CBSE CLASS 11 | PHYSICS

Motion in a Straight Line

Complete Question Bank — All CBSE Question Types with Full Solutions

What's inside this PDF

- Quick concept revision — definitions, graphs & every formula you need
- MCQs, Assertion–Reason, VSA, SA, Case-Study & Long Answer questions
- HOTS (High Order Thinking) and Previous Year Board Questions
- Complete Answer Key with step-by-step solutions at the end

40+ Practice Questions | **All Marking Schemes** | **Full Solved Answers** | **Exam-Ready Formula Sheet**

1. Quick Concept Revision

Basic Terms

Distance: Total path length covered by an object. It is a scalar quantity and is always positive; it never decreases with time.

Displacement: The shortest straight-line distance between the initial and final position, along with direction. It is a vector quantity and can be positive, negative, or zero.

Speed: Distance travelled per unit time (scalar). **Average speed** = Total distance / Total time.

Velocity: Displacement per unit time (vector). **Average velocity** = Total displacement / Total time.

Acceleration: Rate of change of velocity with time (vector). Uniform if velocity changes by equal amounts in equal time intervals.

Remember: Average speed ≥ magnitude of average velocity always, since distance ≥ |displacement|.

Graphs — Key Interpretations

Position–Time (x–t) graph: Slope of the x–t graph at any instant gives the instantaneous velocity. A straight line means uniform velocity; a curved line means the velocity is changing (acceleration present). A horizontal line means the object is at rest.

Velocity–Time (v–t) graph: Slope of the v–t graph gives instantaneous acceleration. Area enclosed between the v–t graph and the time-axis gives the displacement in that interval. A straight horizontal line means zero acceleration (uniform velocity); a straight sloped line means uniform (constant) acceleration.

Acceleration–Time (a–t) graph: Area under the a–t graph gives the change in velocity over that interval.

2. Formula Sheet (Uniform Acceleration)

Three Equations of Motion (initial velocity u, final velocity v, acceleration a, time t, displacement s)

1)	$\mathbf{v = u + at}$	— relates velocity and time
2)	$\mathbf{s = ut + \frac{1}{2}at^2}$	— relates displacement and time
3)	$\mathbf{v^2 = u^2 + 2as}$	— relates velocity and displacement

Additional Useful Results

Distance in n^{th} second:	$\mathbf{s_n = u + (a/2)(2n - 1)}$
Average velocity (uniform acceleration):	$\mathbf{v_{avg} = (u + v)/2}$
Relative velocity of A w.r.t. B:	$\mathbf{v_{AB} = v_A - v_B}$
Free fall (taking g downward positive, u = 0):	$\mathbf{v = gt,\ h = \frac{1}{2}gt^2,\ v^2 = 2gh}$

Sign convention tip: Choose one direction as positive at the start of the problem and stick to it — velocity, acceleration and displacement in the opposite direction must all be taken negative.

3. Multiple Choice Questions (1 Mark Each)

Q1 A particle moves in a straight line and covers equal distances in equal intervals of time. Its motion is: 1 mark

(a) Uniformly accelerated
(b) Non-uniform
(c) Uniform velocity
(d) Retarded

Q2 The area under a velocity–time graph represents: 1 mark

(a) Acceleration
(b) Displacement
(c) Speed
(d) Force

Q3 A body starts from rest and moves with uniform acceleration. The ratio of distances covered in the 1st, 2nd and 3rd seconds is: 1 mark

(a) 1 : 2 : 3
(b) 1 : 4 : 9
(c) 1 : 3 : 5
(d) 1 : 1 : 1

Q4 Which of the following can be negative? 1 mark

(a) Distance travelled
(b) Speed
(c) Displacement
(d) Magnitude of velocity

Q5 The slope of a position–time graph gives: 1 mark

(a) Acceleration
(b) Velocity
(c) Displacement
(d) Jerk

Q6 A stone is dropped from a tower. Its velocity after falling for 2 s ($g = 10\ m/s^2$) is: 1 mark

(a) 5 m/s
(b) 10 m/s
(c) 20 m/s
(d) 40 m/s

Q7 If the velocity–time graph of a body is a straight line parallel to the time axis, the body has: 1 mark

(a) Zero velocity
(b) Uniform velocity
(c) Uniform acceleration
(d) Variable acceleration

