UNIT 2 Kinematics

Section A Multiple Choice Questions (M.C.Qs)

Tick mark (✓) the correct answer:

01. *Scalar quantities have_____ and suitable unit.*
(a) magnitude (b) direction (c) both a and b (d) None of them

02. *Vector quantities have_____ along with magnitude and unit.*
(a) magnitude (b) direction (c) both a and b (d) None of them

03. *Which one is a vector quantity?*
(a) Mass (b) Weight (c) Time (d) temperature

04. *Which one is a scalar quantity?*
(a) Time (b) Force (c) Velocity (d) Acceleration

05. *Distance is a_____ quantity.*
(a) Vector (b) Scalar (c) both a and b (d) None of these

06. *What is S.I unit of acceleration?*
(a) ms^{-1} (b) ms^{-2} (c) nm (d) m^2s

07. *What is a S.I Unit of velocity?*
(a) Nm (b) ms^{-1} (c) ms^{-2} (d) m^2s

08. *Shortest distance between two points is called:*
(a) distance (b) speed (c) displacement (d) velocity

09. *The branch of physics which is related with the study of motion of objects is called:*
(a) thermodynamics (b) kinematics (c) dynamics (d) mechanics

10. *The word kinematics is derived from Greek word "Kinema" which means:*
(a) motion (b) rest (c) speed (d) body

11. *The branch of Mechanics which deals with motion of objects without reference of force which cause motion is called:*
(a) thermodynamics (b) kinematics (c) dynamics (d) mechanics

12. *All objects in universe are:*
(a) in motion (b) at rest (c) oval in shape (d) None of them

13. *Types of motion are:*
(a) five (b) four (c) three (d) two

14. *Motion of a body along a straight line is called:*
(a) translatory motion (b) random motion (c) vibratory motion (d) linear motion

15. *The motion of a rider on the Ferris wheel is an example of:*
(a) circular motion (b) rotatory motion (c) random motion (d) vibratory motion

16. *Back and forth motion of a body about its mean position is called:*
(a) vibratory motion (b) oscillatory motion (c) Both 'a' & 'b' (d) None of them

PHYSICS NOTES FOR CLASS 9TH (FOR SINDH)

17. *The motion of the clock's pendulum is an example of:*
(a) circular motion (b) rotatory motion (c) translatory motion (d) vibratory motion

18. *The body moves back and forth about mean position in:*
(a) vibratory motion (b) rotatory motion (c) circular motion (d) translatory motion

19. *Its S.I. unit is meter.*
(a) Distance (b) Displacement (c) Both 'a' & 'b' (d) None of these

20. $\frac{S}{t}$ *is the expression for:*
(a) speed (b) velocity (c) Both 'a' & 'b' (d) None of these

21. *Speed of an object in a certain direction is:*
(a) acceleration (b) velocity (c) displacement (d) distance

22. *Acceleration is produced whenever:*
(a) the velocity of an object changes (b) direction of motion of the object changes
(c) Both 'a' & 'b' (d) None of these

23. *Due to decrease in velocity, acceleration will be:*
(a) positive & is in the direction of velocity
(b) negative & is in the direction of velocity
(c) positive & is opposite to that of change velocity
(d) negative & is opposite to that of change velocity

24. *Density is a:*
(a) scalar quantity (b) vector quantity (c) Both 'a' & 'b' (d) None of these

25. *The gradient on the distance-time graph is numerically equal to the:*
(a) acceleration (b) speed (c) force (d) momentum

26. *When bus travels with non-uniform speed, the distance time graph is a:*
(a) broken line (b) straight line (c) circle (d) curve

27. *The gradient on speed – time graph gives the:*
(a) acceleration (b) speed (c) force (d) momentum

28. *The basic equations of motion for bodies moving with uniform acceleration are:*
(a) two (b) three (c) four (d) five

29. $v_i + at =$
(a) aS (b) 2aS (c) v_f (d) v_f^2

30. $S = v_i t + \frac{1}{2}$ .....
(a) v_f (b) v_f^2 (c) at (d) at^2

31. $2aS =$ .....
(a) $v_f + v_i$ (b) $v_f^2 + v_i^2$ (c) $v_f - v_i$ (d) $v_f^2 - v_i^2$

32. *If two stones of different sizes are dropped from same height simultaneously, which of them will hit the ground first?*
(a) Heavier stone (b) Lighter stone
(c) Both hit the ground at the same time (d) Depends on the weather

33. *The value of acceleration due to gravity 'g' near the surface of earth is found to be:*
(a) 9.81 ms^{-2} (b) 9.81 ms^{-1} (c) 9.81 ms (d) 9.81 ms^2

34. *Gravitational acceleration is taken negative for objects moving:*
(a) upward (b) downward (c) left direction (d) right direction

Answers

1.	(a)	2.	(b)	3.	(b)	4.	(a)	5.	(b)	6.	(b)	7.	(b)
8.	(c)	9.	(d)	10.	(a)	11.	(b)	12.	(a)	13.	(c)	14.	(d)
15.	(b)	16.	(c)	17.	(d)	18.	(a)	19.	(c)	20.	(c)	21.	(b)
22.	(c)	23.	(d)	24.	(a)	25.	(b)	26.	(d)	27.	(a)	28.	(b)
29.	(c)	30.	(d)	31.	(d)	32.	(c)	33.	(a)	34.	(b)		

Section B & C Short & Detailed Answer Questions

Introduction

When we throw a ball straight up in the air, how high does it go? When a glass slips from our hand, how much time do we have to catch it before it hits the ground? How will we describe the motion of a jet fighter being catapulted down the deck of an aircraft carrier? These and some other similar questions we will learn to answer in this unit.

Q.1 *Define mechanics.*

Ans: ***Mechanics:*** The branch of physics which is related to the study of the motion of objects is called Mechanics.
It is divided into two parts.
(i) Kinematics (ii) Dynamics

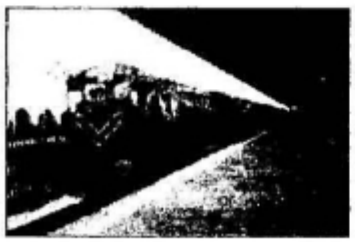
Q.2 *Define kinematics.*

Ans: ***Kinematics:*** The word kinematics is derived from the Greek word "Kinema" which means motion. Kinematics is the branch of Mechanics which deals with the motion of objects without reference to force which causes motion.

