AL AMAL LEARNING CENTER

PHYSICS KEY BOOK

Class 9 | Unit 2

KINEMATICS

EXERCISE QUESTIONS

What is inside

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1	Short Response Questions (Q II, questions 1 to 10)
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About this part

Model answers for the Class 9 Physics Unit 2 exercise: short response and long response questions, written in exam style with tables, examples and graphs. Every question of Q II and Q III is covered.

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PART SHORT RESPONSE QUESTIONS (Q II)

Give a short response to the following questions.

1. In a park, children are enjoying a ride on Ferris wheel as shown. What kind of motion the big wheel has and what kind of motion the riders have?

	Body	Type of motion	Reason
a	Big wheel	**Rotatory motion**	The whole wheel turns around its fixed axis passing through its centre.
b	Riders (in the cabins)	**Circular motion** (a curvilinear translatory motion)	Each rider moves along a circular path of constant radius while the cabin keeps its orientation.

2. A boy moves for some time, give two situations in which his displacement is zero but covered distance is not zero?

	Situation	Distance	Displacement
i	He runs once around a 400 m track and stops at the starting point	400 m	0 m
ii	He walks 50 m to a shop and returns to the same place	100 m	0 m

In both cases the final position is the same as the initial position, so $\Delta d = d_f - d_i = 0$, but the path covered is not zero.

3. A stone tied to string is whirling in circle, what is direction of its velocity at any instant?

> The velocity is always along the **tangent** to the circle at that point, in the direction in which the stone is moving at that instant.

The speed may stay constant, but the direction of the tangent keeps changing, so the velocity keeps changing. If the string breaks, the stone flies off along this tangent.

4. Is it possible to accelerate an object without speeding it up or slowing it down?

> **Yes.** Acceleration is the rate of change of **velocity**, and velocity changes when speed, direction, or both change.

If only the direction changes while the speed stays constant, the object still accelerates. Examples: a car turning a bend at constant speed, a satellite moving in a circular orbit, the drone in Figure 2.10.

5. Can a car moving towards right have direction of acceleration towards left?

> **Yes.** When the car slows down (brakes are applied), the acceleration is opposite to the velocity, so it points to the left.

Example: a car moves right at 20 m/s and stops in 10 s. $a = (0 - 20) \div 10 = -2$ m/s². The negative sign shows the acceleration is towards the left (deceleration).

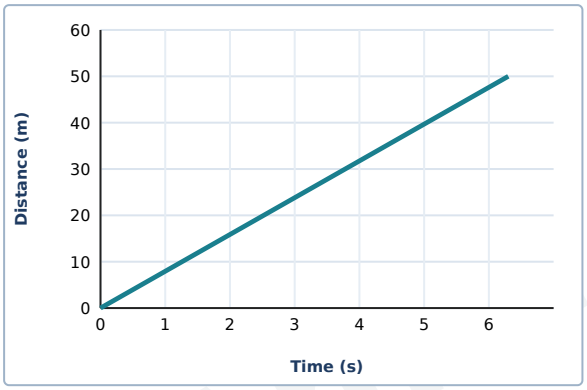
6. With the help of daily life examples, describe the situations in which:

	Situation	Daily-life example
a	Acceleration is in the direction of motion	A car speeding up after the traffic signal turns green; a stone falling freely towards the ground.
b	Acceleration is against the direction of motion	A car or bicycle slowing down when brakes are applied; a ball thrown upward (gravity acts downward).
c	Acceleration is zero and body is in motion	A car moving at a constant speed on a straight motorway; a train running with uniform velocity.

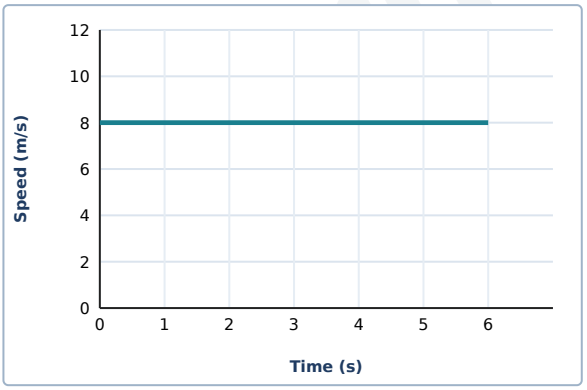
7. Examine distance-time graph of a motorcyclist (as shown), what does this graph tell us about the speed of motorcyclist? Also plot its velocity-time graph.

