acceleration–time graph

- Axes: a vs t
- Shape: Line with slope or irregular curve
- Concept: Variable acceleration (not constant).
- Key point: Still, area under curve = Δv .