Q.3 *When is a body said to be in the state of rest?*

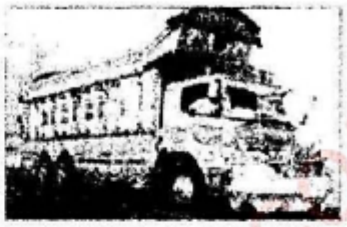
Ans: ***Rest:*** If we have a look around in our classroom, we can observe various things like tables, chairs, books etc. all are in the state of rest. A car is in a state of rest with respect to trees and bushes around it. Thus rest can be defined as:

A body is said to be at rest if it does not change its position with respect to its surroundings.



A train is stationed at the platform. A person can notice that the train does not change its position with respect to surroundings; hence the train is in a state of rest.

Q.4 ***Define motion.***



Ans: ***Motion:*** When a truck starts moving, its position continuously changing with respect to its surroundings. Now we can say that the truck is in motion. Thus motion can be defined as:
A body is said to be in motion if it changes its position with respect to its surroundings.

Q.5 ***How are rest and motion related to each other?***

Ans: ***Rest and motion are related to each other:*** No body in the universe is in the state of absolute rest or absolute motion. If a body is in the state of rest with respect to some reference point at the same time, it can also be in the state of motion with respect to some other reference point.

For example, a passenger sitting in a moving bus is at rest because the passenger is not changing their position with respect to other passengers or objects in the bus as shown in the given figure. But for another observer outside the bus noticed that the passengers and objects inside the bus are in motion as they are changing their position with respect to the observer standing at the road.
Similarly, a passenger flying on an aeroplane is in motion when observed from the ground but at the same time, he is at rest with reference to other passengers on board.

Q.6 ***How many types of motion are there?***

Ans: ***Types of Motion:*** We observe around us that all objects in the universe are in motion. However the nature of their motion is different, some objects move along a circular path, other move in a straight line while some objects move back and forth only. There are three types of motion.

(i) Translatory motion (linear, circular and random)
(ii) Rotatory motion (iii) Vibratory motion.

Q.7 ***Define Translatory Motion.***

Ans: ***Translatory Motion:*** Different objects are moving around in different ways. We can observe how various objects are moving. A train is moving along a straight track in the given figure. We can observe that every part of the train is moving along that straight path.

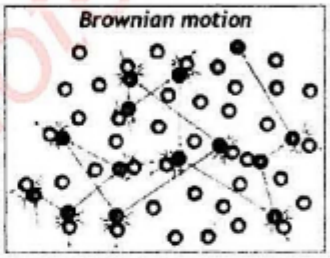
This is called translatory motion. Translatory motion can be defined as:
When all points of a moving body move uniformly along the same straight line, such motion is called translatory motion.

Q.8 ***Define:***
(a) Linear motion (b) Circular motion (c) Random motion

Ans: ***(a) Linear Motion:*** We observe many objects moving along a straight line. The motion of a bus in a straight line on the road is called linear motion. Thus the linear motion can be defined as:
The motion of a body along a straight line is called linear motion.

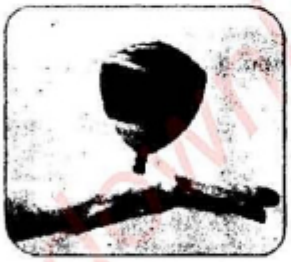
(b) Circular Motion: An artificial satellite moving around the Earth along a circular path is an example of circular motion. Thus circular motion can be defined as:
The motion of a body along a circular path is called circular motion.

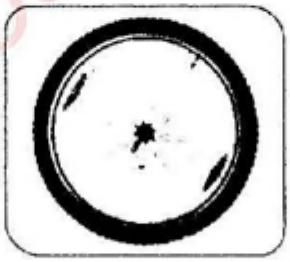
(c) Random Motion: We have observed the motion of flies, insects and birds. They suddenly change their direction. The path of their motion is always irregular. The random motion can be defined as:
The irregular motion of an object is called random motion.
The motion of butterfly, house fly, dust and smoke particles along zigzag paths are examples of random motion. The motion of the particles of a gas or a liquid known as the Brownian motion which is an example of random motion.


Brownian motion

Q.9 ***Define rotatory motion with examples.***

Ans: ***Rotatory Motion:*** If we notice the type of motion of a fan and a spinning top, we will find that every point of the top moves in a circle around a fixed axis. Thus every particle of the top possesses circular motion.


Spinning top


A Wheel


Ferris Wheel

But the top as whole moves around an axis which passes through the top itself so the motion of the top is rotatory. Thus rotatory motion can be defined as:
The motion of the body around a fixed axis which passes through the body itself is called spin or rotatory motion.
The motion of a wheel about the axle, the motion of a rider on the Ferris wheel are some examples of rotatory motion.

Q.10 ***What is vibratory motion?***

Ans: ***Vibratory Motion:*** If we look at the motion of a child in a swing when the swing is pulled away from its mean position and then released, the swing starts moving back and forth about the mean position. This type of motion is called vibratory or oscillatory motion. Thus vibratory motion can be defined as:
The back and forth motion of a body about its mean position is called vibratory or oscillatory motion.

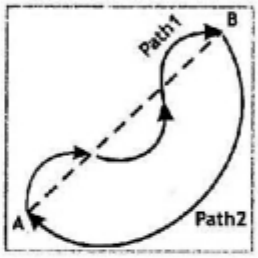
There are many examples of vibratory or oscillatory motion in daily life. For example, the motion of the clock's pendulum.

Q.11 How can we describe the motion of an object?

Ans: The motion of an object can be described by specifying its position, change in position, speed, velocity and acceleration.

Q.12 Define distance and displacement.

Ans: A person can use three different paths to move from place A to place B.



Distance: If a person moves from point 'A' to point 'B' then the total length of the curved path is called the distance moved by the body.