The graph is a **straight line through the origin**. A constant slope means the distance increases by equal amounts in equal times, so the motorcyclist moves with **uniform (constant) speed**.

Reading from the graph	Working	Result
Slope = Δs ÷ Δt	≈ 48 m ÷ 6 s (the line reaches about 24 m at 3 s)	**≈ 8 m/s**
Acceleration	Slope of the speed is zero (constant speed)	**0 m/s²**



Given: distance–time graph



Plotted: speed–time graph

The speed–time graph is a **horizontal straight line** at about 8 m/s, showing constant speed and zero acceleration.

8. Which controls in the car can produce acceleration or deceleration in it?

Control	Effect
Accelerator (gas) pedal	Increases the speed, so it produces positive acceleration.
Brake pedal	Decreases the speed, so it produces deceleration (negative acceleration).
Gear lever / clutch	Changes the gear, which changes the speed of the car.
Steering wheel	Changes the direction of motion. Velocity changes, so the car accelerates even at constant speed.

9. If two stones of 10 kg and 1 kg are dropped from a 1 km high tower. Which will hit the ground with greater velocity? Which will hit the ground first? (Neglect the air resistance)

> **Both** stones hit the ground with the **same velocity** and at the **same time**.

In free fall every body has the same acceleration g = 9.8 m/s², independent of its mass (Galileo's experiment at the leaning tower of Pisa). For a 1 km (1000 m) tower: t = √(2h ÷ g) = √(2000 ÷ 9.8) ≈ 14.3 s and v = g t ≈ 9.8 × 14.3 ≈ 140 m/s for both stones.

10. A 100 g ball is just released (from rest) and another is thrown downward with velocity of 10 m/s, which will have greater acceleration? (Neglect the air resistance)

> **Neither.** Both balls have the **same acceleration**, g = 9.8 m/s² downward.

Acceleration due to gravity does not depend on the mass or on the initial velocity. The ball thrown downward has the greater **velocity** at every instant (it starts at 10 m/s), but both gain speed at the same rate: 9.8 m/s every second.

> **Note:** Numerical Response Questions (Q IV) are fully solved in the Unit 2 Numericals Key Book. Multiple Choice Questions (Q I) are in the MCQs Key Book.

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PART LONG RESPONSE QUESTIONS (Q III)

Give a detailed response to questions below.

1. Differentiate between rest and motion. With the help of example, show that rest and motion are relative to observer.

Point	Rest	Motion
Definition	An object does not change its position with passage of time, with respect to an observer.	An object changes its position with passage of time, with respect to an observer.
Distance covered	Zero	Not zero
Example	A bench fixed under a tree in a park, for a person standing near it	A car moving on the road, for a person on the roadside

Rest and motion are relative. An object can be at rest and in motion at the same time. It depends on the observer (reference point), so we must always say "with respect to whom".

- **Example 1:** A passenger sitting in a moving bus is at rest with respect to the seat and the other passengers (their position does not change), but in motion with respect to a person standing on the roadside.
- **Example 2 (from the chapter):** A parked car is at rest with respect to us. But the Earth spins on its axis, goes around the Sun, and the Sun moves with the solar system through the Milky Way. So with respect to the Sun the "parked" car is in motion.

Conclusion: No object is absolutely at rest or absolutely in motion. We state it with reference to some observer.

2. What are different types of motion? Define each type of motion with examples from daily life.

Motion is broadly divided into three types: translatory, rotatory and vibratory.