Q8 Two cars A and B move in the same direction with speeds 20 m/s and 15 m/s respectively. The relative velocity of A with respect to B is: 1 mark

(a) 5 m/s
(b) 35 m/s
(c) 15 m/s
(d) 20 m/s

Q9 A particle's displacement is zero over a time interval. The average velocity over that interval must be: 1 mark

(a) Zero
(b) Maximum
(c) Equal to average speed
(d) Undefined

Q10 Which quantity remains constant in uniformly accelerated motion? 1 mark

(a) Velocity
(b) Speed
(c) Acceleration
(d) Displacement

4. Assertion–Reason Questions (1 Mark Each)

For each question, choose: (a) Both A and R are true and R is the correct explanation of A (b) Both A and R are true but R is NOT the correct explanation of A (c) A is true, R is false (d) A is false, R is true

Q11 **Assertion (A):** The displacement of an object can never be greater than the distance travelled.
Reason (R): Displacement is the shortest path between initial and final positions, while distance is the actual path length. 1 mark

Q12 **Assertion (A):** A body having zero velocity will not necessarily have zero acceleration.
Reason (R): At the highest point of a vertically thrown ball, velocity is zero but acceleration is g, directed downward. 1 mark

Q13 **Assertion (A):** Average speed of an object can be equal to the magnitude of its average velocity.
Reason (R): This happens only when the object moves along a straight line without changing direction. 1 mark

5. Very Short Answer Questions (1 Mark Each)

Q14 Can a body have zero velocity and still be accelerating? Justify with an example. — 1 mark

Q15 Is it possible for a body to have a constant speed but a varying velocity? Explain. — 1 mark

Q16 What does the slope of a velocity–time graph represent? — 1 mark

Q17 Write the SI unit and dimensional formula of acceleration. — 1 mark

Q18 Under what condition is the magnitude of average velocity equal to the average speed? — 1 mark

6. Short Answer Questions (2–3 Marks Each)

Q19 Derive the equation $v = u + at$ using a velocity–time graph. — 2 marks

Q20 A car travels the first half of a distance at 40 km/h and the second half at 60 km/h. Find its average speed for the whole journey. — 2 marks

Q21 Explain, with the help of a velocity-time graph, how displacement is calculated when acceleration is not uniform. — 2 marks

Q22 A ball is thrown vertically upward with a speed of 20 m/s. Calculate (i) the maximum height reached and (ii) the total time taken to return to the point of projection. ($g = 10$ m/s²) — 3 marks

Q23 Derive the equation $s = ut + \frac{1}{2}at^2$ using the area under a velocity–time graph. — 3 marks

Q24 Two trains, each of length 100 m, moving in opposite directions with velocities 20 m/s and 30 m/s, cross each other. Find the time taken to cross each other completely. — 3 marks

7. Case-Study Based Question (4 Marks)

Q25 **Read the passage and answer the questions that follow:**
A cyclist rides along a straight road. For the first 10 s, he accelerates uniformly from rest to a speed of 10 m/s. He then moves at this constant speed for the next 20 s, and finally decelerates uniformly to rest in the next 5 s.

(i) Sketch the nature of the velocity–time graph for the entire journey (describe its shape). 1 mark
(ii) Calculate the acceleration of the cyclist during the first 10 s. 1 mark
(iii) Calculate the total distance travelled by the cyclist in the 35 s. 2 marks

8. Long Answer / Numerical Questions (5 Marks Each)

Q26 A car moving with a speed of 72 km/h is brought to rest by applying brakes in 5 seconds. Calculate (i) the retardation and (ii) the distance travelled by the car before it stops. 5 marks

Q27 A body covers a distance of 100 m in the 4th second and 150 m in the 8th second of its motion under uniform acceleration. Find the initial velocity and the acceleration of the body. 5 marks

Q28 Two stations A and B are connected by a straight track 100 km long. A train travels from A to B taking 30 minutes, halts at B for 15 minutes, and returns to A in 40 minutes. Calculate (i) the average speed and (ii) the average velocity of the train over the entire journey. 5 marks

9. HOTS — High Order Thinking Questions

Q29 A lift is moving upward with an acceleration of 2 m/s². A ball is dropped from a height of 2 m above the floor of the lift. Find the time taken by the ball to reach the floor of the lift as observed by a person standing inside the lift. (g = 10 m/s²) — 4 marks

