# Motion in a Straight Line — Assignment 1

Class 11 Physics · Topic-wise question bank covering every concept of the chapter · Narayan Gurukul Academy

Instructions: (1) Attempt all questions. This worksheet walks through every concept of the chapter, topic by topic.
(2) The interactive MCQ version of these questions (with instant answer reveal) is available on the notes page.
(3) Universal values: g = 10 m/s^2 unless stated. Give answers with correct SI units.

## Position, Distance and Displacement

### MCQ Questions (choose the correct option)

1. A particle moves from A to B along a semicircular path of radius R. The ratio of the distance travelled to the magnitude of its displacement is —

(A) π : 2
(B) 2 : π
(C) π : 1
(D) 1 : π

2. A runner completes exactly one full lap of a circular track of radius 200 m. Her distance travelled and the magnitude of her displacement are respectively —

(A) 2π(200) m and 0
(B) 0 and 2π(200) m
(C) 400 m and 2π(200) m
(D) 2π(200) m and 400 m

3. A body moves 3 m due north and then 4 m due east. The magnitude of its displacement from the starting point is —

(A) 5 m
(B) 7 m
(C) 1 m
(D) 12 m

4. Which of the following statements about a moving body can never be true?

(A) Distance equals the magnitude of displacement.
(B) Distance is greater than the magnitude of displacement.
(C) Distance is less than the magnitude of displacement.
(D) The magnitude of displacement is zero even though the distance travelled is non-zero.

### 1 Mark Questions

1. Define a point object (particle) in the study of motion.

2. Write the SI unit of displacement.

3. When is the magnitude of displacement equal to the distance travelled?

4. Can the displacement of a moving body be zero while the distance travelled is non-zero? Give one example.

### 2 Mark Questions

1. Distinguish between distance and displacement, giving one example each.

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

3. A man walks 5 m north, 3 m east and finally 5 m south. Find the magnitude of his displacement and the distance he walked.

4. Explain, with an example, why the magnitude of displacement is never greater than the distance travelled.

### 3 Mark Questions

1. Define position, trajectory and displacement. A particle moves from x = 2 m to x = 8 m and then back to x = 5 m. Find the distance travelled and its displacement.

2. A cyclist rides one full round of a square park of side 100 m in 12 minutes. Find (i) the distance travelled, (ii) the magnitude of his displacement, and (iii) his average speed in m/s.

## Average Speed and Average Velocity — the Two Exam Traps

### MCQ Questions (choose the correct option)

1. A car covers the first half of its journey at 40 km/h and the second half at 60 km/h. Its average speed for the whole journey is —

   (A) 48 km/h

   (B) 50 km/h

   (C) 45 km/h

   (D) 52 km/h

2. A body moves at 20 m/s for a time t and then at 30 m/s for an equal time t. Its average speed is —

   (A) 25 m/s

   (B) 24 m/s

   (C) 26 m/s

   (D) 40 m/s

3. 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

4. For a body that completes a round trip, the average velocity over the whole trip is —

   (A) zero

   (B) equal to the average speed

   (C) half the average speed

   (D) equal to the arithmetic mean of the two speeds

### 1 Mark Questions

1. Define average speed.

2. Define average velocity.

3. Can the average velocity of a moving body over an interval be zero while its average speed is non-zero? Give one example.

4. What is the average speed of a body that moves at speeds $v_1$ and $v_2$ for two equal time intervals?

### 2 Mark Questions

1. Derive the expression for the average speed of a body that covers equal distances at speeds $v_1$ and $v_2$.

2. 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 round trip.

3. Distinguish between average speed and average velocity. When do their magnitudes become equal?

4. A particle moves at 10 m/s for 5 s and then at 20 m/s for 10 s. Find its average speed.

### 3 Mark Questions

1. A body covers the first half of a journey at speed $v_1$ and the second half at speed $v_2$. Show that its average speed is $2v_1v_2/(v_1 + v_2)$.