Type	Definition	Examples
Translatory motion	All points of a moving object move uniformly in the same direction, with no change in the object's orientation. The path can be straight, curved or random.	Ball, car, flying birds, airplane
Rotatory motion	An object rotates on its own axis (a line passing through the object). Its particles move in circles.	Blades of a fan, helicopter rotors, spinning basketball
Vibratory motion	An object moves to and fro repeatedly about a fixed mean position.	Swing, strings of a sitar or guitar

Translatory motion has three kinds:

Kind	Definition	Examples
Rectilinear	Translatory motion along a straight-line path.	Train on a track, a bullet fired from a gun, a falling apple
Curvilinear	Translatory motion along a curved path. **Circular motion** is a special case in which the radius stays constant.	A kicked football, roller coaster, a vehicle taking a turn
Random	Translatory motion with no specific (irregular) path.	A kite flying in the sky, motion of clouds, a butterfly

> **Note:** An object can have a combination of these types. For example, a wheel of a moving car is in translatory motion (the car goes forward) and rotatory motion (the wheel spins) at the same time.

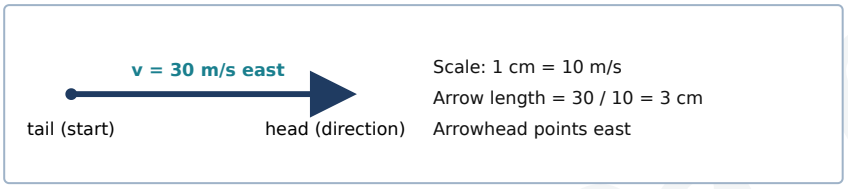
3. What are scalars and vectors? Give examples. How are vectors represented symbolically and graphically?

	Scalar	Vector
Definition	A physical quantity with **magnitude only** (a number and a unit).	A physical quantity with **magnitude and direction**.
Examples	Distance, speed, time, mass	Position, displacement, velocity, acceleration, force
Adding	Ordinary addition	Needs direction (head-to-tail method)

Symbolic representation: a vector is written with an arrow above the letter, for example $\vec{d}$, $\vec{v}$, $\vec{a}$ (or in bold type). The magnitude is written without the arrow, or inside bars, for example $|\vec{v}| = v$.

Graphical representation: a vector is drawn as a straight arrow to a chosen scale.

- The **length** of the arrow is proportional to the magnitude (taken from the scale).
- The **arrowhead** shows the direction.
- The **tail** is the starting point and the **head** is the end point.



Note: This chapter gives the quantities as scalar (distance, speed) and vector (displacement, velocity, acceleration). The detailed vector rules are from Unit 1, so the definitions and drawing steps above are the standard ones.

4. Define the term position. Differentiate between distance and displacement.

Position is the distance and direction of a body from a fixed reference point.

Point	Distance	Displacement
Definition	The length of the path travelled between two positions.	The shortest (straight, directed) distance from the initial position to the final position.
Type	Scalar (magnitude only)	Vector (magnitude and direction)
Formula	Δs (or Δx, Δr, Δd, Δl)	$\Delta\vec{d} = \vec{d}_f - \vec{d}_i$
SI unit	metre (m)	metre (m)
Depends on path?	Yes, it depends on the path taken.	No, only on the initial and final positions.
Can it be zero?	No, not if the body has moved.	Yes, if the body returns to the starting point.
Comparison	Always $\geq$ displacement	Always $\leq$ distance

- **Example 1 (chapter):** From Faisal Masjid to Blue Area in Islamabad, the twisted road is the distance. The straight line between the two places is the displacement, which is shorter.
- **Example 2:** After one full lap of a 400 m track, distance = 400 m but displacement = 0.
- Distance and displacement are equal only when the body moves in a straight line without changing direction.

5. Differentiate between speed and velocity. Also define average speed, uniform and variable speeds, average velocity, uniform and variable velocities.

