Motion in a Straight Line — CBSE Pattern Test 2

Class 11 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

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General Instructions: (1) This paper has four sections — Section A (1 × 10), Section B (2 × 4), Section C (3 × 4) and Section D (5 × 2) — total 40 marks. Time allowed: 90 minutes.
(2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.
(3) For MCQ questions choose the single correct option; for VSA answers write a single line.
(4) Take g = 10 m/s^2. All symbols carry their usual meaning. Use of a calculator is not permitted.

Section A — MCQ & VSA (10 × 1 = 10 marks)

1. A body starts from rest and moves with a uniform acceleration of 2 m/s^2. Its velocity after 5 s is
   (A) 10 m/s
   (B) 5 m/s
   (C) 2.5 m/s
   (D) 20 m/s
2. The area enclosed between a velocity–time graph and the time axis over an interval gives the
   (A) displacement
   (B) acceleration
   (C) average velocity
   (D) curvature
3. A ball is thrown vertically upward at 20 m/s. Taking g = 10 m/s^2, the maximum height reached is
   (A) 20 m
   (B) 40 m
   (C) 10 m
   (D) 2 m
4. Two bodies of different masses are dropped from the same height in a vacuum. They reach the ground
   (A) simultaneously
   (B) the heavier one first
   (C) the lighter one first
   (D) the body with the larger surface area first
5. A man travels from A to B at 10 km/h and returns from B to A at 15 km/h. His average speed for the round trip is
   (A) 12 km/h
   (B) 12.5 km/h
   (C) 13 km/h
   (D) 14 km/h
6. A swimmer capable of 4 m/s in still water crosses a 200 m wide river flowing at 3 m/s, aiming perpendicular to the flow. The time to cross is
   (A) 50 s
   (B) 200 s
   (C) 66.7 s
   (D) 28.6 s
7. Define acceleration.

8. What is retardation?

9. What does the area under an acceleration–time graph over an interval give?

10. Write the relation a = v(dv/dx). When is this form especially useful?

Section B — Short Answer I (4 × 2 = 8 marks)

11. A ball is thrown upward with a speed of 30 m/s. Taking g = 10 m/s², find (i) the maximum height reached and (ii) the total time of flight.

12. A train travels from station P to station Q at 40 km/h and returns along the same route at 30 km/h. Find its average speed for the whole round trip.

13. A body travels 40 m due north and then 30 m due east. Find the total distance travelled and the magnitude of its displacement.

14. A body starting from rest moves with a uniform acceleration of 5 m/s². Find its displacement in the 8th second.

Section C — Short Answer II (4 × 3 = 12 marks)

15. A stone is dropped from the top of a tower 100 m high and, at the same instant, another stone is thrown vertically upward from the foot of the tower at 25 m/s. Taking g = 10 m/s², find when and where the two stones meet.

16. A car moving at 10 m/s is 25 m behind a scooter moving at 8 m/s in the same direction. Find (i) the time after which the car overtakes the scooter and (ii) the distance the car covers in that time.

17. A train moving at 72 km/h slows uniformly to 36 km/h while covering a distance of 200 m. Find its retardation and the time taken.

18. A particle moving along the x-axis has acceleration a = −2x (x in metres). If it starts from rest at x = 2 m, find its speed at x = 1 m.

Section D — Long Answers (2 × 5 = 10 marks)

19. (a) Show, for a body thrown vertically upward (air resistance neglected), that the time of ascent equals the time of descent. (b) A police van moving on a highway at 30 km/h fires a bullet at a car speeding away in the same direction at 192 km/h. If the muzzle speed of the bullet is 150 m/s, find the speed with which the bullet hits the car.

20. (a) Derive the condition for a swimmer to cross a river along the shortest possible path — the angle at which he must aim and the time taken, in terms of his still-water speed u, the current speed w and the width d of the river. (b) A boy rows at 4 m/s in still water across a river 400 m wide flowing at 3 m/s, aiming perpendicular to the flow. Find how far downstream he lands and his resultant speed relative to the ground.

Answer Key (Marking Scheme)

Q1 — (A) 10 m/s (v = at = 2 × 5). Q2 — (A) displacement. Q3 — (A) 20 m (H = u²/2g = 400/20).

Q4 — (A) simultaneously (in vacuum all bodies fall equally). Q5 — (A) 12 km/h (2·10·15/25). Q6 — (A) 50 s (t = d/u = 200/4).

Q7 — Acceleration = rate of change of velocity = dv/dt; SI unit m/s².

Q8 — Retardation is the rate of decrease of speed — acceleration directed opposite to the velocity, with magnitude |dv/dt|.

Q9 — The change in velocity over that interval (∫a dt = Δv).

Q10 — a = v(dv/dx); used when velocity is given as a function of displacement, so that time is eliminated and a depends on x alone.

Q11 — H = u²/2g = 45 m; T = 2u/g = 6 s. Q12 — 2·40·30/(40 + 30) = 2400/70 ≈ 34.3 km/h.

Q13 — Distance = 70 m; displacement = $\sqrt{(40^2 + 30^2)} = 50$ m due north-east.

Q14 — $s_n = u + (a/2)(2n - 1) = 0 + (5/2)(15) = 37.5$ m.

Q15 — Lower stone: $s_1 = \frac{1}{2}gt^2$; upper stone: $s_2 = 25t - \frac{1}{2}gt^2$. $s_1 + s_2 = 100 \Rightarrow 25t = 100 \Rightarrow t = 4$ s; height $s_1 = \frac{1}{2}(10)(16) = 80$ m from the foot (i.e. 20 m below the top).

Q16 — Relative speed = 10 − 8 = 2 m/s; t = 25/2 = 12.5 s; distance covered by the car = 10 × 12.5 = 125 m.

Q17 — 72 km/h = 20 m/s, 36 km/h = 10 m/s; $v^2 = u^2 + 2as \Rightarrow a = (100 - 400)/(2 \times 200) = -0.75$ m/s² (retardation 0.75 m/s²); t = (10 − 20)/(−0.75) ≈ 13.3 s.

Q18 — $v(dv/dx) = -2x \Rightarrow v^2/2 = -x^2 + C$; at x = 2, v = 0 $\Rightarrow C = 4 \Rightarrow v^2 = 8 - 2x^2$; at x = 1 m: $v^2 = 6 \Rightarrow v = \sqrt{6} \approx 2.45$ m/s.

Q19 — (a) At the top v = 0: t(up) = u/g and t(down) = u/g (same height, same speed), hence equal. (b) Speed of car relative to van = 192 − 30 = 162 km/h = 45 m/s; bullet relative to car = 150 − 45 = 105 m/s.

Q20 — (a) Aim upstream at $\theta = \sin^{-1}(w/u)$ with the straight-across direction; resultant speed across the river = $\sqrt{(u^2 - w^2)}$; $t = d/\sqrt{(u^2 - w^2)}$. (b) t = 400/4 = 100 s; drift = w·t = 300 m downstream; resultant speed = $\sqrt{(4^2 + 3^2)} = 5$ m/s.