

KINEMATICS

2

KIPS MULTIPLE CHOICE QUESTIONS

1. Study of motion of the bodies is known as:
a) Heat b) Light c) Atomic physics d) Mechanics
2. Study of motion without the reference of force and motion is called:
a) Kinematics b) Dynamics c) Heat d) Motion
3. If a body does not change its position with respect to some observer then it will be in a state of:
a) Rest b) Motion c) Uniform motion d) Relative motion
4. If a body changes its position with respect to some observer then it will be in a state of:
a) Rest b) Motion c) Uniform motion d) Relative motion
5. Rest and motion are ----- states:
a) Absolute b) Constant c) Variable d) Relative
6. Such a type of motion in which every particle of a body has exactly the same motion is known as:
a) Translatory b) Vibratory c) Rotatory d) none of these
7. When each point of a body moves around a fixed point or axis then the motion of the body is known as:
a) Translatory b) Vibratory c) Rotatory d) none of these
8. When a body moves to and fro about a point and repeats its motion again and again about the same point then this motion is known as:
a) Translatory b) Vibratory c) Rotatory d) none of these
9. The motion of the string of a violin is:
a) Translatory b) Vibratory c) Rotatory d) none of these
10. Total length between two points is known as:
a) Velocity b) Acceleration c) Speed d) Distance
11. The shortest distance between two points is known as:
a) Velocity b) Displacement c) Speed d) Distance
12. The distance and direction of a body from a fixed point shows its:
a) Velocity b) Acceleration c) Speed d) Displacement
13. SI unit of speed is:
a) ms^{-1} b) mh^{-1} c) kms^{-1} d) All of these
14. Speed is a ----- quantity:
a) Vector b) Scalar c) Both d) none of these
15. If a body covers equal distance in equal intervals of time, however small the intervals may be, then the speed of the body is known as:
a) Uniform b) Variable c) Constant d) All of these

16. The rate of displacement with respect to body is known as:
a) Distance b) Speed c) Velocity d) Acceleration
17. If the speed and direction of the moving body does not change with time then its velocity is said to be:
a) Uniform b) Variable c) Constant d) All of these
18. If the speed or direction of the moving body changes with time then its velocity is said to be:
a) Uniform b) Variable c) Constant d) All of these
19. Rate of change of velocity is known as:
a) Distance b) Speed c) Velocity d) Acceleration
20. If the velocity of the body is increasing then its acceleration will be:
a) Positive b) Negative c) Uniform d) Variable
21. If the velocity of the body is decreasing then its acceleration will be:
a) Positive b) Negative c) Uniform d) Variable
22. If the velocity of a body is uniform then its acceleration will be:
a) Positive b) Negative c) Zero d) Doubled
23. SI unit of acceleration is:
a) ms^{-1} b) kmh^{-1} c) kms^{-2} d) ms^{-2}
24. If velocity of a body changes equally in equal intervals of time then its acceleration will be:
a) Uniform b) Variable c) Constant d) Relative
25. The velocity and acceleration of a body moving with uniform speed in a circular path will be:
a) In the same direction b) In the opposite direction
c) Mutually perpendicular d) Equal
26. The direction of motion of body and acceleration is in same direction then acceleration will be:
a) Uniform b) Positive c) Negative d) Zero
27. The direction of motion of body and acceleration is in opposite direction then acceleration will be:
a) Uniform b) Positive c) Negative d) Zero
28. The quantity which can be described by a number, with suitable unit only is called:
a) Vector b) Scalar c) Speed d) Acceleration
29. The quantity which are described by magnitude as well as direction is called:
a) Vector b) Scalar c) Speed d) Acceleration
30. In equations of motion, motion will always be taken along ----- line:
a) Circular b) Straight c) Elliptical d) None of above
31. In equations of motion, Acceleration will always be:
a) Uniform b) Variable c) Positive d) Negative

32. In equations of motion, initial velocity will be taken as:
 a) Uniform b) Variable c) Positive d) Negative
33. In equations of motion, quantities in the direction of initial velocity are taken as:
 a) Uniform b) Variable c) Positive d) Negative
34. In equations of motion, quantities opposite to the direction of initial velocity are taken as:
 a) Uniform b) Variable c) Positive d) Negative
35. Which is not the value of 'g' in SI at sea level is:
 a) 9.8ms^{-2} b) 980 cms^{-2} c) 32fts^{-2} d) all of them
36. Series of experiment on free fall of heavy bodies was performed by:
 a) Newton b) Einstein c) Galileo d) Al-Kundi
37. When a body is falling freely under the gravity then in equations of motion 'a' is replaced by:
 a) m b) d c) S d) g
38. If a body is falling under the gravity then its initial velocity will be:
 a) Positive b) Negative c) uniform d) Zero
39. If a body is falling under the gravity then its gravitational acceleration will be:
 a) Positive b) Negative c) Increasing d) Zero
40. If a body is thrown vertically upward then its final velocity will be:
 a) Positive b) Negative c) uniform d) Zero
41. If a body is thrown upward, then its gravitational acceleration will be:
 a) Positive b) Negative c) Increasing d) Zero
42. A ball is dropped from the top of the tower. The distance covered by it in the first second is:
 a) 100m b) 10m c) 50m d) 5m
43. If a car is moving with uniform speed in a circle then its velocity will be:
 a) Uniform b) Variable c) Zero d) None of the above
44. There are ----- equations of motion which are used to solve the problems about the motion of bodies:
 a) 1 b) 2 c) 3 d) 4