2. A man walks 2.5 km to a market at 5 km/h and returns at 7.5 km/h. Find (i) his average speed for the round trip and (ii) the magnitude of his average velocity for the whole trip.

## Acceleration and Retardation

### MCQ Questions (choose the correct option)

1. A body moving with velocity v is given an acceleration directly opposite to its velocity. The body will —
   (A) slow down (its speed decreases)
   (B) speed up
   (C) move with constant velocity
   (D) stop instantly
2. The SI unit of acceleration is —
   (A) $m/s^2$
   (B) m/s
   (C) $m^2/s$
   (D) km/h
3. The velocity of a body changes uniformly from 10 m/s to 20 m/s in 5 s. Its average acceleration is —
   (A) 2 $m/s^2$
   (B) 10 $m/s^2$
   (C) 4 $m/s^2$
   (D) 5 $m/s^2$
4. A body moving with uniform velocity has acceleration —
   (A) zero
   (B) constant but non-zero
   (C) ever-increasing
   (D) that cannot be determined

### 1 Mark Questions

1. Define acceleration.

2. What is retardation?

3. A body starts from rest and has a uniform acceleration of 2 $m/s^2$. Find its velocity after 4 s.

4. Can a body have negative acceleration while it is speeding up? Explain in one line.

### 2 Mark Questions

1. Distinguish between acceleration and retardation with an example.

2. A car moving at 72 km/h is brought to rest by applying brakes in 5 s. Find its retardation.

3. Why is a negative acceleration not always retardation? Explain with an example.

4. The velocity of a particle changes from 5 m/s to 25 m/s in 4 s. Find its average acceleration.

### 3 Mark Questions

1. Define average acceleration and instantaneous acceleration, and show that they are equal when acceleration is constant.

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

3. A body moving with uniform acceleration covers 20 m in the 1st second and 40 m in the 2nd second. Find its initial velocity and acceleration.

## Equations of Motion and the nth-Second Formula

### MCQ Questions (choose the correct option)

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. A body starts from rest with a uniform acceleration of 10 $m/s^2$. The distance covered by it in the 3rd second is —
   (A) 25 m
   (B) 45 m
   (C) 15 m
   (D) 35 m
3. A car increases its speed uniformly from 10 m/s to 20 m/s while covering a distance of 50 m. Its acceleration is —
   (A) 3 $m/s^2$
   (B) 5 $m/s^2$
   (C) 2 $m/s^2$
   (D) 6 $m/s^2$
4. The equations $v = u + at$, $s = ut + \frac{1}{2}at^2$ and $v^2 = u^2 + 2as$ are all valid when —
   (A) acceleration is constant
   (B) velocity is constant
   (C) acceleration varies linearly with time
   (D) the body is in free fall under gravity only

### 1 Mark Questions

1. State the three equations of motion for a uniformly accelerated body.
2. Write the formula for the displacement of a body during the nth second of its motion.
3. Under what condition does the nth-second formula give the true distance travelled rather than just the displacement?
4. A body starts from rest and accelerates uniformly at 5 $m/s^2$. Find its velocity after 4 s.

### 2 Mark Questions

1. Derive the first equation of motion, $v = u + at$, using the definition of acceleration.
2. Derive the expression for the displacement of a body in the nth second: $s_n = u + (a/2)(2n - 1)$.
3. A body starting from rest moves with a uniform acceleration of 5 $m/s^2$. Find its displacement in the 8th second.
4. A stone is dropped from rest. Taking $g = 10\ m/s^2$, find the distance it falls in the 4th second.

### 3 Mark Questions

1. Derive the three equations of motion for a body moving with uniform acceleration.
2. A particle starts from rest with a uniform acceleration of 6 $m/s^2$. Find the distance covered (i) in the first 5 s and (ii) in the 5th second.

