

MOTION IN A STRAIGHT LINE

CONCEPT SUMMARY

KEY CONCEPTS | FORMULAS | RECOGNITION CUES
MISCONCEPTIONS | EXAM TRAPS | QUICK CHECKS

$$v = u + at$$

$$\Delta x = x_f - x_i$$

x_i

x_f

x



UNDERSTAND
THE PHYSICS



RECOGNIZE
THE PATTERN



SOLVE WITH
CONFIDENCE

SAME PHYSICS.
A HIGHER SCORE.

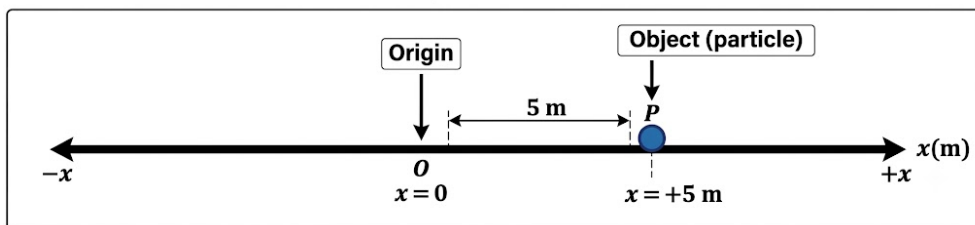
1. CHAPTER INTRODUCTION

Motion in a Straight Line is the foundation of one-dimensional kinematics. It connects position, displacement, velocity, acceleration, motion models and graphs.

2. CHAPTER IN ONE VIEW

STEP	THINK
Reference system	Choose origin and positive direction.
Position	Where is the object?
Displacement	How did position change?
Velocity	How is position changing?
Acceleration	How is velocity changing?
Model	What physical condition governs the motion?
Representation	What does the equation or graph show?
Observer	Relative to whom?
Verification	Do sign, units and Physics make sense?
MASTER EXAM CHAIN PHYSICS SITUATION → MODEL → FORMULA → CONDITION → APPLY → VERIFY	

Reference System in One Dimension

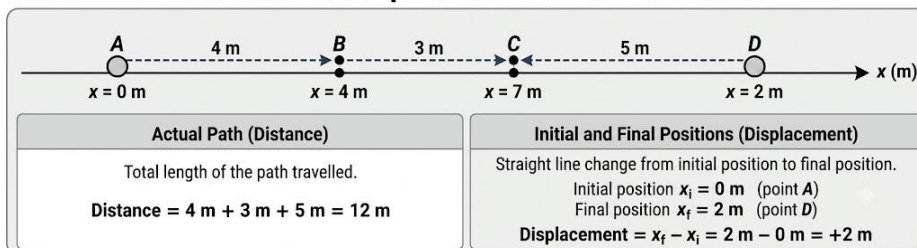


Reference system: origin and positive direction define the coordinate language.

3. MUST-KNOW CONCEPTS

CONCEPT	ESSENTIAL IDEA
Reference / coordinate	Origin and positive direction are choices. Negative coordinate does not automatically mean negative motion.
Position x	Tells where the object is relative to the chosen reference.
Displacement Δx	Net change in position: $\Delta x = x_f - x_i$.
Distance	Total path length. Distance $\geq$ displacement .
Speed	Magnitude of velocity.
Velocity	Rate of change of position; its sign gives direction.
Acceleration	Rate of change of velocity.

Distance and Displacement in One Dimension



Distance vs displacement: path length and net position change are not the same.

SPEEDING UP / SLOWING DOWN

v and a same sign $\rightarrow$ speeding up. v and a opposite signs $\rightarrow$ slowing down.

MATHEMATICAL & GRAPH LANGUAGE

IDEA	MOTION MEANING
Derivative / slope	Rate of change.
Integral / area	Accumulated change.
$x-t$ slope	Velocity.
$v-t$ slope	Acceleration.
$v-t$ area	Displacement.
$a-t$ area	Change in velocity.
RELATION	RECOGNIZE
$v = dx/dt$	Instantaneous velocity.
$a = dv/dt$	Instantaneous acceleration.
$\Delta x = \int v \, dt$	Displacement accumulated from velocity.
$\Delta v = \int a \, dt$	Velocity change accumulated from acceleration.

5. AVERAGE & INSTANTANEOUS QUANTITIES

QUANTITY	RELATION	RECOGNIZE
Average speed	total distance / total time	Whole journey; use distance.
Average velocity	displacement / total time	Whole interval; use signed displacement.
Instantaneous speed	$ v $	Speed at one instant.
Instantaneous velocity	dx/dt	Velocity at one instant.
Average acceleration	$\Delta v/\Delta t$	Velocity change over an interval.
Instantaneous acceleration	dv/dt	Acceleration at one instant.
FAST CHECK Returns to starting point $\rightarrow$ displacement = 0, but distance may be non-zero.		