ANSWER KEY

Q.	Ans								
1	d	11	b	21	b	31	a	41	b
2	a	12	d	22	c	32	c	42	d
3	a	13	a	23	d	33	c	43	b
4	b	14	b	24	a	34	d	44	c
5	d	15	a	25	c	35	d		
6	a	16	c	26	b	36	c		
7	c	17	a	27	c	37	d		
8	b	18	b	28	b	38	d		
9	b	19	d	29	a	39	a		
10	d	20	a	30	b	40	d		

KIPS SHORT QUESTIONS

Q.1 Define Kinematics.

Ans: The study of motion of an object without discussing the cause of motion is called the kinematics.

Q.2 Define dynamics.

Dynamics deals with forces and their action on the motion of bodies.

Q.3 Differentiate between Kinematics and Dynamics.

Ans:

Kinematics	Dynamics
Kinematics is the study of motion of bodies without the reference of force and mass.	Dynamics deals with forces and their action on the motion of bodies.

Q.4 How you will define the rest?

Ans: If a body does not change its position with respect to surroundings then it is said to be in a state of rest.

Surroundings are the places in its neighborhood where various objects are present.

Q.5 How you will define the motion?

Ans: If a body continuously changes its position with respect to surroundings then it is said to be in a state of motion.

Q.6 How we can say that rest and motion are relative states?

Ans: The state of rest or motion of a body is relative. For example, a passenger is sitting in the moving bus is at rest because he/she is not changing his/her position with respect to the other passengers sitting in the bus. But to an observer outside the bus, the passengers and objects are in motion because they are changing their positions.

Q.7 Define Rotatory motion.

Ans: The spinning motion of a body around its axis is called rotatory motion.

Example

- Motion of Earth around its geographic axis
- Motion of wheel and steering wheel around its axis
- Motion of a ceiling electric fan

Motion of Individual Particles

Particles of spinning body move in circles and thus individual particles possess circular motion.

Axis of Rotation

A line around which a body rotates is called axis of rotation.

Q.8 Differentiate between circular motion and rotatory motion

Ans: In circular motion, the point about which a body moves around, is outside the body while in rotatory motion, the line around which a body moves about is passing through the body itself.

Q.9 Define Vibratory motion.

Ans: When a body moves to and fro about its mean position is called vibratory motion. The motion of the body repeats from one extreme motion to the other extreme position.

Examples

- Motion of swing back and forth about its mean position
- Motion of pendulum of wall clock
- Motion of see-saw
- Motion of hammer of ringing electric bell
- Motion of the strings of sitar

Q.10 What do you know about scalar and vector quantities

Ans: A physical quantity which can be completely described by its magnitude only is called a scalar. The magnitude of a quantity means its numerical value with appropriate unit.

Examples

Mass, length, time speed, volume, area, energy etc.

Vector

A physical quantity which can be completely described by its magnitude along with its direction.

Example

Velocity, force, displacement, momentum, torque etc.

Q.11 How are vector quantities important to us in our daily life?

Ans: It would be meaningless to describe vectors without direction. For example, distance of a place from reference point is insufficient to locate that place. This direction of that place from reference point is also necessary to locate it.

Q.12 What do you know about Vector Representation?

Ans: Symbolic Representation

To represent vectors, we generally use bold letters to represent vector quantities.

Examples

F, a, d or a bar or arrow over their symbols such as \vec{F} , \vec{a} , \vec{d} or \bar{F} , \bar{a} and \bar{d}

Graphical Representation

Graphically, a vector can be represented by a line segment with an arrow head. The line AB with arrow head at B represents the vector. The length of the line AB gives the magnitude of the vector on a selected scale. While the direction of the line from A to B gives the direction of the vector.



Q.13 What is Position?

Ans: The term position describes the location of place or a point with respect to some reference point. This reference point is called the origin.

Example

If you want to describe the position of your school from your home. The can be represented by S and home by H. The position will be represented by a straight line HS in the direction from H to S as shown in figure.

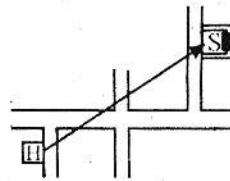


Figure 2.16: Position of the school S from the home H

Q.14 What is meant by distance?

Ans: Distance

The total length/separation of a path between two points is known as distance between those points.

Quantity

It is a scalar quantity

Unit

Its unit is meter (m).

Representation

It is represented by "S".

Q:15 What do you know about Displacement?

Ans: The shortest distance between two points is known as displacement which has magnitude and direction. It is directed from initial to final point.

Representation

It is represented by "d".

Quantity

It is a vector quantity and it is directed from initial to final point.

Unit

Its unit is meter (m).