3. A body starts from rest with uniform acceleration a. Show that the distances covered in successive seconds are in the ratio 1 : 3 : 5 : 7 ... .

## Reading Motion Graphs

### MCQ Questions (choose the correct option)

1. The slope of a position–time graph at any instant gives the —
   (A) instantaneous velocity
   (B) instantaneous acceleration
   (C) average velocity
   (D) displacement
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. The position–time graph of a body moving with constant acceleration is a —
   (A) parabola
   (B) straight line
   (C) hyperbola
   (D) circle
4. The velocity–time graph of a body moving with constant velocity is —
   (A) a straight line parallel to the time axis
   (B) a straight line through the origin sloping upward
   (C) a parabola
   (D) a straight line sloping downward

### 1 Mark Questions

1. What does the slope of a velocity–time graph represent?
2. What does the area under an acceleration–time graph give?
3. What is the nature of the x–t graph of a body at rest?
4. Can a position–time graph for a real particle ever be vertical? Give a reason.

### 2 Mark Questions

1. Derive the relation $s = ut + \frac{1}{2}at^2$ using the area under a velocity–time graph.
2. Draw the v–t graph of a body (i) at rest, (ii) moving with uniform velocity, and (iii) moving with uniform acceleration.
3. The velocity of a particle increases uniformly from 10 m/s to 25 m/s in 5 s. Using the v–t graph, find the distance covered.
4. What does the slope of an x–t graph and the area under a v–t graph represent?

### 3 Mark Questions

1. Draw the x–t, v–t and a–t graphs for a ball thrown vertically upward until it returns to the thrower (air resistance neglected).
2. From the velocity–time graph of a uniformly accelerated body, derive all three equations of motion.

## Motion Under Gravity (Free Fall)

### MCQ Questions (choose the correct option)

1. 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
2. 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
3. A stone released from rest (g = 10 m/s$^2$) falls a distance of 35 m during —
   (A) the 4th second
   (B) the 3rd second
   (C) the 1st second
   (D) the 2nd second
4. For a ball thrown vertically upward (air resistance neglected), the time taken to rise to the highest point is —
   (A) equal to the time taken to fall back
   (B) greater than the time taken to fall back
   (C) less than the time taken to fall back
   (D) twice the time taken to fall back

### 1 Mark Questions

1. Define free fall.
2. What is the approximate value of acceleration due to gravity on the Earth's surface?
3. Write the three kinematic relations for a body dropped from rest.
4. In what ratio do the distances fallen from rest in successive seconds stand?

### 2 Mark Questions

1. Derive the expression for the maximum height reached by a body thrown vertically upward with speed u.
2. A ball is thrown upward with a speed of 30 m/s. Taking g = 10 m/s$^2$, find (i) the maximum height reached and (ii) the total time of flight.
3. Show that the time of ascent equals the time of descent for a body thrown vertically upward (air resistance neglected).
4. A stone dropped from a tower reaches the ground in 3 s. Taking g = 10 m/s$^2$, find the height of the tower and the velocity of impact.

### 3 Mark Questions

1. A ball thrown vertically upward returns to its starting point in 6 s. Taking g = 10 m/s$^2$, find (i) its initial velocity and (ii) the maximum height reached.
2. 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/s$^2$, find when and where the two stones meet.
3. A body is thrown vertically upward with a speed of 40 m/s. Taking g = 10 m/s$^2$, find (i) its height after 2 s, (ii) the total time of flight, and (iii) the velocity with which it passes the thrower's hand on its way down.

