Chapter 2: Motion in a Straight Line - Answer Key

NCERT Physics Class 11

BACK EXERCISES - SOLUTIONS

2.1 Point Object Consideration

In which of the following examples of motion, can the body be considered approximately a point object:

(a) Railway carriage moving without jerks between two stations Answer: YES - The size of carriage is much smaller than the distance between stations.

(b) Monkey sitting on top of a man cycling smoothly on a circular track Answer: YES - Both monkey and man can be treated as point objects compared to track dimensions.

(c) Spinning cricket ball that turns sharply on hitting the ground Answer: NO - The spinning motion and sharp turn depend on the ball's size and shape, so it cannot be treated as a point object.

(d) Tumbling beaker that has slipped off the edge of a table Answer: NO - The tumbling motion involves rotation which depends on the beaker's dimensions and shape.

2.2 Position-Time Graph Analysis

Choose the correct entries in the brackets:

(a) (A/B) lives closer to the school than (B/A) Answer: A - From graph, A's home (point P) is closer to school O than B's home (point Q).

(b) (A/B) starts from the school earlier than (B/A) Answer: A - A starts at t = 0, while B starts later.

(c) (A/B) walks faster than (B/A) Answer: B - B has steeper slope, indicating higher speed.

(d) A and B reach home at the (same/different) time Answer: same - Both reach their respective homes at the same time.

(e) (A/B) overtakes (B/A) on the road (once/twice) Answer: A overtakes B once - The lines intersect once during the journey.

2.3 Position-Time Graph for Woman's Journey

Given:

- Home to office: 2.5 km at 5 km/h (30 minutes)
- Stay at office: 9:30 AM to 5:00 PM (7.5 hours)
- Return home: 2.5 km at 25 km/h (6 minutes)

Solution:

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Phase 1 (9:00-9:30 AM): Linear increase from 0 to 2.5 km
Phase 2 (9:30 AM-5:00 PM): Constant at 2.5 km
Phase 3 (5:00-5:06 PM): Linear decrease from 2.5 km to 0
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2.4 Drunkard's Motion

Pattern: 5 steps forward, 3 steps backward, repeat **Each step:** 1 m, 1 s

Solution:

- Net progress per cycle = 5 - 3 = 2 m in 8 s
- After 6 complete cycles: 12 m in 48 s
- 7th cycle: 5 more steps forward in 5 s
- Total time to reach 13 m away pit = 48 + 1 = 49 s

Graph: Sawtooth pattern with net positive slope of 0.25 m/s.

2.5 Car Retardation Problem

Given: v_0 = 126 km/h = 35 m/s, v = 0, s = 200 m

Solution: Using $v^2 = v_0^2 + 2as$:

$$0 = (35)^2 + 2a(200)$$
$$a = -1225/400 = -3.06 \text{ m/s}^2$$

Retardation = 3.06 m/s²

Time taken using $v = v_0 + at$:

$$0 = 35 + (-3.06)t$$
$$t = 35/3.06 = 11.4 \text{ s}$$

2.6 Ball Thrown Upward

Given: v_0 = 29.4 m/s, g = 9.8 m/s²

(a) Direction of acceleration during upward motion: Answer: Downward (opposite to velocity direction)

(b) Velocity and acceleration at highest point: Velocity: 0 m/s **Acceleration:** -9.8 m/s² (still downward)

(c) With given coordinate system (x = 0 at highest point, downward positive):

- **Upward motion:** position (-), velocity (-), acceleration (+)
- **Downward motion:** position (+), velocity (+), acceleration (+)

(d) Maximum height and time calculations:

Maximum height: $h = v_0^2/(2g) = (29.4)^2/(2\times9.8) = 44.1$ m
Time to reach max height: $t = v_0/g = 29.4/9.8 = 3.0$ s
Total time of flight: $2t = 6.0$ s

2.7 True/False Analysis

(a) Particle with zero speed at an instant may have non-zero acceleration Answer: TRUE Example: Ball at highest point of vertical throw has $v = 0$ but $a = -g \neq 0$

(b) Particle with zero speed may have non-zero velocity Answer: FALSE Reason: Speed is magnitude of velocity. If speed = 0, then $|v| = 0$, so $v = 0$

(c) Particle with constant speed must have zero acceleration Answer: TRUE for one-dimensional motion Reason: In 1D, constant speed means constant velocity, hence $a = 0$

(d) Particle with positive acceleration must be speeding up Answer: FALSE Reason: Depends on direction of velocity. If $v < 0$ and $a > 0$, particle is slowing down

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2.8 Ball Drop with Energy Loss

Given: h_0 = 90 m, loses 1/10 speed each collision

Solution:

Time for first fall: $t_1 = \sqrt{(2h_0/g)} = \sqrt{(180/9.8)} = 4.29$ s
Speed before first collision: $v_1 = gt_1 = 42.1$ m/s
Speed after first collision: $0.9 \times 42.1 = 37.9$ m/s

Heights after successive collisions:
$h_1 = v_1^2/(2g) = (37.9)^2/(19.6) = 73.2$ m
$h_2 = 0.81 \times 73.2 = 59.3$ m
$h_3 = 0.81 \times 59.3 = 48.0$ m

Graph: Decreasing amplitude sawtooth with reducing time intervals.

