PHYSICS SOLUTIONS HANDBOOK

CHAPTER 2: KINEMATICS

Complete Solved Exercise & Step-by-Step Solutions

Includes:

- Multiple Choice Questions with Explanations
- Short Answer Questions
- Constructed Response Questions
- Comprehensive Explanations
- Step-by-Step Numerical Solutions

Comprehensive Academic Solutions Series

A. Multiple Choice Questions

2.1 The numerical ratio of displacement to distance is:

(a) always less than one
(b) always equal to one
(c) always greater than one
(d) equal to or less than one ✓

Explanation: Displacement is the shortest distance between initial and final positions, while distance is total path length. Displacement magnitude is always ≤ distance. Thus, ratio is equal to or less than one.

2.2 If a body does not change its position with respect to some fixed point, then it will be in a state of:

(a) rest ✓
(b) motion
(c) uniform motion
(d) variable motion

Explanation: An object is at rest if its position relative to a fixed reference origin does not change over time.

2.3 A ball is dropped from the top of a tower, the distance covered by it in the first second is:

(a) 5 m ✓
(b) 10 m
(c) 50 m
(d) 100 m

Explanation: $s = ut + \frac{1}{2}at^2$. Initial $u = 0, t = 1\ s, a = g = 10\ m/s^2$. $s = 0 + \frac{1}{2}(10)(1)^2 = 5\ m$.

2.4 A body accelerates from rest to a velocity of 144 km h⁻¹ in 20 seconds. The distance covered by it is:

(a) 100 m
(b) 400 m ✓
(c) 1400 m
(d) 1440 m

Explanation: $v = 144 \times (5/18) = 40\ m/s$. $u = 0$. $a = (40 - 0)/20 = 2\ m/s^2$. Distance $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}(2)(20)^2 = 400\ m$.

2.5 A body is moving with constant acceleration starting from rest. It covers a distance S in 4 seconds. How much time does it take to cover one-fourth of this distance?

(a) 1 s

(b) 2 s ✓

(c) 4 s

(d) 16 s

Explanation: $S = \frac{1}{2}a(4)^2 = 8a$. For distance $S/4 = 2a$: $2a = \frac{1}{2}at^2 \Rightarrow t^2 = 4 \Rightarrow t = 2\ s$.

2.6 The displacement time graphs of two objects A and B are shown. Point out the true statement:

(a) The velocity of A is greater than B. ✓

(b) The velocity of A is less than B.

(c) The velocity of A is equal to that of B.

(d) The graph gives no information in this regard.

Explanation: Slope of displacement-time graph gives velocity. Line A is steeper than B, meaning slope and velocity of A are greater.

2.7 The area under the speed-time graph is numerically equal to:

(a) velocity
(b) uniform velocity
(c) acceleration
(d) distance covered ✓

Explanation: Area under speed-time graph represents total distance. Area = Speed × Time = Distance.

2.8 Gradient of the speed-time graph is equal to:

(a) speed
(b) velocity
(c) acceleration ✓
(d) distance covered

Explanation: Gradient (slope) of speed-time graph represents rate of change of speed, which is acceleration.

2.9 Gradient of the distance-time graph is equal to the:

(a) speed ✓
(b) velocity
(c) distance covered
(d) acceleration

Explanation: Gradient of distance-time graph represents rate of change of distance, which is speed.

2.10 A car accelerates uniformly from 80.5 km h^{-1} at t = 0 to 113 km h^{-1} at t = 9 s. Which graph best describes the motion?

(a) Graph A
(b) Graph B
(c) Graph (c) ✓
(d) Graph D

Explanation: Non-zero initial velocity with uniform acceleration gives a straight line with positive slope starting above zero on y-axis.

B. Short Answer Questions

2.1 Define scalar and vector quantities.

- **Scalar Quantities:** Completely described by magnitude and unit, no direction needed (e.g., mass, time, distance).
- **Vector Quantities:** Described by magnitude, unit, and specific direction (e.g., displacement, velocity, force).