Displacement: Actual distance moved by a body from a point 'A' toward point 'B' in a straight line (dashed line) is called displacement.

If a body travels a path 'AB' and returns back to point 'A' after taking another path 'BA' (path 2) then the total distance travelled by the body will be the length of the path, however, its displacement will be zero, as the initial and the final points are the same.

Q.13 Define speed, average speed and uniform speed.

Ans: ***Speed:*** The speed of an object determines how fast an object is moving. It is the rate of change of position of an object. There are many ways to determine the speed of an object. These methods depend on the measurement of two quantities:

(i) The distance traveled (ii) The time taken to travel that distance

Thus the average speed of an object can be calculated as:

$$\text{Speed} = \frac{\text{distance traveled}}{\text{time taken}}$$

$$V = \frac{S}{t}$$

Speed is a scalar quantity and its S.I unit is ms^{-1}.

Average Speed: The equation for average speed in symbols can be written as:

$$V = \frac{S}{t}$$

where "V" is the speed of the object, "S" distance traveled by it and "t" time taken by it. Thus average speed can be defined as:

Distance covered by an object in a unit time is called speed.

Uniform Speed: The above equation gives only the average speed of the body it cannot be said that it was travelling with uniform speed or non-uniform speed. For example, a racing car can be timed by using a stopwatch over a fixed distance say, 500m.

More Information:

The average speed of different animals and objects.

Animal/Object	Speed (kmh^{-1})
White-tailed deer	48
Ren deer	60 – 80
Cheetah	100 – 120
Walking man	6
Grand Prix car	360
Passenger jet	900
Sound	1200
Space shuttle	36000

Dividing distance by time gives the average speed, but it may speed up or slow down along the way. An object covers an equal distance in an equal interval of time its speed is known as uniform speed.

Q.14 Define velocity, average velocity and uniform velocity.

Ans: ***Velocity:*** Velocity means the speed of an object in a certain direction. Velocity is a vector quantity. Thus the velocity of an object can be defined as:
The rate of change of displacement with respect to time is called velocity.

$$\text{Velocity} = \frac{\text{Change in displacement}}{\text{time taken}}$$

$$V = \frac{\Delta d}{t}$$

Here d is the displacement of the moving object. It is the time taken by the object and v is velocity. S.I unit of velocity is ms^{-1}.

Average Velocity: The velocity of an object is constant when it moves with constant speed in one direction. The velocity of an object does not remain constant when it changes direction without changing its speed, or it changes speed with no change in direction. Thus the average velocity of an object is given by

$$\text{Velocity} = \frac{\text{total displacement}}{\text{total time taken}}$$

Uniform Velocity: A body is said to have uniform velocity if it covers equal distance in an equal interval of time in a particular direction.

Q.15 Define acceleration and uniform acceleration.

Ans: ***Acceleration:*** An object accelerates when its velocity changes. Since velocity is a vector quantity so it has both magnitude and direction. Thus acceleration is produced whenever:

(i) velocity of an object changes.
(ii) direction of motion of the object changes
(iii) speed and direction of motion of the object change.

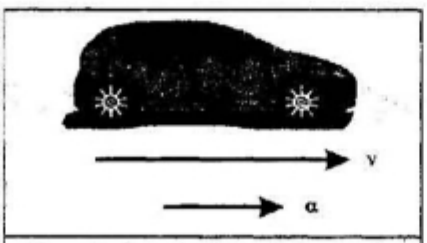
Thus acceleration can be defined as:
The rate of change of velocity of an object with respect to time is called acceleration.

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

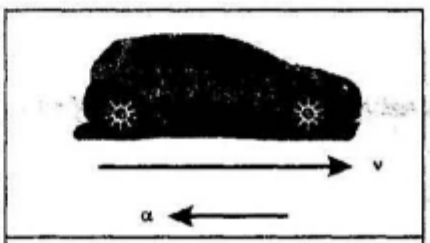
$$a = \frac{\Delta v}{t} \qquad \because \Delta v = v_f - v_i$$

$$\therefore \quad a = \frac{v_f - v_i}{t}$$

Acceleration is a vector quantity. Its S.I unit is metre per second square (ms^{-2}).
When the velocity of an object increases or decreases with the passage of time it causes acceleration. The increase in velocity gives rise to positive acceleration. It means the acceleration is in the direction of velocity. Whereas acceleration due to a decrease in velocity is negative and is called deceleration or retardation. The direction of deceleration is opposite to that of change velocity.



The velocity of this car is increasing



The velocity of this car is decreasing

Uniform Acceleration: A body has uniform acceleration if the velocity of the body changes by an equal amount in every equal time period.

When the change i.e., increase or decrease, in the velocity of an object is the same for every second then its acceleration is uniform when the velocity of an object is increasing by $10ms^{-1}$. When the velocity of the object is decreasing is $10ms^{-2}$ every second, the deceleration is $10ms^{-1}$.

Thus, uniform acceleration can be defined as:

A constant rate of change of velocity is called uniform acceleration.

The uniform acceleration can be calculated by using the following formula:

$$\vec{a} = \frac{\Delta\vec{V}}{\Delta t} = \frac{\vec{V}_f - \vec{V}_i}{t_2 - t_1}$$

where
- v_t = initial velocity (in ms^{-1})
- v_f = final velocity (in ms^{-1})
- t_1 = time at which an object is at final velocity v (in sec)
- Δv = change in velocity (in ms^{-1})
- Δt = time interval between t_1 and t_2 (in sec)

Q.16 *Explain scalar and vector quantities.*

Ans: All physical quantities are divided into two types based on the information required to describe them completely.

(i) Scalars (ii) Vectors

Scalars: There are certain physical quantities that can be described through their magnitude and a suitable unit. This information is enough to describe them, for example, the mass of a watermelon is 3kg, where 3 is the magnitude and kg is a suitable unit such quantities are called scalar quantities. Thus we can define scalar quantities as:

The physical quantities that have magnitude and a suitable unit are called scalar quantities.

The other examples of scalar quantities are speed, temperature, mass, density etc.