Example

Consider the figure in a curved path. Let S be the length of the curved path between two points A and B on it. Then S is the distance between A and B.

In this figure, join A and B by a straight line. The straight line AB gives the distance which is shortest between A and B. This shortest distance d in a particular direction is called displacement.

Q:16 What do you know about speed?

Ans: The distance covered by an object in unit time is known as its speed.

Mathematical form

If a body covers distance 'S' in time 't' then its speed 'v' can be mathematically written as,
Speed = Distance covered/Total time

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

Distance = speed x time

$$S = v \times t$$

Quantity

It is a scalar quantity.

Unit

SI unit of speed is meter per second ($m s^{-1}$).

Q:17 How will define the uniform speed?

Ans: Speed is the average speed of a body because speed of the body may be changing during the time interval t. If the speed does not vary and has same value then it is taken as uniform speed and it is defined as:

"If a body covers equal distances in equal intervals of time, however small the intervals may be, the speed of the body is said to be uniform".

Q:18 A body is moving with uniform speed. Will its velocity be uniform?

Ans: If a body is moving with uniform speed may have uniform or variable velocity.

If the direction of the body is not changing then its velocity will also be uniform.

Example 1

A body moving with uniform speed in the straight line will have uniform velocity.

If the direction of the body is changing then its velocity will be variable.

Example 2

A body moving with uniform speed in the circular path will have variable velocity because its direction changes at every point on the circle.

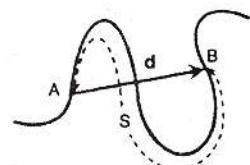


Figure 2.17: Distance S (dotted line) and displacement d (red line) from points A to B.

Q.19 What do you know about velocity?

Ans: The rate of displacement of a body with respect to time is called velocity.

OR

Speed of a body along with the direction in which the body is moving is known as velocity.

Mathematical form

$$\text{Average velocity} = \frac{\text{displacement}}{\text{time taken}}$$

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

Or $d = v \times t$

Here d is the displacement of the body moving with velocity v in time t . Here v is the average velocity of the body during time t .

Quantity

It is a vector quantity and its direction is same as the direction of displacement.

Unit

SI unit of velocity is same as that of speed that is meter per second (ms^{-1}).

Q.20 What do you know about uniform velocity?

Ans: If speed and direction of a body does not change then body has uniform velocity. In this case, during any time interval body has same magnitude and direction. Uniform velocity can be defined as:

"If body has uniform velocity if it covers equal displacement in equal intervals of time however short the interval may be".

Example

- Motion of the car with uniform speed in the straight line

Q.21 Differentiate between uniform and variable velocity.**Ans:**

Uniform velocity	Variable velocity
<ul style="list-style-type: none"> If the speed and direction of the moving body does not change with time then its velocity is said to be uniform. <p>Example Body moving in straight line with uniform speed.</p>	<ul style="list-style-type: none"> If the speed or direction of the moving body changes with time then its velocity is said to be variable. <p>Example Body moving in circular path with uniform or non-uniform speed.</p>

Q.22 Does speedometer of a car measure its velocity?

Ans: The speedometer of a car measures only magnitude of velocity not the direction. Therefore, we can say that speedometer of the car does not measure its velocity.

Q.23 Why a body moving along a circle with uniform speed has variable velocity?

Ans: A body moving along a circle with uniform speed has variable velocity because its direction is changing at every point on the circular path.

Q.24 What is meant by the acceleration?

Ans: The rate of change of velocity of a body is known as acceleration.
Velocity of the body changes due to change either in magnitude or direction or both.

Mathematical form

If a body is moving with initial velocity ' v_i ' and after some time 't' its velocity becomes ' v_f ' then change in velocity will occur for time t. In this case, rate of change of velocity that is acceleration will be the average acceleration in time t.

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

$$\text{Acceleration} = \frac{\text{final velocity} - \text{initial velocity}}{\text{time}}$$

$$\text{So } a_{av} = \frac{v_f - v_i}{t}$$

Unit

In SI, the unit of acceleration is meter per second per second (ms^{-2}).

Quantity

It is a vector quantity.

Q.25 What is meant by uniform acceleration?

Ans: Let the time is divided into many small intervals of time. If the change in velocity during these entire interval remains constant then acceleration will also be constant this is called uniform acceleration which can be defined as:

"If a body has equal changes in velocity in equal intervals of time, however small the intervals may be, then the acceleration of the body is said to be uniform".

Q.26 What is meant by positive acceleration and negative acceleration?

Ans: **Positive acceleration**

If the velocity of the body is increasing then acceleration will be positive. The direction of positive acceleration is the same to the direction in which the body is moving without change in its direction.

Example

If a car is moving in straight line and the driver presses the accelerator the velocity of the car starts to increase. So the acceleration of the body will be positive.

Negative acceleration or retardation

If the velocity of the body is decreasing then acceleration will be negative. The direction of negative acceleration is opposite to the direction in which the body is moving. Negative acceleration is also called retardation.

Example

If the driver applies brake, the velocity will start to decrease. So acceleration of the body will be negative and direction of acceleration is opposite to the direction of velocity.