2.2 Give 5 examples each for scalar and vector quantities.

- **Scalars:** Mass, Speed, Distance, Time, Volume.
- **Vectors:** Velocity, Displacement, Acceleration, Force, Momentum.

2.3 State head-to-tail rule for addition of vectors.

Place tail of second vector at head of first vector. Resultant vector is drawn from tail of first vector to head of second vector.

2.4 What are distance-time graph and speed-time graph?

- **Distance-time graph:** Plots distance vs time. Slope = speed.
- **Speed-time graph:** Plots speed vs time. Slope = acceleration; Area = distance.

2.5 Falling objects near the Earth have the same constant acceleration. Does this imply that a heavier object will fall faster than a lighter object?

No. Without air resistance, all objects fall with same acceleration due to gravity (g), regardless of mass.

2.6 The vector quantities are sometimes written in scalar notation (not bold face). How is the direction indicated?

Direction is indicated using an arrow over the symbol (e.g., A)□or explicitly giving angle and direction (e.g., 10 N North).

2.7 A body is moving with uniform speed. Will its velocity be uniform? Give reason.

Not necessarily. Velocity changes if direction changes (e.g., circular motion with uniform speed has changing velocity).

2.8 Is it possible for a body to have acceleration when moving with: (i) constant velocity (ii) constant speed?

- **(i) Constant velocity:** No, because change in velocity is zero.
- **(ii) Constant speed:** Yes, if direction changes (e.g., centripetal acceleration in circular motion).

C. Constructed Response Questions

2.1 Distance and displacement may or may not be equal in magnitude. Explain this statement.

Distance is total path length; displacement is shortest straight line. They are equal only during straight-line single-direction motion. Otherwise, distance is greater.

2.2 In which gun is the acceleration of the bullet larger: longer barrel or shorter barrel?

Shorter barrel has larger acceleration ($a = \Delta v/\Delta t$). Velocity is gained over a shorter distance and time interval, yielding higher rate of change.

2.3 Can instantaneous velocity be negative if average velocity for complete trip is positive?

Yes. If total displacement is positive, average velocity is positive. However, object could move backward temporarily, giving negative instantaneous velocity.

2.4 A ball thrown vertically upward returns in time T. Which graph represents this motion?

Graph (c). Velocity starts positive, linearly decreases to 0 at top ($T/2$), then turns negative increasing downwards till hitting ground at T.

2.5 Distance-time graph segment velocities for cyclist:

- **Segment a:** $v = 1.6\ km / 8\ min = 0.2\ km/min = 200\ m/min$
- **Segment b:** $v = 0\ km/min$ (at rest at 2.0 km)
- **Segment c:** $v = -2.0\ km / 8\ min = -0.25\ km/min = -250\ m/min$

2.6 Is it possible that velocity is zero at an instant, but acceleration is not zero?

Yes. At highest point of vertically thrown ball, velocity is momentarily 0, but gravity ($g = 9.8\ m/s^2$ downwards) continuously acts.

D. Comprehensive Questions

2.1 How a vector can be represented graphically? Explain.

Represented by a straight line with an arrowhead:

- Length of line = Magnitude according to scale.
- Arrowhead = Direction.
- Start point = Tail; End point = Head.

2.2 Differentiate between: (i) Rest and motion (ii) Speed and velocity

- **Rest vs Motion:** Rest does not change position relative to surroundings; Motion continuously changes position.
- **Speed vs Velocity:** Speed is scalar rate of distance covered; Velocity is vector rate of displacement covered.

2.3 Describe different types of motion with examples.

- **Translatory:** All parts move equal distance in same direction (linear car, circular fan, random bee).
- **Rotatory:** Body spins about fixed axis (spinning top, Earth's axis rotation).
- **Vibratory:** To and fro motion about mean position (pendulum, guitar string).

2.4 Explain the difference between distance and displacement.

Distance is scalar total path length (always positive). Displacement is vector shortest distance between initial and final points (can be positive, negative, or zero).