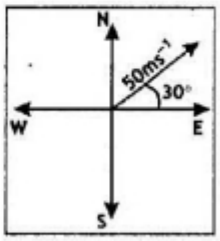
Vectors: Some physical quantities need direction along with their magnitude and unit for their complete description, for example, a bus traveling with a velocity of $50ms^{-1}$ in direction of the north. The vector quantities can be defined as:

The physical quantities which are completely specified by magnitude with the suitable unit and particular direction are called "vector" quantities.

Force, acceleration, momentum, torque and magnetic field are examples of vector quantities.

Q.17 *How can we represent a vector quantity?*

Ans: ***Representation of Vector:*** Vector diagram is an easy way to represent a vector quantity. The directed line segment can be used to represent a vector. The length of the line segment gives the magnitude of the vector and the arrow head gives its direction. For example, the given figure represents the velocity of a car travailing at $50ms^{-1}$ in the direction of 30° North of East.



Q.18 *Describe distance–time and speed–time graphs.*

Ans: Graph gives the complete information about the motion of the object based on the measured physical quantities such as distance, speed, time etc.

Distance–Time Graphs: A bus travels along a straight road from one bus stop to another bus stop. The distance of the bus from the first bus stop is measured every second. The possible motion of the bus is shown by three examples.

PHYSICS NOTES FOR CLASS 9TH (FOR SINDH)

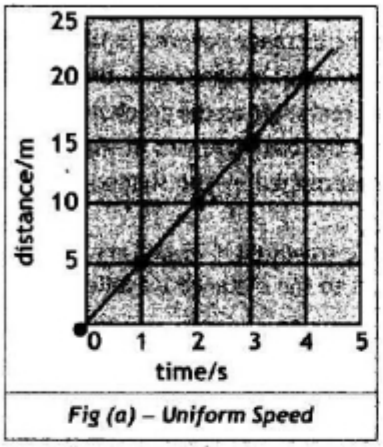


Fig (a) – Uniform Speed

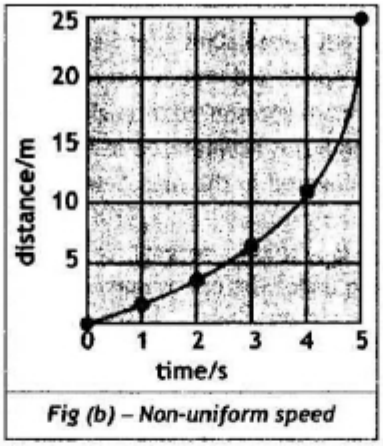


Fig (b) – Non-uniform speed

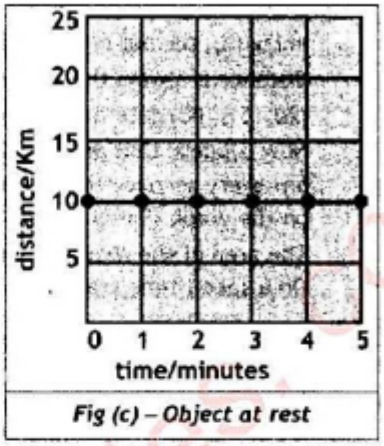


Fig (c) – Object at rest

The vertical axis gives rise of the graph while the horizontal axis shows its run. The rise divided by run is called gradient. The gradient on the distance–time graph is numerically equal to the speed.

When a bus travels with a uniform speed, the distance–time graph is a straight line. Fig (a) shows graph of the motion of the bus with steady speed, the line rises 5m on the distance scale for every 1 second on the time scale.

$$\text{Gradient} = \frac{20}{4} = 5$$

$$\text{Thus speed} = 5\text{ms}^{-1}$$

When a bus travels with non-uniform speed, the distance–time graph is a curve. Fig (b) shows the motion of the bus, for this case the speed rises every second. So the bus covers more distance each second than the one before.

When the bus stops at the next bus stop to drop or pick the passengers the time continues running but the distance stays the same. The graph line is now parallel to the time axis which shows the bus does not change its position (fig c).

Speed–Time Graph: Speed–time graph tells us that how much speed is increasing or decreasing every second. Thus, the gradient on speed - time graph gives the acceleration of the moving object.

If the gradient is positive then acceleration is also positive. On the other hand, if the gradient is negative then acceleration will be negative which is known as deceleration or retardation.

In graph (Fig a), the bus is at rest for an interval of 5 seconds. Therefore, the speed of the bus remains zero the entire time.

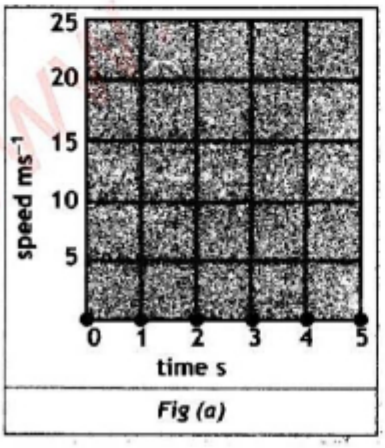


Fig (a)

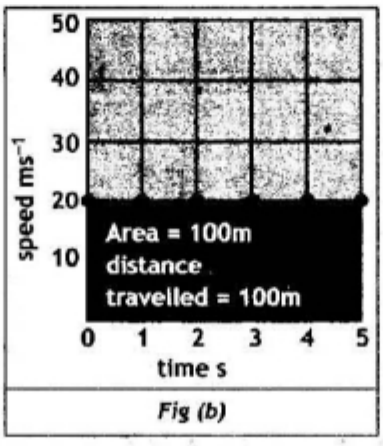


Fig (b)

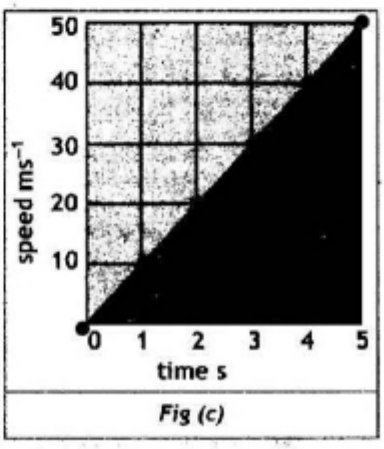


Fig (c)

In Fig (b), the bus moves at a steady speed 20ms^{-1} for 5 seconds, so the distance covered is 100m. The distance is always the product of speed and time, therefore two magnitudes on the speed–time graph ($20 \times 5 = 100$) determine the distance represented through the shaded rectangle on the graph (Fig b).
Now suppose that once again the bus is accelerated as the speed of the bus increases at the rate of 5m every second, the distance covered in the next 5 seconds is determined by the shaded triangle on the graph (Fig c).
The area of the shaded triangle is ½ (base × height). So the distance travelled is 75 meters.
On a speed-time graph, the area under the line is numerically equal to the distance travelled.

