CHAPTER 2

Motion in a Straight Line

CBSE · Physics · Class 11

WHAT THIS CHAPTER DOES

Boards prep that builds confidence, not anxiety.

TODAY'S MISSION

Today's mission

WHY THIS MATTERS

Why this chapter matters

TOPIC

A

Part A — Position, distance, displacement

TOPIC

Position vs distance vs displacement

POINT 1	POINT 2	POINT 3	POINT 4

WORKED EXAMPLE

Example 1: Round trip on a number line

TOPIC

Mid-chapter recap — can you do this?

TOPIC

B

Part B — Speed, velocity, acceleration

TOPIC

Average vs instantaneous quantities

POINT 1	POINT 2	POINT 3	POINT 4

TOPIC

Sign of v, sign of a — what is the body doing?

TOPIC

C

Part C — Equations of motion + free fall

THEOREM · LOAD-BEARING RESULT

The three master equations (uniformly accelerated motion)

> If a body moves with CONSTANT acceleration a, starting with initial velocity u, then after time t: (1) v = u + at, (2) s = ut + (1/2)at^2, (3) v^2 = u^2 + 2as. Additionally, distance in nth second: s_n = u + (a/2)(2n - 1).

STATEMENT

If a body moves with CONSTANT acceleration a, starting with initial velocity u, then after time t: (1) v = u + at, (2) s = ut + (1/2)at^2, (3) v^2 = u^2 + 2as. Additionally, distance in nth second: s_n =

WHY THIS MATTERS

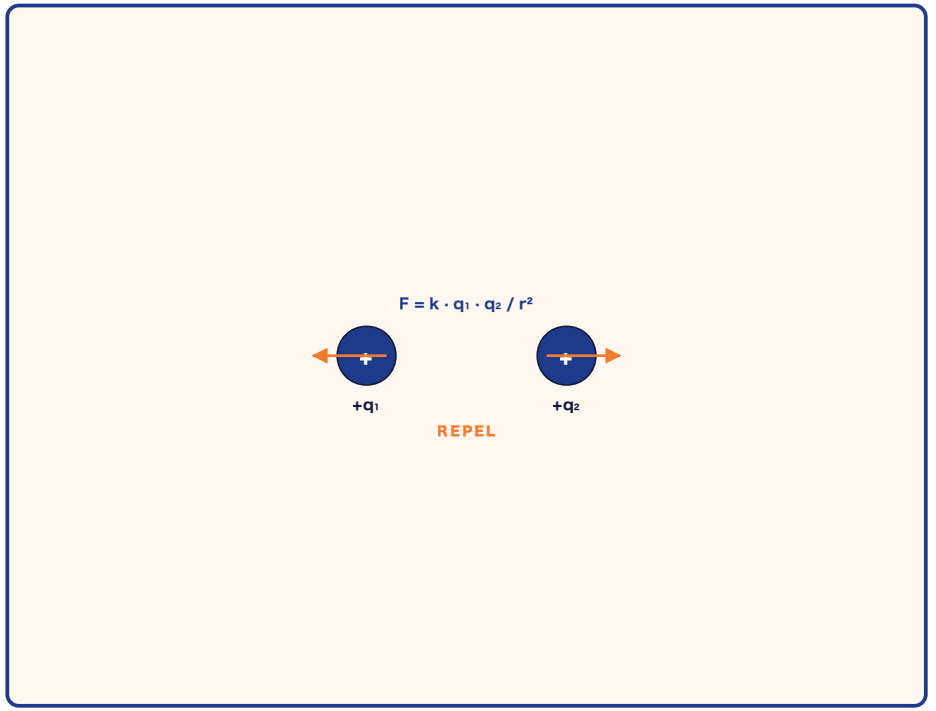
- These four formulas connect the five quantities {u, v, a, s, t}
- Given any three, you can find the other two
- They are derived from the definitions a = dv/dt and v = dx/dt by integrating with constant a.

WATCH OUT FOR

NOTE All four equations require a = constant. Do NOT use them when acceleration varies. For variable acceleration use calculus (integrate a(t) to get v(t), integrate v(t) to get x(t)).