## Non-Uniform Acceleration and Calculus

### MCQ Questions (choose the correct option)

1. The position of a particle is $x = a + bt^2$ (a and b constant). Its acceleration is —
   (A) 2b, a constant
   (B) 2bt, increasing with time
   (C) b, a constant
   (D) zero
2. A particle starts from rest with acceleration $a = kt$ (k constant). Its velocity at time t is —
   (A) $\frac{1}{2}kt^2$
   (B) kt
   (C) 2kt
   (D) $\frac{1}{2}kt$
3. The position of a particle is $x = 3 + 8t + 7t^2$ (x in metres, t in seconds). Its velocity at t = 0 is —
   (A) 8 m/s
   (B) 3 m/s
   (C) 14 m/s
   (D) 7 m/s
4. A particle starts from rest with acceleration $a = 3t^2 + 2t + 2$ ($m/s^2$). Its velocity at t = 1 s is —
   (A) 4 m/s
   (B) 7 m/s
   (C) 3 m/s
   (D) 5 m/s

### 1 Mark Questions

1. Write the differential definitions of velocity and acceleration.
2. Can the equation $v = u + at$ be used when the acceleration varies with time? Give a reason.
3. Write the relation $a = v(dv/dx)$. When is this form especially useful?
4. The displacement of a particle is $x = 2t^2 - 3t$. Find its velocity at t = 2 s.

### 2 Mark Questions

1. For a particle with $x = 3 + 8t + 7t^2$ (x in metres, t in seconds), find its velocity and acceleration at any time t.
2. A particle starts from rest with an acceleration $a = 6t$ ($m/s^2$). Find its velocity and displacement as functions of time.
3. Explain why the three kinematic equations cannot be applied when the acceleration is not constant.
4. The velocity of a particle is $v = 3t^2 + 4t + 2$ (m/s). Find its acceleration at t = 1 s.

### 3 Mark Questions

1. A particle starts from rest at t = 0 with an acceleration $a = 3t^2 + 2t + 2$ ($m/s^2$). Find its velocity and displacement at t = 2 s.
2. A particle has acceleration $a = -kv$ (k constant) and initial velocity u. Find its velocity as a function of time.
3. 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.

## Frames of Reference

### MCQ Questions (choose the correct option)

1. A passenger sitting inside a moving train is at rest with respect to —
   (A) a fellow passenger seated beside him
   (B) a person standing on the platform
   (C) a tree on the roadside
   (D) the platform clock
2. A frame of reference in which Newton's laws hold in their simple form is called —
   (A) an inertial frame
   (B) a non-inertial frame
   (C) an accelerating frame
   (D) a rotating frame
3. A bus taking a sharp turn without changing its speed is —
   (A) a non-inertial frame
   (B) an inertial frame
   (C) a frame at rest
   (D) an inertial frame because its speed is constant
4. The Earth is treated as an approximately inertial frame because —
   (A) its rotation and its acceleration around the Sun are very small
   (B) it has no acceleration at all
   (C) it is much more massive than other bodies
   (D) gravity acts vertically downward

### 1 Mark Questions

1. Define a frame of reference.
2. What is an inertial frame of reference?
3. Why is a pseudo-force required in a non-inertial frame?
4. Is a frame moving with constant velocity inertial or non-inertial?

### 2 Mark Questions

1. Distinguish between inertial and non-inertial frames of reference, giving one example of each.
2. Two passengers sit face to face inside a train moving at uniform velocity. Explain why they see each other at rest while a person on the platform sees them in motion.
3. A lift accelerates upward with acceleration a. Find the effective weight of a man of mass m standing in the lift, as observed from the ground frame.
4. Is the Earth a perfect inertial frame? Give a reason.

### 3 Mark Questions

1. Explain with examples why motion is relative — a body at rest in one frame is in motion in another.
2. A mass m hangs from a spring balance in a lift. The lift accelerates upward at a. Show, from the lift frame and from the ground frame, that the balance reads m(g + a).
3. State the condition for a frame to be inertial, and show that any frame moving uniformly with respect to an inertial frame is itself inertial.