Q.19 *Describe the first equation of motion.*

Ans: ***Equations of Motion:*** There are three basic equations of motion for bodies moving with uniform acceleration. These equations are used to calculate the displacement (S), velocity (v), time (t) and acceleration (a) of a moving body.
Suppose a body is moving with uniform acceleration "a" during some time interval "t" its initial velocity "v_t" changes and is denoted as final velocity "v_f". It covers a distance "S" in this duration of time.
First Equation of Motion: The first equation of motion determines the final velocity of a uniform acceleration body.
where v_f = final velocity v_i = initial velocity a = acceleration t = time
The average acceleration is the change in velocity over a time interval.

$$a = \frac{\textit{change in velocity}}{\textit{time}}$$

$$a = \frac{v_f - v_i}{t}$$

$$at = v_f - v_i$$

$$\therefore \quad v_f - v_i + at$$

This is known as the first equation of motion.

Q.20 *Explain the second equation of motion.*

Ans: ***The Second Equation of Motion:*** The second equation of motion determines the distance covered during some time interval "t", while a body is accelerating from a known initial velocity.
As we know the average velocity $= \frac{v_f + v_i}{2}$
From the first equation of motion, we know that $v_f = v_i + at$. Putting this value of v, we get:

$$\text{Average velocity} = \frac{(v_i + at) + v_i}{2} = \frac{v_i + at + v_i}{2}$$

$$= \frac{2v_i + at}{2} = \frac{2v_i}{2} + \frac{at}{2}$$

$$= v_i + \frac{1}{2}at$$

As the $S = vt$ or $v = \frac{S}{t}$ the above equation becomes

$$\frac{S}{t} = v_i + \frac{1}{2}at$$

$$\therefore \quad S = v_i t + \frac{1}{2}at^2$$

This equation is known as the second equation of motion.

Q.21 Derive the third equation of motion.

Ans: ***The Third Equation of Motion:*** The third equation of motion determines the relationship between the velocity and the distance covered by a uniform acceleration body, where the time interval is not mentioned.

Let us take the first equation of motion.

$$v_f = v_i + at$$

By squaring the both sides of equation we get:

$$v_f^2 = (v_i + at)^2$$

$$v_f^2 = v_i^2 + 2v_iat + a^2t^2$$

$$v_f^2 = v_i^2 + 2a(v_it + \frac{1}{2}at^2) \quad \text{----------(1)}$$

According to second equation of motion:

$$S = v_it + \frac{1}{2}at^2$$

Therefore, equation (1) becomes:

$$v_f^2 = v_i^2 + 2a(S)$$

$$2aS = v_f^2 - v_i^2$$

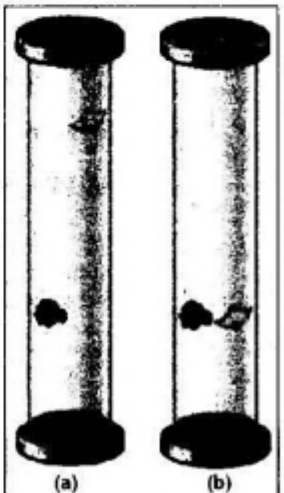
This is known as the third equation of motion for bodies moving with uniform acceleration.

Q.22 Describe the motion due to gravity.

Ans: ***Motion Due to Gravity:*** If two stones of different sizes are dropped from the same height simultaneously, we can observe that heavier and lighter stones catch the same acceleration and hit the ground at the same time.

To discover this Galileo Galilei carried out a series of experiments from at leaning tower of Pisa and carefully observed that all objects catch the same acceleration due to the gravity of the earth. The mass or size of the object has no effect.

It was against the widely accepted claim of Aristotle that heavier objects would fall faster than the lighter one. A small feather and a stone are dropped in an air-filled tube. Since air resistance greatly affects the feather, so the stone falls faster. On the other hand, when a feather and a stone are dropped in absence of air resistance, they acquire the same acceleration and reach the bottom at the same time.



A piece of feather and a piece of stone dropped together in an air filled glass tube (a) and an evacuated air free glass tube (b).

Acceleration due to gravity 'g' is a constant. Its value near the surface of the earth is found to be 9.81 ms^{-2}. However, for ease of calculation value of 'g' is approximated to 10 ms^{-2}.

Gravitational acceleration is taken negative for objects moving downward and positive for objects moving upward.

For the motion of bodies under the influence of gravity, the equations of motion are slightly modified. Where distance is taken as (S=h) and acceleration is taken as g(a=g).

Therefore, equations of motion are taken as:

(i) $v_f = v_i + gt$

(ii) $h = v_it - \frac{1}{2}gt^2$

(iii) $2ah = v_f^2 - v_i^2$

PHYSICS NOTES FOR CLASS 9TH (FOR SINDH)

Differences

01. ***Differentiate between translatory motion, rotatory motion and vibratory motion.***

Ans: ***Distinguish between Translatory, Vibratory and Rotatory***

Translatory Motion	*Rotatory Motion*	*Vibratory Motion*
A body moves along a straight line.	The spinning of a body about its axis.	The body moves back and forth about the mean position.
Movement of an object from one place to another.	The motion of an object about a fixed point.	The body moves up and down.
All particles of the rigid body move with the same velocity at every instant of time.	The motion of a rigid body about a fixed axis. Every particle of the body move in a circular path.	An object repeats its motion itself.