Q30 The velocity–time graph of a particle moving along a straight line is a triangle. If the base of the triangle represents a total time T and the height represents maximum velocity v_{max}, show that the average velocity of the particle over time T is $v_{max}/2$. — 3 marks

Q31 A particle moves along the x-axis according to the equation $x = 4 + 3t - t^2$ (x in metres, t in seconds). Find (i) the position, velocity and acceleration at t = 2 s, and (ii) the time at which the particle momentarily comes to rest. — 4 marks

10. Previous Year Board-Style Questions

Q32 Define instantaneous velocity. Derive its expression from average velocity by taking the limit as the time interval tends to zero. — 3 marks · PYQ pattern

Q33 Draw the position-time graph and velocity-time graph for (i) an object at rest, (ii) an object moving with uniform velocity, and (iii) an object moving with uniform acceleration. — 3 marks · PYQ pattern

Q34 A jet airplane travelling at the speed of 500 km/h ejects its products of combustion at the speed of 1500 km/h relative to the jet plane. What is the speed of the latter with respect to an observer on the ground? — 3 marks · NCERT/PYQ

Q35 On a long horizontal moving belt, a child runs to and fro with a speed of 9 km/h (relative to the belt) in a direction opposite to the belt's motion. The belt moves with a speed of 4 km/h. For an observer standing on the ground, what is the speed of the child running in the direction of the belt's motion? — 3 marks · NCERT/PYQ

✅ Complete Answer Key & Solutions

Section 3 — MCQ Answers

Q1: (c) Uniform velocity — equal distance in equal time means constant speed and direction.

Q2: (b) Displacement — area under v–t graph gives displacement.

Q3: (c) 1 : 3 : 5 — from $s_n = u + (a/2)(2n-1)$, with u = 0, ratio of distances is 1 : 3 : 5.

Q4: (c) Displacement — it is a vector and can point in the negative direction.

Q5: (b) Velocity — slope of x–t graph = dx/dt = velocity.

Q6: (c) 20 m/s — using $v = u + gt = 0 + 10\times2 = 20$ m/s.

Q7: (b) Uniform velocity — a horizontal line on v–t graph means velocity is constant, so acceleration is zero.

Q8: (a) 5 m/s — $v_{AB} = v_A - v_B = 20 - 15 = 5$ m/s.

Q9: (a) Zero — average velocity = displacement/time = 0/time = 0.

Q10: (c) Acceleration — it stays constant throughout uniformly accelerated motion.

Section 4 — Assertion–Reason Answers

Q11: (a) — Both true, R correctly explains A, since the straight-line path (displacement) is always the shortest possible path.

Q12: (a) — Both true, R correctly explains A, as the ball's velocity is momentarily zero at the highest point while gravity still acts on it.

Q13: (a) — Both true, R correctly explains A, since only unidirectional straight-line motion makes distance equal to the magnitude of displacement.

Section 5 — VSA Answers

Q14: Yes. At the highest point of a vertically projected object, its velocity is momentarily zero, but the acceleration due to gravity (g, directed downward) continues to act on it.

Q15: Yes. In circular or curved motion, the speed (magnitude) can stay constant while the direction of velocity keeps changing continuously, making velocity a variable vector quantity.

Q16: The slope of a velocity–time graph represents the instantaneous acceleration of the body at that point.

Q17: SI unit: m/s². Dimensional formula: $[M^0L^1T^{-2}]$.

Q18: When the object moves along a straight line in one direction only, without reversing, so that distance travelled equals the magnitude of displacement.

Section 6 — Short Answer Solutions

Q19: On a v–t graph, consider a body with initial velocity u at t = 0, reaching velocity v at time t, moving with uniform acceleration a. The slope of the straight line = a = (v − u)/t. Rearranging gives **v = u + at**.

Q20: Let total distance = 2d. Time for first half = d/40, time for second half = d/60. Total time = d/40 + d/60 = (3d + 2d)/120 = 5d/120 = d/24. Average speed = 2d ÷ (d/24) = **48 km/h**.

Q21: When acceleration is non-uniform, the v–t graph is a curve rather than a straight line. The displacement over any interval is still equal to the area enclosed between the curve and the time axis; this area is found by dividing the region into thin vertical strips and summing their areas (i.e., integrating v with respect to t).