6. MOTION MODEL: CONSTANT ACCELERATION

MODEL CONDITION Use the standard UAM equations only when acceleration is constant throughout the interval.	
SEE THIS	USE THIS
$u, a, t \rightarrow v$	$v = u + at$
$u, a, t \rightarrow$ displacement	$\Delta x = ut + \frac{1}{2}at^2$
$u, v, \Delta x \rightarrow$ no time	$v^2 = u^2 + 2a\Delta x$
$u, v, t \rightarrow$ displacement	$\Delta x = \frac{1}{2}(u + v)t$

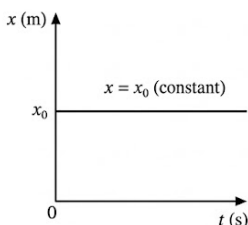
7. MOTION GRAPHS – SEE THIS → THINK THIS

SEE THIS	THINK THIS
x–t graph with positive slope	Positive velocity.
x–t graph with negative slope	Negative velocity.
Horizontal x–t graph	Zero velocity.
Changing slope on x–t	Changing velocity.
Positive slope on v–t	Positive acceleration.
Negative slope on v–t	Negative acceleration.
Horizontal v–t	Zero acceleration.
Area under v–t	Displacement.

Position–Time (x–t) Graphs

- Horizontal axis: time t
- Vertical axis: position x
- Each point on the graph gives the position of the object at that time.

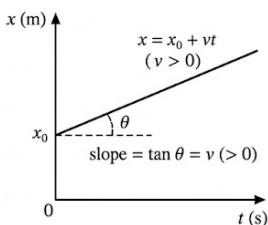
(a) Horizontal Line
(Object at rest)



Key features

- Position is constant ($x = x_0$).
- Slope = 0 $\Rightarrow v = 0$.
- Object is at rest.

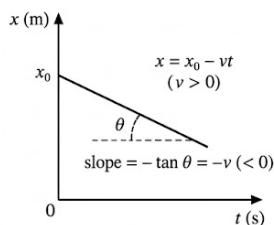
(b) Straight Line with Positive Slope
(Uniform motion in +x direction)



Key features

- Position increases uniformly with time.
- Slope is constant and positive.
- Velocity is constant and positive ($v = \tan \theta > 0$).
- Uniform motion in the +x direction.

(c) Straight Line with Negative Slope
(Uniform motion in –x direction)



Key features

- Position decreases uniformly with time.
- Slope is constant and negative.
- Velocity is constant and negative ($v = -\tan \theta < 0$).
- Uniform motion in the –x direction.

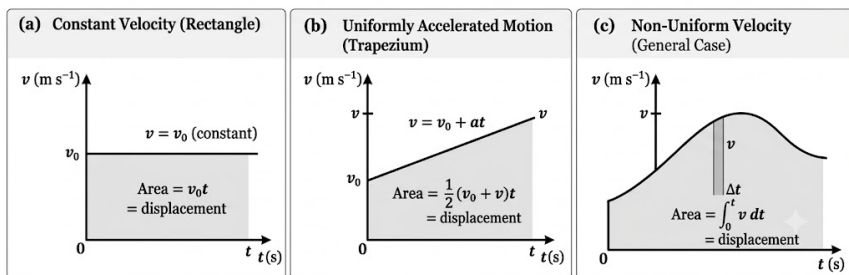
Position–time graphs: the slope tells the velocity.

GRAPH TRAP

Signed v–t area gives displacement. If the graph crosses the time axis, total distance requires adding the magnitudes of separate

areas.

Area under Velocity–Time (v – t) Graph (Displacement)



Velocity–time graph: signed area gives displacement.

8. SPECIAL CASES

Free Fall

Free fall is UAM with gravitational acceleration when air resistance is neglected.

CHOICE	ACCELERATION
Upward positive	$a = -g$
Downward positive	$a = +g$
HIGHEST POINT $v = 0$, but acceleration remains downward. Zero velocity does not mean zero acceleration.	

Relative Motion

RELATION	MEANING
$V_{A/B} = V_A - V_B$	Velocity of A measured by observer B.
$a_{A/B} = a_A - a_B$	Relative acceleration of A with respect to B.

- “How does A appear to B?” $\rightarrow$ relative velocity.

- Identify the observer and sign convention before subtracting.
- For meeting/catching questions, think in terms of relative position and relative velocity.