## Relative Velocity in a Straight Line

### MCQ Questions (choose the correct option)

1. Two cars move toward each other along a straight road with speeds 20 m/s and 30 m/s. The speed with which they approach each other is —

(A) 50 m/s

(B) 10 m/s

(C) 25 m/s

(D) 600 m/s

2. Two trains move in the same direction with speeds 20 m/s and 30 m/s. The speed of the faster train relative to the slower one is —

(A) 10 m/s

(B) 50 m/s

(C) 30 m/s

(D) 0

3. The relative velocity of B with respect to A, both moving along the same straight line, is —

(A) $v_B - v_A$

(B) $v_A - v_B$

(C) $v_A + v_B$

(D) always $|v_A| + |v_B|$

4. A 150 m long train moving at 15 m/s crosses a pole. The time taken is —

(A) 10 s

(B) 150 s

(C) 15 s

(D) 2.25 s

## 1 Mark Questions

1. Define relative velocity.

2. Write the expression for the relative velocity of A with respect to B when both move along the same straight line.

3. Two bodies move along the same line in the same direction with speeds 20 m/s and 15 m/s. What is their relative velocity?

4. When is the relative velocity of two bodies equal to the sum of their individual speeds?

## 2 Mark Questions

1. Derive the expression $v_{BA} = v_B - v_A$ for two bodies moving along a straight line.

2. Two cars move toward each other with speeds 20 m/s and 30 m/s. Find the rate at which their separation decreases and the reduction in separation in 10 s.

3. A 120 m long train moving at 10 m/s overtakes an 80 m long train moving at 6 m/s in the same direction. Find the time taken to completely pass it.

4. A police van moving 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.

## 3 Mark Questions

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

2. A car moving at 20 m/s is 60 m behind a bus moving at 15 m/s in the same direction. Find (i) how long the car takes to catch the bus and (ii) the distance covered by the car before catching it.

3. Show that for two bodies moving toward each other along a straight line, the time to collision depends only on the initial separation and the sum of their speeds.

## River–Boat and Rain–Man Problems

### MCQ Questions (choose the correct option)

1. 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

2. A boat rows with a still-water speed b in a river of current speed w. Its speed downstream is —

(A) b + w

(B) b − w

(C) w − b

(D) $\sqrt{(b^2 + w^2)}$

3. Rain falls vertically at 3 m/s while a man runs horizontally at 4 m/s. To the man, the rain appears to fall with a speed of —

(A) 5 m/s

(B) 7 m/s

(C) 1 m/s

(D) √7 m/s

4. To cross a river along the shortest possible path, a swimmer must —

(A) aim upstream at a suitable angle

(B) swim perpendicular to the flow

(C) aim downstream at a suitable angle

(D) swim exactly against the current

### 1 Mark Questions

1. Write the velocity-addition relation for an object moving in a river: velocity relative to the ground in terms of its velocity relative to the water and the current's velocity.

2. For a swimmer crossing a river perpendicular to the flow, what determines the time of crossing?

3. What is meant by drift in a river-boat problem?

4. A boat's speed in still water is u and the current speed is w. What is its speed downstream?

### 2 Mark Questions

1. A boat rows perpendicular to the banks of a 1 km wide river at 5 km/h in still water, while the current flows at 3 km/h. Find the time to cross and the drift.

2. Rain falls vertically at 3 m/s and a man runs horizontally at 4 m/s. Find the speed with which the rain strikes the man and the direction in which he should hold his umbrella.

3. Derive an expression for the drift of a swimmer who aims perpendicular to a river of width d, with current speed w and still-water speed u.

4. 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.

### 3 Mark Questions

1. 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 u, w and the width d.

2. A swimmer crosses a 200 m wide river at 4 m/s in still water aiming perpendicular to the flow, while the current is 3 m/s. Compute (i) the time to cross, (ii) the point of landing downstream, and (iii) the angle the actual path makes with the straight-across direction.

3. Rain is falling with a velocity of 10 m/s at 30° to the vertical, and a man is running horizontally at 5 m/s in the direction in which the rain has its horizontal component. Find the velocity of the rain relative to the man.