2.5 What do gradients of distance-time and speed-time graph represent?

- **Distance-Time Gradient:** Represents Speed ($\Delta y / \Delta x = Speed$).
- **Speed-Time Gradient:** Represents Acceleration ($\Delta v / \Delta t = Acceleration$).

2.6 Prove area under speed-time graph equals distance covered.

For uniform speed v over time t, area = rectangle height × width = $v \times t$. Since $Speed \times Time = Distance$, $Area = Distance$.

2.7 Equations of motion under gravity:

Replace acceleration a with $\pm g$ and distance s with height h:

- $v = u \pm gt$
- $h = ut \pm \frac{1}{2}gt^2$
- $2gh = v^2 - u^2$

E. Numerical Problems

2.1 Graphical Vector Representative Lines:

(a) Draw line at 60° to +x-axis (Scale: 1 cm = 100 m/s ⇒ 4 cm line with arrow).

(b) Draw line at 120° to +x-axis (Scale: 1 cm = 10 N ⇒ 5 cm line with arrow).

2.2 Car moving at 72 km/h covering 360 km:

$$Time = Distance / Speed = 360 / 72 = 5 \text{ hours}$$

Answer: 5 h

2.3 Truck reaching 90 km/h from rest in 50 s:

$$v = 90 \times (5/18) = 25 \text{ m/s}, u = 0, t = 50 \text{ s}$$

$$a = (v - u)/t = (25 - 0)/50 = 0.5 \text{ m/s}^2$$

Answer: 0.5 m s^{-2}

2.4 Car at 5 m/s accelerates at 1.5 m/s² for 5 s:

$v = u + at = 5 + (1.5 \times 5) = 5 + 7.5 = 12.5\ m/s$

Answer: 12.5 m s⁻¹

2.5 Motorcycle at 18 km/h accelerating at 2 m/s² for 10 s:

$u = 18 \times (5/18) = 5\ m/s$

$s = ut + ½at^2 = (5 \times 10) + ½(2)(10)^2 = 50 + 100 = 150\ m$

Answer: 150 m

2.6 Wagon at 54 km/h stops in 25 m after braking:

$u = 54 \times (5/18) = 15\ m/s,\ v = 0,\ s = 25\ m$

$v^2 = u^2 + 2as \Rightarrow 0 = (15)^2 + 2a(25) \Rightarrow a = -225 / 50 = -4.5\ m/s^2$

Answer: -4.5 m s⁻²

2.7 Stone dropped from height of 45 m:

$u = 0, s = 45\ m, g = 10\ m/s^2$

Time: $45 = \frac{1}{2}(10)t^2 \Rightarrow 5t^2 = 45 \Rightarrow t = 3\ s$

Velocity: $v = u + gt = 0 + 10(3) = 30\ m/s$

Answer: Time = 3 s, Velocity = 30 m s^{-1}

2.8 Car travel: 10 km @ 20 m/s, then 0.8 km @ 4 m/s:

Part 1: $t_1 = 10000 / 20 = 500\ s$

Part 2: $t_2 = 800 / 4 = 200\ s$

$Avg\ Velocity = (10000 + 800)/(500 + 200) = 10800 / 700 = 15.4\ m/s$

Answer: 15.4 m s^{-1}

2.9 Ball dropped reaches ground in 5 s:

$h = \frac{1}{2}gt^2 = \frac{1}{2}(10)(5)^2 = 125\ m$

$v = gt = 10(5) = 50\ m/s$

Answer: Height = 125 m, Velocity = 50 m s^{-1}

2.10 Cricket ball reaching top in 3 s (hit 1 m above ground):

Initial Velocity: $0 = u - 10(3) \Rightarrow u = 30\ m/s$

Rise Height: $h_1 = (30)(3) - \frac{1}{2}(10)(3)^2 = 45\ m$

Total Height: $45 + 1 = 46\ m$

Answer: Initial velocity = 30 m s^{-1}, Height = 46 m

END OF EXERCISE

All Questions, MCQs, Explanations, and Step-by-Step Numericals from Chapter 2 (Kinematics) Have Been Successfully Solved.

Keep Learning & Best of Luck with Your Physics Studies!