Q.27 A body moving with uniform velocity. What will be its acceleration?

Ans: A body is moving with uniform velocity then its acceleration will be zero because acceleration is defined as the rate of change of velocity. When the body is moving with uniform velocity, the change in velocity will be zero and therefore the acceleration will also be zero.

Q.28 Can a body moving with certain velocity in the direction of east can have acceleration in the direction of west?

Ans: Yes, a body moving with certain velocity in the direction of east can have acceleration in the direction of west. It is the case when the velocity of the body decreases. When velocity decreases, acceleration is produced in opposite direction to the direction of motion.

Q.29 What do you know about graph?

Ans: Graph is a pictorial way of presenting the information about the relation between various quantities. The quantities used in plotting a graph are called the variables.

Independent variable quantity

The quantity which can be changed with our wish is called independent variable quantity.

Dependent variable quantity

The quantity, value of which varies with the change in independent variable quantity is called the dependent variable quantity.

Q.30 Is velocity-time graphing a straight line? If yes then what information we get from it?

Ans: Yes, the velocity-time graph is a straight line and it shows that velocity of the body is changing uniformly and acceleration of the body will be uniform.

Q.31 What do you know about gravitational acceleration?

Ans: If we neglect air resistance, then all the bodies either lighter or heavier will fall down with uniform acceleration. This uniform acceleration of freely falling bodies is known as gravitational acceleration. It is represented by 'g'. Its value is 9.8ms^{-2} , but for simplicity we shall use the value of g as 10ms^{-2} .

Q.32 How can we use equations of motion for bodies, which are falling freely under the gravity?

Ans: Equations of motion can be used for bodies moving under gravity. In such cases we replace 'a' by 'g' and S by h. so equations of motion for bodies falling freely can be written as,

$$v_f = v_i + gt$$

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

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

Q.33 What are the points kept in mind when bodies are moving freely under gravity?

Ans: When bodies are moving in downward direction:

- Initial velocity ' v_i ' of the freely falling body will be zero
- Gravitational acceleration will be positive

When bodies are moving in upward direction:

- Final velocity ' v_f ' of the body will be zero.
- Gravitational acceleration will be negative.

Q.34 When a body is thrown vertically upward, its velocity at the highest point is zero. Why?

Ans: When a body is thrown vertically upward, it moves under gravity against the force of attraction of the earth. So after every second the velocity of the body decreases by 9.8ms^{-2} and ultimately becomes zero at the highest point. That is why the velocity of a body becomes zero at the highest point.

LONG QUESTIONS

2.2 TYPES OF MOTION

Q.No.1 Define Translatory motion and its types.

Ans: Such type of motion in which a body moves along a line without any rotation. The line may be straight or curved.

Examples

- Motion of a car in straight line
- Motion of electron around the nucleus
- Motion of gas molecules
- Aeroplane moving straight is in translational motion

Types of Translatory Motion

There are three types of translatory motion.

- (i) **Linear motion**
- (ii) **Circular motion**
- (iii) **Random motion**

(i) **Linear motion**

If the motion of a body is in straight line, it is known as linear motion.

Examples

- The motion of freely falling bodies
- A car moving along the straight line

(ii) **Circular motion**

If a body moves in a circle then its motion is known as circular motion.

Examples

- A stone attached with thread, when whirled, it will move along a circular path.
- A toy train moving on a circular track.
- A bicycle or car moving along a circular track
- Earth moving around the sun in solar system

(iii) **Random motion**

The disorder or irregular motion of an object is called random motion.

Examples

- The flight of a insect and birds
- Brownian motion of gas or liquid molecules
- Motion of dust or smoke particles in air

2.5 GRAPHICAL ANALYSIS OF MOTION

Q.No.2 Explain Distance – time Graph.

Ans: The term distance and displacement are used interchangeably when the motion is in straight line. Similarly, if the motion is in a straight line then speed and velocity are also used interchangeably.

In distance – time graph, time is taken along horizontal axis while the vertical axis shows the distance covered by the object.

Object at Rest

In the graph shown in figure, if the distance moved by the object with time is zero then the object is at rest. Thus a horizontal line parallel to time axis on a distance – time graph shows the speed of the object is zero.

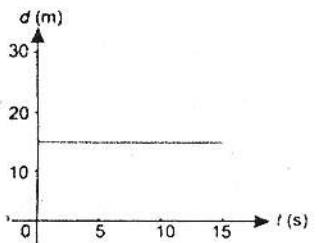


Figure 2.18: Distance-time graph when the object is at rest.

Object moving with Constant Speed

The speed of an object is said to be constant if it covers equal distance in equal intervals of time. The distance – time graph as shown in figure is a straight line. Its slope gives the speed of the object.

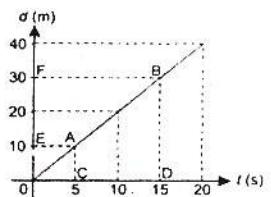


Figure 2.19: Distance-time graph showing constant speed.