02. ***What is the difference between distance and displacement?***

Ans: ***Difference Between Distance and Displacement***

Distance	*Displacement*
• The total length is covered by a moving body without mentioning the direction of motion.	• The distance is measured in a straight line in a particular line.
• It is a scalar quantity.	• It is a vector quantity.
• The S.I unit is metre (m).	• The S.I unit is metre (m).
• Distance covered can never be negative. It is always positive or zero.	• Displacement may be positive, negative or zero.
• Distance between two given points may be the same or different path chosen.	• The displacement between two given points is always the same.

03. ***Differentiate between vector and scalar quantities.***

Ans: ***Difference Between Scalar and Vector Quantities***

	Scalar Quantities	*Vector Quantities*
1.	Scalar quantities are specified by magnitude only.	Vector quantities are specified by both magnitude and direction.
2.	Scalar quantities change with change in magnitude only.	Vector quantities change either with the change in magnitude or with the change in direction or with the change of both magnitude and direction.
3.	Scalar quantities with the same units can be added or subtracted according to the ordinary rule of algebra.	Vector quantities cannot be added or subtracted algebraically.
4.	These are represented by ordinary letters.	These are represented by bold-faced letters or letters having a arrow over them e.g. $\vec{A}$ is read as vector A.

04. ***What is the difference between speed and velocity?***

Ans:

	Scalar Quantities	*Vector Quantities*
1.	It is the ratio between distance and time.	It is the ratio between displacement and time.
2.	It is a scalar quantity.	It is a vector quantity.
3.	Mathematically: $V = \frac{S}{t}$	Mathematically: $\vec{V} = \frac{\vec{d}}{t}$

Scientific Reasons

01. ***Why gravity is taken negative for an object moving in an upward direction?***

Ans: If a body is going upwards, the acceleration due to gravity is downwards and hence, it acts in the opposite direction of the velocity. So, it is considered negative.

Section D — Numerical

Worked Examples of the Textbook

01. ***A car travels 700m in 35 seconds what is the speed of a car?***

Solution:

Step 1: Write the known quantities and point out quantities to be found.

$d = 700\ m$ $t = 35s$ $v = ?$

Step 2: Write the formula and rearrange if necessary.

$$v = \frac{d}{t}$$

Step 3: Put the value in the formula and calculate.

$$v = \frac{700}{35} = 20\ ms^{-1}$$

Thus the average speed of car is $20ms^{-1}$.

02. ***The speed of a train is 108 kmh^{-1}. How much distance will be covered in 2 hours?***

Solution:

Step 1: Write the known quantities and point out quantities to be found.

$$v = \frac{108\ km}{h} = \frac{108 \times 1000\ m}{3600s} = 30\ ms^{-1}$$

$t = 2h = 2 \times 3600s = 7200\ s$

$d = ?$

Step 2: Write the formula and rearrange if necessary.

$$v = \frac{d}{t}$$

$$d = v \times t$$

Step 3: Put the value in the formula and calculate.

$$d = 30 \times 7200 = 216000\ m$$

Thus distance traveled by train is 216000m.

03. ***A bus starts from rest and travels along a straight path its velocity becomes $15ms^{-1}$ in 5 seconds. Calculate the acceleration of the bus?***

Solution:

Step 1: Write the known quantities and point out quantities to be found.

$v_i = 0\ ms^{-1}$ $v_f = 15\ ms^{-1}$

$t = 5$ second $a = ?$

Step 2: Write the formula and rearrange if necessary.

$$a = \frac{v_f - v_i}{t}$$

Step 3: Put the value in the formula and calculate.

$$a = \frac{15 - 0}{5} = \frac{15}{5} = 3\ ms^{-2}$$

The acceleration of the bus is $3ms^{-2}$.

04. ***A motorcyclist moving along a straight path applies brakes to slow down from $10ms^{-1}$ to $3ms^{-1}$ in 5 seconds. Calculate its acceleration.***

Solution:

Step 1: Write the known quantities and point out quantities to be found.

$v_i = 10\ ms^{-1}$ $\quad$ $v_f = 3\ ms^{-1}$

$t = 5$ second $\quad$ $a = ?$

Step 2: Write the formula and rearrange if necessary.

$$a = \frac{v_f - v_i}{t}$$

Step 3: Put the value in the formula and calculate.

$$a = \frac{3 - 10}{5} = \frac{-7}{5} = -1.4\ ms^{-1}$$

Deceleration of motorcycle is $-1.4ms^{-2}$.

The negative sign shows the retardation in the opposite direction of velocity.

05. ***A car moving on a road with a velocity $30ms^{-1}$, when brakes are applied its velocity decreases at a rate of 6 meters per second. Find the distance it will cover before coming to rest.***

Solution:

Step 1: Write the known quantities and point out quantities to be found.

$a = -6\ ms^{-1}$ $\quad$ $v_i = 30\ ms^{-1}$

$v_f = 0$ $\quad$ $S = ?$

Step 2: Write the formula and rearrange if necessary.

$$\frac{2aS}{2a} = \frac{v_f^2 - v_i^2}{2a}$$

$$S = \frac{v_f^2 - v_i^2}{2a}$$

Step 3: Put the value in the formula and calculate.

$$S = \frac{(0)^2 - (30)^2}{2(-6)} = \frac{-900}{-12} = 75\ m$$

Thus the car will stop after moving 75m distance.

06. ***A motorcycle moving with a velocity of $40ms^{-1}$. It gets accelerating at a rate of 8 ms^{-2}. How much distance will it cover in the next 10 seconds?***

Solution:

Step 1: Write the known quantities and point out quantities to be found.

$v_i = 40\ ms^{-1}$ $\quad$ $a = 8\ ms^{-2}$

$t = 10\ s$ $\quad$ $S = ?$

Step 2: Write the formula and rearrange if necessary.

$$S = v_i t + \frac{1}{2} at^2$$

Step 3: Put the value in formula and calculate.

$$S = (40)(10) + \frac{1}{2}(8)(10)^2$$

$$S = 400 + \frac{1}{2}(8)(100) = 400 + \frac{800}{2} = 400 + 400 = 800\ m$$

Thus motorcycle covers 800m in the next 10 seconds.