Q22: (i) Maximum height: using $v^2 = u^2 - 2gh$ with v = 0, u = 20 m/s: $h = u^2/2g = 400/20 =$ **20 m**. (ii) Time to reach top: t = u/g = 20/10 = 2 s. Total time up and down = **4 s**.

Q23: On a v–t graph, displacement equals the area under the line from 0 to t. This area is a trapezium made of a rectangle (area = ut) and a triangle (area = ½t(v−u) = ½t(at) = ½at²). Adding these areas gives **$s = ut + \frac{1}{2}at^2$**.

Q24: Relative velocity (opposite directions) = 20 + 30 = 50 m/s. Total distance to be covered for complete crossing = sum of lengths = 100 + 100 = 200 m. Time = 200/50 = **4 s**.

Section 7 — Case Study Solution

Q25 (i): The v–t graph rises in a straight line from 0 to 10 m/s during 0–10 s, stays flat at 10 m/s from 10–30 s, then falls in a straight line back to 0 from 30–35 s — an overall trapezium shape.

Q25 (ii): a = (v − u)/t = (10 − 0)/10 = **1 m/s²**.

Q25 (iii): Distance = area of trapezium = area of triangle (accelerating) + area of rectangle (constant speed) + area of triangle (decelerating) = (½×10×10) + (20×10) + (½×5×10) = 50 + 200 + 25 = **275 m**.

Section 8 — Long Answer Solutions

Q26: u = 72 km/h = 20 m/s, v = 0, t = 5 s. (i) a = (v−u)/t = (0−20)/5 = **−4 m/s²** (retardation = 4 m/s²). (ii) s = ut + ½at² = 20×5 + ½(−4)(25) = 100 − 50 = **50 m**.

Q27: Using $s_n = u + (a/2)(2n-1)$: For n = 4: u + 3.5a = 100. For n = 8: u + 7.5a = 150. Subtracting: 4a = 50, so **a = 12.5 m/s²**. Substituting back: u = 100 − 3.5×12.5 = 100 − 43.75 = **56.25 m/s**.

Q28: Total distance = 100 + 100 = 200 km. Total time = 30 + 15 + 40 = 85 min = 85/60 h. (i) Average speed = 200 ÷ (85/60) = **≈141.2 km/h**. (ii) Net displacement = 0 (train returns to A), so **average velocity = 0**.

Section 9 — HOTS Solutions

Q29: Relative to the lift, the ball's effective downward acceleration = g − a_{lift}... actually since the lift accelerates upward at 2 m/s² while the ball is in free fall (acceleration g downward in ground frame), the ball's acceleration relative to the lift = g + a = 10 + 2 = 12 m/s² downward. Using $h = \frac{1}{2}a_{rel}t^2$: 2 = ½(12)t² → t² = 1/3 → **t ≈ 0.58 s**.

Q30: Total displacement = area of triangle = ½ × T × v_{max}. Average velocity = displacement/time = (½×T×v_{max})/T = $\mathbf{v_{max}/2}$, as required.

Q31: x = 4 + 3t − t². Velocity v = dx/dt = 3 − 2t. Acceleration a = dv/dt = −2 m/s² (constant). At t = 2 s: x = 4 + 6 − 4 = **6 m**; v = 3 − 4 = **−1 m/s**; a = **−2 m/s²**. Particle momentarily at rest when v = 0: 3 − 2t = 0 → **t = 1.5 s**.

Section 10 — Previous Year Question Solutions

Q32: Instantaneous velocity is the velocity of an object at a particular instant of time, defined as the limit of average velocity as the time interval approaches zero: v = lim (Δt→0) Δx/Δt = dx/dt.

Q33: (i) Rest: x–t graph is horizontal; v–t graph lies on the time axis. (ii) Uniform velocity: x–t graph is a straight sloped line; v–t graph is a horizontal line above the axis. (iii) Uniform acceleration: x–t graph is a curve (parabola); v–t graph is a straight sloped line.

Q34: Speed of gases relative to ground = speed of gases relative to jet + speed of jet relative to ground (with appropriate sign, since gases are ejected backward) = −1500 + 500 = **−1000 km/h**, i.e., 1000 km/h in the direction opposite to the jet's motion.

Q35: Speed of child relative to ground when running in the direction of the belt = speed of child relative to belt + speed of belt relative to ground = 9 + 4 = **13 km/h**.