Object moving with variable speed

When an object does not cover equal distances in equal intervals of time then its speed is not constant. In this case the distance – time graph is not a straight line as shown in figure. The slope of the curve at any point can be found from the slope of the tangent at that point.

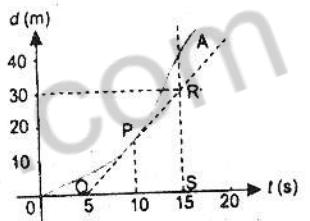


Figure 2.20: Distance-time graph showing variable speed.

Q.No.3 Explain Speed – Time Graph.

Ans: In a speed – time graph, time is taken along x – axis and speed is taken along y – axis.

Object moving with constant speed

When speed of an object is constant with time, then the speed – time graph will be horizontal line parallel to time – axis along x – axis as shown in figure. In other words, a straight line parallel to time axis represents constant speed of the object.

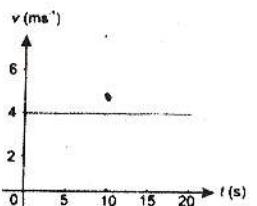


Figure 2.22: Speed-time graph showing constant speed.

Object moving with uniformly changing speed (uniform acceleration)

When the speed of an object is constant with time, then the speed – time graph will be a horizontal line parallel to time – axis along x – axis as shown in figure. In other words, a straight line parallel to time axis represents constant speed of the object.

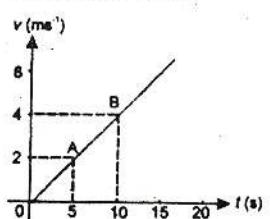


Figure 2.23: Graph of an object moving with uniform acceleration.

Distance traveled by a moving object

The area under a speed – time graph represents the distance traveled by the object. If the motion is uniform then the area can be calculated using appropriate formula for geometrical shapes represented by the graph.

2.6 EQUATIONS OF MOTION

Q.No.4 Derive the equations of motion for uniformly accelerated rectilinear motion

Ans: Equations of Motion

There are three basic equations of motion for bodies moving with uniform acceleration. These equations relate initial velocity, final velocity, acceleration, time and distance covered by a moving body.

Important points in derivation of equations

- We assume that the motion is along a straight line.
- We consider only the magnitude of displacements, velocities, and acceleration.
- Acceleration is taken as uniform.

Case study

Consider a body moving with initial velocity v_i in a straight line with uniform acceleration a . Its velocity becomes v_f after time t . The motion of the body is described by speed – time graph as shown in figure by line AB. The slope of the line AB is acceleration a . The total distance covered by the body is shown by the shaded area under the line AB. Equations of motion can be obtained easily from this graph.

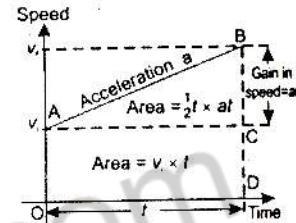


Figure 2.26: Speed-time graph. Area under the graph gives the distance covered by the body.

First equation of motion

Speed – time graph for the motion of a body is shown in figure. Slope of line AB gives the acceleration of the body.

$$\text{Slope of line AB} = a = \frac{BC}{AC}$$

$$\text{As } AC = OD \quad \text{and } BC = BD - CD$$

$$\text{So, } a = \frac{BD - CD}{OD}$$

$$\text{As } BD = v_f, \quad CD = v_i \quad \text{and } OD = t$$

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

$$\text{Or } v_f - v_i = at$$

$$\text{Therefore, } v_f = v_i + at$$

Second equation of motion

In speed – time graph as shown in figure, the total distance S traveled by the body is equal to the total area OABD under the graph. i.e.

$$\text{Total distance} = S = \text{area (rectangle OACD} + \text{triangle ABC)}$$

$$\text{Area of the rectangle OACD} = OA \times OD$$

$$= v_i \times t$$

$$\begin{aligned}\text{Area of the triangle ABC} &= \frac{1}{2} (AC \times BC) \\ &= \frac{1}{2} t \times at\end{aligned}$$

Since Total area OABD = area of rectangle + area of triangle ABC

Putting the values in the above equation, we get

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

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

Third equation of motion

In speed – time graph shown in figure, the total distance S traveled by the body is given by the total area OABD under the graph.

$$\text{Total area OABD} = S = \frac{OA + BD}{2} \times OD$$

$$\text{Or } 2S = (OA + BD) \times OD$$

$$\text{Multiply both sides by } \frac{BC}{OD}, \text{ we get} \quad (\text{as } \frac{BC}{OD} = a)$$

$$2S \times \frac{BC}{OD} = (OA + BD) \times OD \times \frac{BC}{OD}$$

$$2S \times \frac{BC}{OD} = (OA + BD) \times BC$$

$$2S \times \frac{BC}{OD} = (OA + BD) \times (BD - CD) \quad (\text{as } BC = BD - CD)$$

$$\text{As } OA = CD = V_i$$

$$\frac{BC}{OD} = a,$$

$$\text{and } BD = v_f$$

Putting the values in the in the above equation, we have

$$2S \times a = (v_f + v_i) \times (v_f - v_i)$$

$$\text{As } a^2 - b^2 = (a + b)(a - b)$$

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

MINI EXERCISE

(1) When a body is said to be at rest?