Point	Speed	Velocity
Definition	Distance covered per unit time	Displacement covered per unit time
Formula	$v = \Delta s \div \Delta t$	$\vec{v} = \Delta\vec{d} \div \Delta t$
Type	Scalar	Vector
Direction	Not needed	Needed, same as displacement
SI unit	m/s	m/s

Term	Definition	Formula / example
Average speed	Total distance covered in total time.	$v_{ave} = s \div t$. Example: 800 m in 40 s gives 20 m/s.
Instantaneous speed	The speed at one particular instant of time.	Shown on a car's speedometer.
Uniform speed	An object covers **equal distances in equal intervals of time**. It does not get faster or slower.	A car moving at a steady 70 km/h.
Variable speed	The object covers unequal distances in equal intervals of time.	A car in city traffic.
Average velocity	Total displacement in total time.	$\bar{v} = \vec{d} \div t$. Example: 600 m displacement in 40 s gives 15 m/s.
Instantaneous velocity	Velocity measured over a very small time interval. Speed **and** direction at that moment must be given.	Velocity of a car at one instant.
Uniform velocity	An object covers **equal displacements in equal intervals of time**. Neither speed nor direction changes.	A car on a straight road at constant speed.
Variable velocity	Speed or direction (or both) changes.	A satellite in a circular orbit has constant speed but variable velocity, because its direction keeps changing.

6. What are freely falling bodies? What is gravitational acceleration? Write down sign conventions for gravitational acceleration. Write three equations of motion of a freely falling body?

Freely falling bodies: bodies that fall towards the Earth under the force of gravity alone, with air resistance neglected. Example: a coin and a piece of paper fall together in a vacuum. Galileo showed that bodies of different masses dropped from the leaning tower of Pisa reach the ground at the same time.

Gravitational acceleration (g): the acceleration of a freely falling body due to Earth's gravity. It is directed downward towards the centre of the Earth, is the same for all bodies whatever their mass, and near the Earth's surface **g = 9.8 m/s²** (32.2 ft/s²).

Motion of the body	Sign of g	Reason
Moving **with** gravity (falling down)	**+g** = +9.8 m/s²	Speed increases
Moving **against** gravity (thrown up)	**−g** = −9.8 m/s²	Speed decreases

Three equations of motion of a freely falling body (initial velocity v_i, final velocity v_f, time t, height h, acceleration g):

	Equation	Meaning
1	$v_f = v_i + g\,t$	Final velocity after time t
2	$h = v_i\,t + \frac{1}{2}\,g\,t^2$	Height (distance) covered in time t
3	$v_f^2 = v_i^2 + 2\,g\,h$	Final velocity after covering height h (no time)

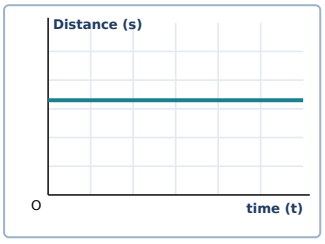
Derivation. From $g = (v_f - v_i) \div \Delta t$ we get $\mathbf{v_f = v_i + g\,t}$. Average velocity $= (v_i + v_f) \div 2$, so $h = \frac{1}{2}(v_i + v_f)\,t$. Putting v_f from equation 1 gives $\mathbf{h = v_i\,t + \frac{1}{2}\,g\,t^2}$. Eliminating t between equations 1 and 2 gives $\mathbf{v_f^2 = v_i^2 + 2\,g\,h}$.

Example: a stone dropped from a cliff ($v_i = 0$) after 4 s: $v_f = 0 + 9.8 \times 4 = 39.2$ m/s downward. Distance fallen $= \frac{1}{2} \times 9.8 \times 4^2 = 78.4$ m.

> **Note:** The chapter itself derives only the first equation (from the definition of acceleration, Example 2.5). Equations 2 and 3 are the standard equations of motion that the question asks for.

7. Draw distance-time graphs for rest, uniform speed, increasing speed and decreasing speed.

In a distance–time graph, time is on the horizontal axis and distance on the vertical axis. The **gradient (slope) = Δs ÷ Δt = speed**.