WORKED EXAMPLE

Example 2: Uniformly accelerated motion



TRY IT · SOLVE BEFORE YOU PEEK

Quick test — can you pick the right equation?

Work it out before you flip the answer.

SOLUTION

WORKED EXAMPLE

Example 3: Free fall — object dropped from a height

TRY IT · SOLVE BEFORE YOU PEEK

Pause — free fall vs projectile

Work it out before you flip the answer.

SOLUTION

WORKED EXAMPLE

Example 4: Vertical throw — find max height + time

TOPIC

Reading motion graphs

POINT 1	POINT 2	POINT 3	POINT 4

TRY IT · SOLVE BEFORE YOU PEEK

Quick check — free fall reasoning

Work it out before you flip the answer.

SOLUTION

PYQ PATTERNS

PYQ patterns — last 5 years

MARKS DISTRIBUTION

Where the marks live (per board paper)

TOPPER TEMPLATE · MARK-BY-MARK

Topper template — Free-fall numerical (3 marks)

1. **SIGN CONVENTION + LIST U, A, S** — 1 m
2. **PICK THE RIGHT EQUATION + SUBSTITUTE** — 1 m
3. **FIND 2ND QUANTITY, UNITS, DIRECTION** — 1 m

TOPIC

Trap

TRAP → TRUTH

× **MISTAKE** Distance and displacement are the same — both measure how far something moved.

✓ **CORRECT** Distance is the total path length (scalar, always positive). Displacement is the straight-line vector from initial to final position (signed, can be zero even when distance is not). A runner finishing a 400 m lap has distance=400 m but displacement=0.

TOPIC

Trap

TRAP → TRUTH

× **MISTAKE** Average velocity equals the average of initial and final speeds.

✓ **CORRECT** Average velocity = total displacement / total time. The (u+v)/2 formula is valid ONLY for uniformly accelerated motion. For variable acceleration or unequal-time segments, you must use total displacement / total time.

TOPIC

Trap

TRAP → TRUTH

× **MISTAKE** An object thrown upward has zero acceleration at the highest point because its velocity is zero there.

✓ **CORRECT** At the highest point velocity is zero, but acceleration is still g = 9.8 m/s^2 downward. Acceleration is the rate of change of velocity, not velocity itself. That is why the object does not stay at the top — gravity is still acting.

TOPIC

Trap

TRAP → TRUTH

× **MISTAKE** Negative velocity means the object is decelerating.

✓ **CORRECT** Negative velocity means motion in the negative direction of the chosen axis. Deceleration occurs when velocity and acceleration have OPPOSITE signs (speed decreasing). A car moving in -x with a = -3 m/s^2 is speeding up, not slowing down.

TOPIC

Trap

TRAP → TRUTH

× **MISTAKE** Distance covered in nth second equals (distance in n seconds) / n.

✓ **CORRECT** Distance in the nth SECOND = s_n - s_(n-1) = u + (a/2)(2n - 1). It is the distance covered during a 1-second interval (between t=n-1 and t=n), not the average per second.

TOPIC

Trap

TRAP → TRUTH

× **MISTAKE** If acceleration is zero, the body must be at rest.

✓ **CORRECT** Zero acceleration means constant velocity. A car cruising at 60 km/h has zero acceleration but is not at rest. Acceleration is about CHANGE in velocity, not its value.

TOPIC

Trap

TRAP → TRUTH

× **MISTAKE** On an x-t graph, a horizontal line means the object is moving slowly.

✓ **CORRECT** Horizontal x-t line means position is not changing — the object is at REST. Slope of x-t = velocity, and zero slope = zero velocity.

TOPIC

Trap

TRAP → TRUTH

× **MISTAKE** Relative velocity of A with respect to B in 1D is always v_A + v_B.

✓ **CORRECT** v_AB = v_A - v_B (with proper signs). It is +v_A + v_B in magnitude only when A and B move in opposite directions. For same direction, use the signed subtraction.