Ans: When a body does not change its position with respect its surroundings. Then it is said to be in the state of rest.

(2) Give an example of a body that is at rest and is in motion at the same time.

Ans: If a person is sitting in a car, he will be in the state of rest with respect to the other person sitting in the car and he will be in the state of motion with respect to the person standing on the road side at the same time.

(3) Mention the type of motion in each of the following.

(i) A ball moving vertically upward.

Ans: Linear motion (Translatory motion)

(ii) A child moving down a slide.

Ans: Linear motion (Translatory motion)

(iii) Movement of a player in a football ground.

Ans: Random motion (Translatory motion)

(iv) The flight of a butterfly.

Ans: Random motion (Translatory motion)

(v) An athlete running in a circular track.

Ans: Circular motion (Translatory motion)

(vi) The motion of a wheel.

Ans: Rotatory motion

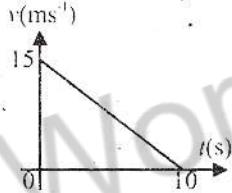
(vii) The motion of a cradle.

Ans: Vibratory motion

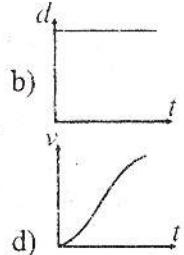
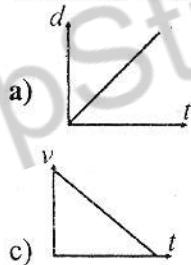
TEXTBOOK EXERCISE

QUESTIONS

- 2.1** Encircle the correct answer from the given choices.
- A body has translatory motion if it moves along a:
 - Straight line
 - circle
 - Straight line without rotation
 - all of these
 - The motion of a body around an axis is called _____ motion.
 - Circular
 - Rotatory
 - Vibratory
 - Random
 - Which of the following is a vector quantity?
 - Speed
 - distance
 - displacement
 - power
 - If an object is moving with constant speed then its distance-time graph will be a straight line.
 - Along time-axis
 - Along distance-axis
 - Parallel to time-axis
 - Inclined to time-axis
 - A straight line parallel to time-axis on a distance-time graph tells that the object is:
 - Moving with constant speed
 - At rest
 - Moving with variable speed
 - In motion
 - The speed-time graph of a car is shown in the figure, which of the following statement is true?
 - Car has an acceleration of 1.5 ms^{-2}
 - Distance travelled by the car is 75 m
 - Car has constant speed of 7.5 ms^{-1}
 - Average speed of the car is 15 ms^{-1}



- vii.** Which of the following graphs is representing uniform acceleration?



- viii.** By dividing displacement of a moving body with time, we obtain:
 - Speed
 - Acceleration
 - Velocity
 - Deceleration
- ix.** A ball is thrown vertically upward. Its velocity at the highest point is:
 - -10 ms^{-2}
 - Zero
 - 10 ms^{-2}
 - None of these
- x.** A change in position is called:
 - Speed
 - Velocity
 - Displacement
 - Distance
- xi.** A train is moving at a speed of 36 kmh^{-1} . Its speed expressed in ms^{-1} is:
 - 10 ms^{-1}
 - 20 ms^{-1}
 - 25 ms^{-1}
 - 30 ms^{-1}

- xii. A car starts from rest. It acquires a speed of 25 ms^{-1} after 20 s. the distance moved by the car during this time is:

a) 31.25 m b) 250 m c) 500 m d) 5000 m

- 2.2 Explain translatory motion and give examples of various types of translatory motion.

Ans. See Q.1 Long Question

- 2.3 Differentiate between the following:

- (i) Rest and motion
- (ii) Circular motion and rotatory motion
- (iii) Distance and displacement
- (iv) Speed and velocity
- (v) Scalars and vectors

- (i) Difference between Speed and Velocity

REST	MOTION
If a body does not change its position with respect to surroundings then it is said to be in a state of rest.	If a body continuously changes its position with respect to surroundings then it is said to be in a state of motion.

- (ii) Circular motion and rotatory motion.

Circular motion	Rotatory motion
The motion of an object in a circular path is known as circular motion. Examples: <ul style="list-style-type: none"> • The motion of earth around the sun. • The motion of electron around nucleus. 	The spinning motion of a body about its axis is called rotatory motion. Examples: <ul style="list-style-type: none"> • The motion of wheel about its axis. • Motion of ceiling fan.

- (iii) Difference between Distance and Displacement.

DISTANCE	DISPLACEMENT
<ul style="list-style-type: none"> • Actual (total) length between two points is known as distance. • It has no direction. • It is a scalar quantity. • It is represented by "S". 	<ul style="list-style-type: none"> • The shortest distance between two points is known as displacement. • It is directed from initial to final point. • It is a vector quantity. • It is represented by "d".