2.9 Displacement vs Path Length

(a) Magnitude of displacement vs total path length: Displacement: Straight line distance between initial and final positions **Path length:** Actual distance traveled along the path **Relationship:** |displacement| ≤ path length **Equality when:** Motion is along straight line in one direction

(b) Magnitude of average velocity vs average speed: Average velocity magnitude: |total displacement|/time **Average speed:** total path length/time **Relationship:** |average velocity| ≤ average speed **Equality when:** Motion is along straight line in one direction

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2.10 Market Trip Analysis

Given: Home to market: 2.5 km at 5 km/h, Market to home: 2.5 km at 7.5 km/h

Time calculations:

- To market: t_1 = 2.5/5 = 0.5 h = 30 min
- From market: t_2 = 2.5/7.5 = 1/3 h = 20 min

(a) Magnitude of average velocity: (i) 0 to 30 min: |2.5 km|/0.5 h = 5 km/h **(ii) 0 to 50 min:** |0 km|/50 min = 0 km/h **(iii) 0 to 40 min:** |1.25 km|/40 min = 1.875 km/h

(b) Average speed: (i) 0 to 30 min: 2.5 km/0.5 h = 5 km/h **(ii) 0 to 50 min:** 5 km/50 min = 6 km/h **(iii) 0 to 40 min:** 3.75 km/40 min = 5.625 km/h

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2.11 Instantaneous Speed vs Velocity Magnitude

Answer: At any instant, both speed and velocity refer to the same instant of time. Since speed is defined as the magnitude of instantaneous velocity, they are always equal: **Instantaneous speed = |instantaneous velocity|**

This differs from average quantities where the path and displacement can be different over a time interval.

2.12 Impossible Position-Time Graphs

(a) Possible - Single-valued function **(b) Impossible** - Multiple positions at same time (vertical line) **(c) Possible** - Valid parabolic motion **(d) Impossible** - Multiple positions at same time

Reason: Position-time graphs must be single-valued functions since an object cannot be at multiple positions simultaneously.

2.13 Motion Path Interpretation

Answer: NO, this interpretation is incorrect.

Correct interpretation: The graph shows one-dimensional motion along a straight line throughout. The change from linear to parabolic represents changing from constant velocity ($t < 0$) to constant acceleration motion ($t > 0$).

Physical context: A car moving at constant speed that starts accelerating at $t = 0$.

2.14 Bullet Speed Relative to Thief's Car

Given:

- Police van speed: 30 km/h = 8.33 m/s
- Thief's car speed: 192 km/h = 53.33 m/s
- Bullet muzzle speed: 150 m/s

Solution:

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Bullet speed relative to ground = 150 + 8.33 = 158.33 m/s
Thief's car speed relative to ground = 53.33 m/s
Bullet speed relative to thief's car = 158.33 - 53.33 = 105 m/s
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Answer: 105 m/s (This is the relevant speed for damage assessment)

2.15 Graph Physical Situations

(a) Position-time: Object moving away from origin, then returning **Example:** Ball thrown upward from ground level

(b) Velocity-time: Object accelerating in positive direction, then decelerating **Example:** Car speeding up then braking

(c) Acceleration-time: Constant positive acceleration, then constant negative **Example:** Rocket with thruster on, then off with air resistance

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2.16 Simple Harmonic Motion Signs

At t = 0.3 s:

- Position: Positive (above x = 0)
- Velocity: Negative (moving toward equilibrium)
- Acceleration: Negative (toward equilibrium)

At t = 1.2 s:

- Position: Negative (below x = 0)
- Velocity: Negative (moving away from equilibrium)
- Acceleration: Positive (toward equilibrium)

At t = -1.2 s:

- Position: Negative (below x = 0)
- Velocity: Positive (moving toward equilibrium)
- Acceleration: Positive (toward equilibrium)

2.17 Average Speed Comparison

Analysis of three equal intervals:

- **Interval 1:** Steepest slope (highest average speed)
- **Interval 2:** Medium slope (medium average speed)
- **Interval 3:** Gentlest slope (lowest average speed)

Average velocity signs:

- **Interval 1:** Positive (increasing position)
- **Interval 2:** Positive (increasing position)
- **Interval 3:** Positive (increasing position)

2.18 Speed-Time Graph Analysis

Greatest average acceleration magnitude: Interval 2 (steepest slope) **Greatest average speed:** Interval 2 (highest on speed axis)

Signs in three intervals:

- **Interval 1:** $v > 0$, $a > 0$ (speeding up in positive direction)
- **Interval 2:** $v > 0$, $a < 0$ (slowing down in positive direction)
- **Interval 3:** $v > 0$, $a = 0$ (constant speed in positive direction)

Accelerations at specific points:

- **Point A:** Positive (upward slope)
- **Point B:** Zero (horizontal tangent)
- **Point C:** Negative (downward slope)

- **Point D:** Zero (horizontal line)

KEY FORMULAS REFERENCE

Kinematic Equations

$v = v_0 + at$
$s = v_0t + \frac{1}{2}at^2$
$v^2 = v_0^2 + 2as$
$s = \frac{1}{2}(v_0 + v)t$

Graphical Relations

x-t graph: slope = velocity
v-t graph: slope = acceleration, area = displacement
a-t graph: area = change in velocity

Free Fall (taking downward as positive)

$v = gt$ (from rest)
$h = \frac{1}{2}gt^2$
$v^2 = 2gh$

Answer Key Complete - All exercise problems solved with detailed explanations and proper reasoning for JEE/NEET preparation.