TOPPER TEMPLATE · MARK-BY-MARK

Free-fall numerical: object dropped from height H or thrown up with initial velocity u. find time/

1	**SET UP AXIS + SIGN CONVENTION + LIST U, A, S** 1 m	Taking downward as positive. Given: u = 0 m/s (dropped), a = g = 9.8 m/s^2, s = 45 m. To find: time of fall t, velocity on hitting ground v.
2	**PICK THE RIGHT KINEMATIC EQUATION AND SUBSTITUTE** 1 m	Using s = ut + (1/2)at^2: 45 = 0*t + (1/2)(9.8)t^2 => t^2 = 45/4.9 = 9.18 => t = 3.03 s.
3	**FIND THE SECOND QUANTITY + STATE BOTH WITH UNITS AND DIRECTION** 1 m	Using v = u + at: v = 0 + 9.8*3.03 = 29.7 m/s downward. Answer: t = 3.03 s, v = 29.7 m/s directed downward.

TOPPER TEMPLATE · MARK-BY-MARK

Distance vs displacement: object moves A->B->C with B->C being a partial back-track. Find

1	**LAY OUT THE MOTION ON A NUMBER LINE WITH POSITIONS** 1 m	Let A = 0 m, B = +60 m (forward 60 m), C = +20 m (back 40 m). Person moves A->B->C.
2	**DISTANCE = SUM OF PATH LENGTHS (SCALAR)** 1 m	Distance = |AB| + |BC| = 60 + 40 = 100 m.
3	**DISPLACEMENT = FINAL - INITIAL POSITION (SIGNED)** 1 m	Displacement = x_C - x_A = 20 - 0 = +20 m, i.e. 20 m in the forward direction. Note: distance != displacement here.

TOPPER TEMPLATE · MARK-BY-MARK

Find average velocity of a multi-stage journey (e.g. half the distance at v1, other half at v2).

1	**WRITE DEFINITION + ASSIGN VARIABLES** 1 m	Average velocity = total displacement / total time. Let total distance = 2d (so each half is d). Speed in first half = v1 = 40 m/s, second half = v2 = 60 m/s.
2	**COMPUTE TIME FOR EACH SEGMENT** 1 m	t1 = d/v1 = d/40, t2 = d/v2 = d/60. Total time t = d/40 + d/60 = (3d + 2d)/120 = 5d/120 = d/24.
3	**COMPUTE AVERAGE VELOCITY (= HARMONIC MEAN HERE, SINCE EQUAL DISTANCES)** 1 m	Average velocity = 2d / (d/24) = 48 m/s. Note: arithmetic mean (40+60)/2 = 50 m/s is WRONG for equal-distance segments.

PYQ PATTERNS

Top PYQ patterns to drill

#1	Free-fall numerical: object dropped/thrown vertically, find time to reach ground, max height, or velocity at impact (g=9.8 or 10 m/s^2 stated). (3 marks)	92%
#2	Distance vs displacement word problem (round trip, return journey, partial back-track). (2 marks)	85%
#3	Read a given x-t or v-t graph and extract velocity, acceleration, or displacement. (2 marks)	78%
#4	Average vs instantaneous velocity	find average velocity for a multi-stage journey (different speeds for different segments). (3 marks) — 70%
#5	Distance covered in nth second	

RECAP · MEMORISE THESE

Summary — what to remember

1 Distance vs displacement: scalar (path) vs vector (signed gap). |Displacement| <= Distance always.

2 Speed vs velocity: scalar vs vector. Average velocity = Δx/Δt, NEVER (u+v)/2 unless a is constant.

3 Three master equations (constant a): v = u + at, s = ut + (1/2)at^2, v^2 = u^2 + 2as.

4 Free fall: a = g downward = 9.8 m/s^2. At peak of vertical throw, v = 0 but a is still g.

5 Graphs: slope x-t = velocity; slope v-t = acceleration; area under v-t = displacement.

6 Relative velocity in 1D: v_AB = v_A - v_B with signs.

WHAT'S NEXT

Next class

Practice now

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