- (iv) Difference between Speed and Velocity

SPEED	VELOCITY
<ul style="list-style-type: none"> • The distance covered in unit time is known as speed. <p>Speed = distance/time</p> $= \frac{s}{t}$ <ul style="list-style-type: none"> • It is a scalar quantity. 	<ul style="list-style-type: none"> • The rate of displacement of a body with respect to time is called velocity. <p>Velocity = displacement/time</p> $= \frac{d}{t}$ <ul style="list-style-type: none"> • It is a vector quantity.

(v) Difference between scalar and vector.

SCALAR	VECTOR
Physical quantities which are completely described by their magnitude and only are known as scalar.	Physical quantities which are completely described by their magnitude and direction as well are known as vector.
Example Speed, distance, time etc.	Example Force, displacement, velocity etc.

2.4 Define the terms speed, velocity, and acceleration.

Ans: Speed

The distance covered by an object in unit time is called its speed.

Mathematical Formula

$$\text{Speed} = \frac{\text{Distance covered}}{\text{Total time}}$$

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

Distance = speed \times time

$$\text{Or } s = v \times t$$

Velocity

The rate of displacement of a body with respect to time is called velocity.

OR

Speed of a body along with the direction in which the body is moving.

Mathematical form

$$\text{Average velocity} = \frac{\text{displacement}}{\text{time taken}}$$

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

$$\text{Or } d = v \times t$$

Here d is the displacement of the body moving with velocity v in time t . Here v is the average velocity of the body during time t .

Acceleration

The rate of change of velocity of a body is known as acceleration.

Velocity of the body changes due change either in magnitude or direction or both.

Mathematical form

If a body is moving with initial velocity ' v_i ' and after some time ' t ' its velocity becomes ' v_f ' then change in velocity will occur for time t . In this case, rate of change of velocity that is acceleration will be the average acceleration in time t .

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{total time}} = \frac{\text{final velocity} - \text{initial velocity}}{\text{total time}}$$

$$\text{Acceleration} = \frac{v_f - v_i}{t}$$

$$\text{So } a_{av} = \frac{v_f - v_i}{t}$$

2.5 Can a body moving at a constant speed have acceleration?

Ans: A body is moving with constant speed may or may not have acceleration.

- If a body is moving with constant speed in straight line does not have acceleration.
- If a body is moving with constant speed and is not moving in straight line have acceleration.

2.6 How do riders in a Ferris wheel possess translatory motion but not circular motion?

Ans: The riders do not move in circle of constant radius therefore their motion is not circular

2.7 Sketch a distance – time graph for a body starting from rest. How will you determine the speed of a body from this graph?

Ans: The distance-time graph is shown below

The slope of the graph gives speed with the help of the formula

$$\text{Speed } (v) \text{ of the object} = \text{slope of line AB}$$

$$\begin{aligned} &= \frac{\text{distance EF}}{\text{time CD}} \\ &= \frac{20\text{m}}{10\text{s}} \\ &= 2 \text{ ms}^{-1} \end{aligned}$$

The speed found from the graph is 2 ms^{-1}

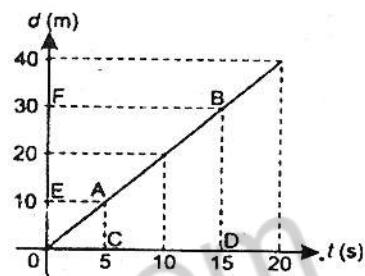


Figure 2.19: Distance-time graph showing constant speed.

2.8 What would be the shape of speed – time graph of a body moving with variable speed?

Ans: The shape of the velocity-time graph is zigzag when the body has variable speed

2.9 Which of the following can be obtained from speed – time graph of a body?

- Initial speed
- Final speed
- Distance covered in time t
- Acceleration of motion

Ans: From velocity-time graph we can calculate Initial speed, final speed, distance covered in time t and acceleration of motion.

2.10 How can vector quantities be represented graphically?

Ans: A vector can be represented graphically by drawing a straight line with an arrow head at one end. The Length of the line tells the magnitude and arrow head shows the direction of the vector

2.11 Why vector quantities cannot be added and subtracted like scalar quantities?

Ans: In addition of vectors, both magnitude and direction are involved. Therefore, vectors cannot be added by simple method of scalar addition.

2.12 How are vector quantities important to us in our daily life?

Ans: It would be meaningless to describe vectors without direction. For example, distance of a place from reference point is insufficient to locate that place. This direction of that place from reference point is also necessary to locate it.

2.13 Derive equations of motion for uniformly accelerated rectilinear motion.

Ans: See Q.no.4 Long Question

2.14 Sketch a velocity – time graph for the motion of the body. From the graph explaining each step, calculate total distance covered by the body.

Ans: Total distance traveled

$$\begin{aligned}
 &= \text{area under the graph} \\
 &\quad (\text{trapezium OABC}) \\
 &= \frac{1}{2} (\text{sum of parallel sides}) \times \text{height} \\
 &= \frac{1}{2} (18\text{s} + 30\text{s}) \times (16 \text{ ms}^{-1}) \\
 &= 384 \text{ m}
 \end{aligned}$$

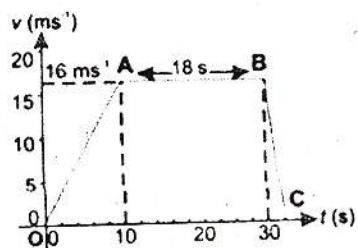


Figure 2.25: Speed-time graph of a car during 30 seconds.