(a) Rest (zero speed)



(b) Uniform speed



(c) Increasing speed

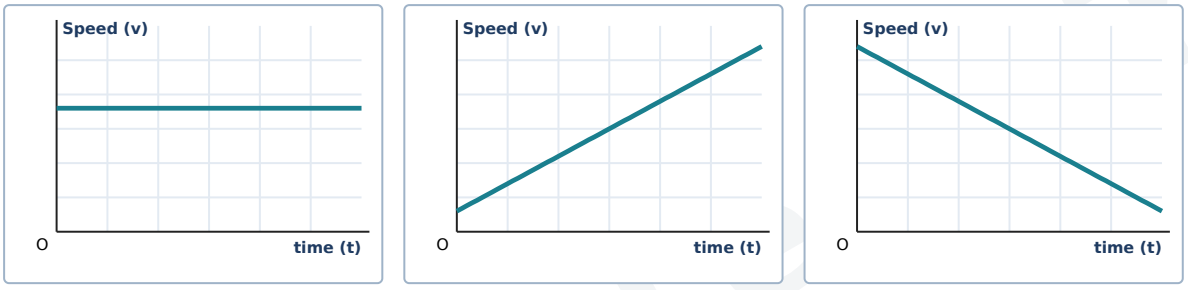


(d) Decreasing speed

Graph	Shape	What it means
(a) Rest	Horizontal line	Time passes but distance does not change. Slope = 0, so speed = 0.
(b) Uniform speed	Straight inclined line	Distance increases linearly with time. Slope is constant, so speed is constant.
(c) Increasing speed	Curve bending upward	The slope keeps increasing, so the body is speeding up (accelerating).
(d) Decreasing speed	Curve bending downward	The slope keeps decreasing, so the body is slowing down (decelerating).

8. Draw speed-time graphs for zero acceleration, uniform acceleration, uniform deceleration. Also show that area under speed time graph represents distance covered by the body.

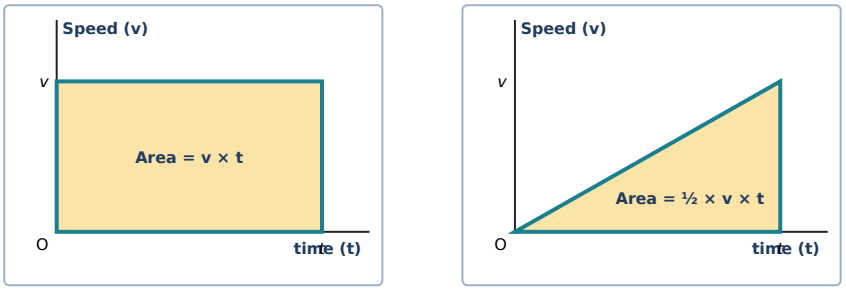
In a speed–time graph, time is on the horizontal axis and speed on the vertical axis. The **gradient = Δv ÷ Δt = acceleration**.



(a) Zero acceleration **(b) Uniform acceleration** **(c) Uniform deceleration**

Graph	Shape	Slope (acceleration)
(a) Zero acceleration	Horizontal line	Slope = 0. Speed is constant (uniform speed).
(b) Uniform acceleration	Straight line rising	Constant positive slope. Speed increases by equal amounts in equal times.
(c) Uniform deceleration	Straight line falling	Constant negative slope. Speed decreases by equal amounts in equal times.

Area under a speed-time graph is the distance covered.



Rectangle (constant speed) **Triangle (uniform acceleration from rest)**

- **Rectangle (constant speed v for time t):** area = width × length = v × t. From equation s = v_{ave} t, the distance is also s = v t. So the **area = distance**.
- **Triangle (speed rises uniformly from 0 to v in time t):** area = ½ × base × height = ½ × v × t. The average speed is v ÷ 2, so s = v_{ave} t = ½ v t. Again **area = distance**.
- For a graph made of several shapes, find each area and add them.

Example 2.6: triangle ½ × 30 × 20 = 300 m, rectangle 30 × 30 = 900 m, triangle ½ × 30 × 10 = 150 m. Total distance = 300 + 900 + 150 = **1350 m**.