Multi-Stage Motion

- Split the motion where physical conditions change.
- Choose the valid model for each stage.
- Find the transition state.
- Use that state as the initial state of the next stage.
- Verify the final result.

9. FORMULA SELECTION GUIDE

SEE THIS	THINK THIS	USE THIS
Need instantaneous velocity from $x(t)$	Rate of change of position	$v = \frac{dx}{dt}$
Need instantaneous acceleration from $v(t)$	Rate of change of velocity	$a = \frac{dv}{dt}$
Velocity known over time	Accumulated velocity	$\Delta x = \int v \, dt$
Acceleration known over time	Accumulated acceleration	$\Delta v = \int a \, dt$
Constant a ; need v after t	UAM	$v = u + at$
Constant a ; need displacement after t	UAM	$\Delta x = ut + \frac{1}{2}at^2$
Constant a ; time not needed	UAM	$v^2 = u^2 + 2a\Delta x$
Observer/reference changes	Relative motion	$v_{A/B} = v_A - v_B$
Conditions change	Multi-stage motion	Solve stage by

		stage
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10. COMMON MISCONCEPTIONS & EXAM TRAPS

WRONG IDEA	CORRECT PHYSICS
Negative position means moving backward.	Position sign depends on the reference; velocity gives direction.
Negative velocity means slowing down.	Speeding/slowing depends on the signs of v and a .
Acceleration means speed is increasing.	Acceleration means velocity is changing.
$v = 0$ means $a = 0$.	Velocity can be zero while acceleration is non-zero.
Distance = displacement.	Distance is path length; displacement is net position change.
Speed = velocity.	Speed is the magnitude of velocity.
UAM equations work for every motion.	They require constant acceleration.
Relative velocity is just subtraction.	First identify the observer and sign convention.

11. SEE THIS → THINK THIS

CLUE	RECOGNIZE
Negative coordinate	Check the chosen positive direction.
$x-t$ graph	Slope gives velocity.

v–t graph	Slope gives acceleration; area gives displacement.
Constant acceleration	Use UAM relations.
$v = 0$ at highest point	Acceleration is still $-g$ if upward is positive.
“With respect to B”	Relative motion; B is the observer.
Different conditions in different intervals	Split into stages.
v and a same sign	Speeding up.
v and a opposite signs	Slowing down.

Visual memory: reference $\rightarrow$ position $\rightarrow$ slope $\rightarrow$ area. Use the graph to identify the Physics situation before choosing a formula.

12. QUICK CHECKS

Q: A coordinate is negative. Does that prove negative motion?

$\rightarrow$ No. Position sign and velocity sign are different.

Q: What does x–t slope give?

$\rightarrow$ Velocity.

Q: What does v–t area give?

$\rightarrow$ Displacement.

Q: When is $v = u + at$ valid?

$\rightarrow$ When acceleration is constant over the interval.

Q: At the highest point of an upward throw?

$\rightarrow v = 0$, but acceleration is still downward.

Q: Two objects and “relative to B”?

$\rightarrow$ Use relative velocity with B as observer.

Q: A body returns to its starting point?

→ Displacement is zero; distance need not be zero.

Q: Conditions change during motion?

→ Split into stages and connect transition states.

13. MINI EXAM REASONING

EXAMPLE 1

Clue: constant acceleration + u and t are given → UAM → $v = u + at$ → Check: acceleration remains constant.

EXAMPLE 2

Clue: one object is described relative to another → relative motion → $v_{A/B} = v_A - v_B$ → Check: identify observer and signs.

14. ONE-MINUTE RECALL

- Reference system → origin + positive direction.
- Position → where the object is.
- Displacement → final position – initial position.
- Distance → total path length.
- Velocity → rate of change of position.
- Acceleration → rate of change of velocity.
- $x-t$ slope → velocity; $v-t$ slope → acceleration.
- $v-t$ area → displacement.
- Constant acceleration → UAM equations.
- Free fall → UAM with $a = \pm g$.
- Relative velocity → identify observer first.
- Changing conditions → solve stage by stage.

FINAL EXAM SCAN

Situation → Model → Condition → Relation → Sign → Units → Physical sense

COMPLETE CONCEPT BOOK

The complete NEET Physics Essentials Concept Book provides full concept development, detailed diagrams and graphs, microquestions, solved examples, deeper exam reasoning, integrated problem-solving and the complete exam playbook.

Understand the Physics → Recognize the Pattern → Solve with Confidence

Website: www.pickprep.com

WhatsApp: +919737240300

Email: pickprep03@gmail.com



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