07. ***A ball is thrown vertically upward with a velocity of 12ms^{-1}. The ball will be slowing down due to the pull of Earth's gravity on it and will return back to Earth. Find out the time the ball will take to reach the maximum height.***

Solution:

Step 1: Write the known quantities and point out quantities to be found.

$v_i = 12\ ms^{-1}$ $\quad v_f = 0$

$g = -10\ ms^{-2}$ $\quad t = ?$

Step 2: Write the formula and rearrange if necessary.

$$v_f = v_i + gt$$

$$t = \frac{v_f - v_i}{g}$$

Step 3: Put the value in the formula and calculate.

$$t = \frac{0 - 12}{-10} = 1.2\ s$$

The ball will reach maximum height in 1.2 seconds.

Solved Numerical

01. ***Calculate the acceleration of a bus that speeds up from 20ms^{-1} to 40ms^{-1} in 8 seconds.***

Solution:

Data:
Initial Velocity = v_i = 20ms^{-1}
Final Velocity = v_f = 40ms^{-1}
Time = t = 8 sec
Acceleration = a = ?

Calculation: Using the equation

$$a = \frac{v_f - v_i}{t}$$

$$a = \frac{40 - 20}{8} = \frac{20}{8} = \boxed{2.5\ ms^{-2}}$$

02. ***A bus is moving on a road with 15ms^{-1} and it accelerates at 5ms^{-2}. Find the final velocity of the bus after 6 seconds.***

Solution:

Data:
Initial Velocity = v_i = 15ms^{-1}
Acceleration = a = 5ms^{-2}
Final Velocity = v_f = ?
Time = t = 6 sec

Calculation: Using the first equation of motion:

$v_f = v_i + at$

$v_f = 15 + (5)(6) = 15 + 30 = \boxed{45\ ms^{-1}}$

03. ***A car starts moving from rest with an acceleration of 5ms^{-2}. Find out the time to travel 50m distance.***

Solution:

Data:
Initial Velocity = v_i = 0
Acceleration = a = 5ms^{-2}
Time = t = ?
Distance = S = 50 m

Calculation: Using the second equation of motion:

$$S = v_i t + \frac{1}{2} at^2$$

$$50 = (0)t + \frac{1}{2}(5)t$$

$$50 = 0 + \frac{5}{2}t = \frac{5}{2}t$$

$$(50)(2) = 5t$$

$$5t = 100$$

$$t = \frac{100}{5} = \boxed{20 \text{ sec}}$$

04. ***A ball is dropped from a height of 50m. What will be its velocity before touching the ground?***

Solution: *Data:*

Height = h = 50 m
Initial Velocity = v_i = 0
Final Velocity = v_f = ?
Time = t = ?
Acceleration due to gravity = g = 10 ms^{-2}

Calculation: Using equation:

$$h = v_i t + \frac{1}{2}gt^2$$

$$50 = (0)t + \frac{1}{2}(10)(t)^2 = 0 + 5t^2 = 5t^2$$

$$5t^2 = 50$$

$$t^2 = \frac{50}{5} = 25$$

$$t = \sqrt{25} = 5 \text{ sec}$$

Now, Using equation:

$$v_f = v_i + gt$$

$$v_f = 0 + (10)(25) = 0 + 250 = \boxed{250 \text{ m}}$$

05. ***If a body is thrown upward with vertical velocity 50ms^{-1}, calculate maximum height which body can reach.***

Solution: *Data:*

Initial Velocity = v_i = 50ms^{-1}
Final Velocity = v_f = 0
Height = h = ?
Acceleration due to gravity = g = –10 ms^{-2}

Calculation: Using the third equation of motion:

$$2gh = v_f^2 - v_i^2$$

$$2(-10)h = (0)^2 - (50)^2$$

$$-20h = 0 - 2500 = -2500$$

$$h = \frac{-2500}{-20} = \boxed{125 \text{ m}}$$

06. ***A ball falls down from top of height of 70m. How much time the ball will take to reach the ground.***

Solution: *Data:*

Height = h = 70 m
Initial Velocity = v_i = 0
Time = t = ?
Acceleration due to gravity = g = 10 ms^{-2}

Calculation: Using equation:

$$h = v_i t + \frac{1}{2}gt^2$$

$$70 = (0)t + \frac{1}{2}(10)(t)^2 = 0 + 5t^2 = 5t^2$$

$$5t^2 = 70$$

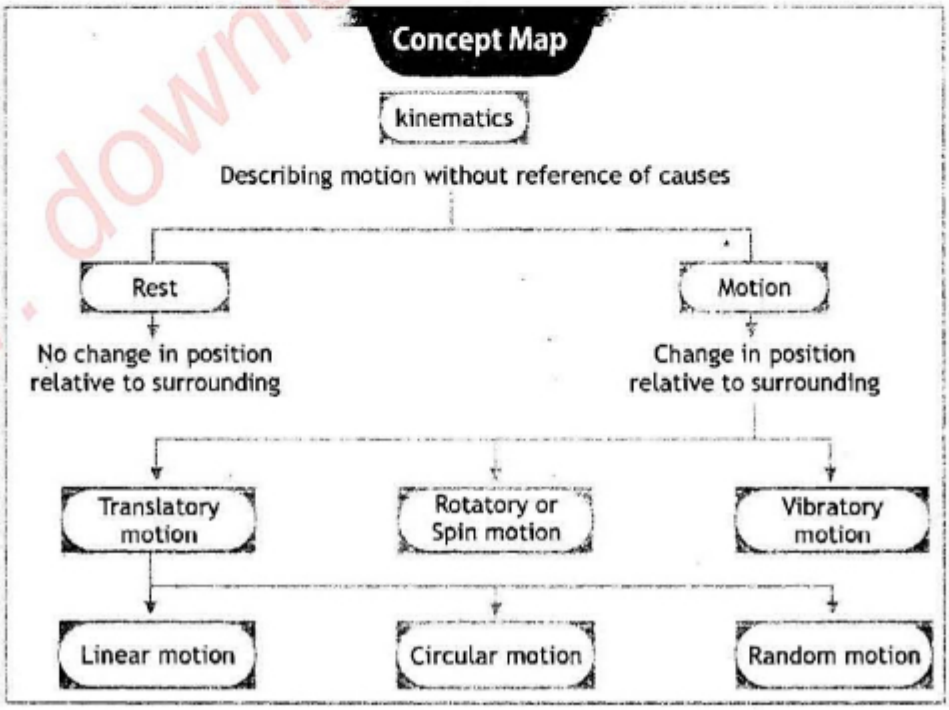
$$t^2 = \frac{70}{5} = 14$$

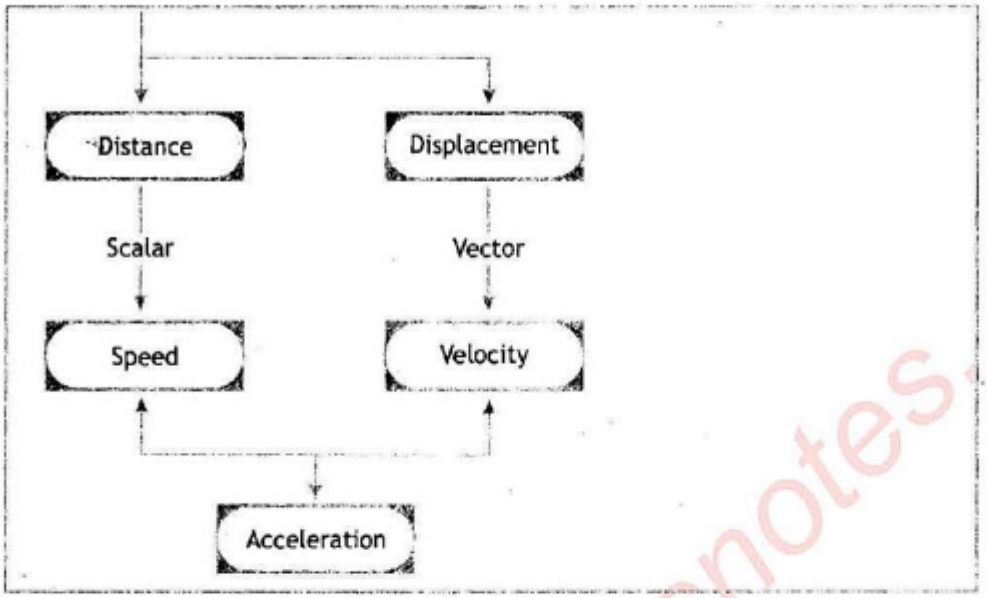
$$t = \sqrt{14} = \boxed{3.741 \text{ sec}}$$

Summary

- A body is said to be at rest if it does not change its position with respect to its surroundings.
- A body is said to be in motion if it changes its position with respect to its surroundings.
- When all points of a moving body move uniformly along the same straight line the motion is called translatory motion.
- The motion of a body along a straight line is called linear motion.
- The motion of a body along a circular path is called circular motion.
- The irregular motion of an object is called random motion.
- The motion of the body around a fixed axis which passes through the body itself is called spin motion.
- The back and forth motion of a body about its mean position is called vibratory oscillatory motion.
- The total length covered by the moving body without mentioning the direction of motion is called distance.
- The distance measured in a straight line in a particular direction is called displacement.
- Distance covered by an object in a unit time is called speed.
- An object covers an equal distance in an equal interval of time is called uniform speed.
- The rate of change of displacement with respect to time is called velocity.
- The rate of change of velocity of an object with respect to time is called acceleration.
- The gradient on the distance-time graph is numerically equal to the speed.
- The physical quantities that have magnitude and suitable units are called scalar quantities.
- The physical quantities completely specified by magnitude in the suitable unit and particular direction are called vectors.
- The motion under the gravitational force of Earth is always directed towards Earth.
- The value of 'g' is taken as $10ms^{-2}$.

Concept Map





End of Unit Questions Solution

SECTION – A: MULTIPLE CHOICE QUESTIONS

Tick Mark (✓) the correct answer:

See "Multiple Choice Questions (M.C.Qs)" – (1) to (8)

SECTION – B: STRUCTURED QUESTIONS

Rest and Motion

(a) Define rest and motion.

Ans: See "Short & Detailed Answer Questions" – Q.3 & 4

(b) What is meant by relative motion?

Ans: See "Short & Detailed Answer Questions" – Q.5

Types of motion

(a) Define speed and velocity.

Ans: See "Short & Detailed Answer Questions" – Q.13 & 14

(b) What is the difference between distance and displacement?

Ans: See "Differences" – Q.2

(c) Define acceleration.

Ans: See "Short & Detailed Answer Questions" – Q.15

(d) Calculate the acceleration of a bus that speeds up from $20ms^{-1}$ to $40ms^{-1}$ in 8 seconds.

Ans: See "Solved Numericals" – Q.1

Scalars and vectors

(a) Define scalar and vector quantities.

Ans: See "Short & Detailed Answer Questions" – Q.16

(b) ***How vector quantities are represented graphically?***

Ans: See "Short & Detailed Answer Questions" – Q.17

Equations of motion

(a) ***A bus is moving on a road with 15ms^{-1} and it accelerates at 5ms^{-2}. Find the final velocity of the bus after 6 seconds.***

Ans: See "Solved Numerical" – Q.2

(b) ***A car starts moving from rest with an acceleration of 5ms^{-2}. Find out the time to travel 50m distance.***

Ans: See "Solved Numerical" – Q.2

Motion due to gravity

(a) ***Define motion under gravity.***

Ans: See "Short & Detailed Answer Questions" – Q.22

(b) ***Why gravity is taken negative for an object moving in an upward direction?***

Ans: See "Scientific Reasons" – Q.1

(c) ***A ball is dropped from a height of 50m. What will be its velocity before touching the ground?***

Ans: See "Solved Numerical" – Q.4

(d) ***If a body is thrown upward with vertical velocity 50ms^{-1}, calculate maximum height which body can reach.***

Ans: See "Solved Numerical" – Q.5

(e) ***A ball falls down from top of height of 70m. How much time the ball will take to reach the ground.***

Ans: See "Solved Numerical" – Q.6