PROBLEMS

2.1 A train moves with a uniform velocity of 36 kmh^{-1} for 10s. Find the distance traveled by it.

Given Data

$$\text{Velocity of train} = V_{av} = 36 \text{ kmh}^{-1} = \frac{36 \times 1000}{3600} = 10 \text{ ms}^{-1}$$

$$\text{Time taken} = t = 10 \text{ s}$$

Required

$$\text{Distance traveled by train} = S = ?$$

Solution

As we know that

$$S = V_{av} \times t$$

By putting the values, we have

$$S = 10 \times 10$$

$$S = 100 \text{ m}$$

Result

$$\text{Distance traveled by train} = S = 100 \text{ m}$$

2.2 A train starts from rest. It moves through 1 km in 100s with uniform acceleration. What will be its speed at the end of 100s.

Given Data

$$\text{Initial velocity of train} = v_i = 0 \text{ ms}^{-1}$$

$$\text{Distance covered by train} = S = 1 \text{ km} = 1000 \text{ m}$$

$$\text{Time taken by train} = t = 100 \text{ s}$$

RequiredSpeed of train after 100 s = v_f = ?**Solution**

First we have to find the acceleration, as we know that

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

By putting the values, we have

$$1000 = 0 \times 100 + \frac{1}{2} \times a \times (100)^2$$

$$1000 = \frac{1}{2} \times a \times 10000$$

$$1000 = a \times 5000$$

$$a = \frac{1000}{5000}$$

$$\text{So, } a = 0.2 \text{ ms}^{-2}$$

Now from first equation of motion, we have

$$v_f = v_i + at$$

by putting the values, we have

$$v_f = 0 + 0.2 \times 100$$

$$v_f = 20 \text{ ms}^{-1}$$

ResultSpeed of train after 100 s = $v_f = 20 \text{ ms}^{-1}$

- 2.3 A car has a velocity of 10 ms^{-1} . It accelerates at 0.2 ms^{-2} for half minute. Find the distance traveled during this and the final velocity of the car.

Given DataVelocity of the car = $v_i = 10 \text{ ms}^{-1}$ Acceleration of the car = $a = 0.2 \text{ ms}^{-2}$ Time taken by car = $t = 0.5 \text{ min.} = 0.5 \times 60 = 30 \text{ s}$ **Required**Distance traveled by car = S = ?**Solution**

As we know that

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

By putting the values, we have

$$S = 10 \times 30 + \frac{1}{2} \times 0.2 \times (30)^2$$

$$S = 300 + 0.1 \times 900$$

$$S = 300 + 90$$

$$S = 390 \text{ m}$$

ResultDistance traveled by car = $S = 390 \text{ m}$

- 2.4 A tennis ball is hit vertically upward with a velocity of 30 ms^{-1} . It takes 3 s to reach the highest point. Calculate the maximum height reached by the ball. How long it will take to return to ground?

Given Data

Initial velocity of the tennis ball = $v_i = 30 \text{ ms}^{-1}$

Time to reach the maximum height = $t = 3 \text{ s}$

Gravitational acceleration = $g = -10 \text{ ms}^{-2}$

Final velocity of the ball = $v_f = 0 \text{ ms}^{-1}$

Required

Maximum height reached by the ball = $h = ?$

Solution

From second equation of motion in vertical motion, we have

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

by putting the values, we have

$$h = 30 \times 3 + \frac{1}{2} \times (-10) (3)^2$$

$$h = 90 - 5 \times 9$$

$$h = 90 - 45$$

$$h = 45 \text{ m}$$

As the ball moves with uniform acceleration in vertical motion, so time taken by the ball in both directions will be same.

Total time taken to return the ground = Time taken upwards + Time taken downwards

Total time taken to return the ground = $3 \text{ s} + 3 \text{ s}$

Total time taken to return the ground = 6 s

Result

Maximum height reached by the ball = $h = 45 \text{ m}$

Total time taken to return the ground = 6 s

- 2.5 A car moves with uniform velocity 40 ms^{-1} for 5 s. It comes to rest in the next 10 s with uniform deceleration. Find

i) deceleration

ii) total distance traveled by the car

- i) When body moves with uniform velocity

Given Data

Velocity of the car = $v_{av} = 40 \text{ ms}^{-1}$

Time taken by the car = $t = 5 \text{ s}$

Required

Distance traveled by the car = $S_1 = ?$

Solution

As we know that

$$S = v_{av} \times t$$

By putting the values, we have

$$S_1 = 40 \times 5$$

$$S_1 = 200 \text{ m}$$

- ii) When speed of the car decreases and it comes to rest.

Given Data

Initial velocity of the car = $v_i = 40 \text{ ms}^{-1}$

Time taken by the car = $t = 10 \text{ s}$

Final velocity of the car = $v_f = 0 \text{ ms}^{-1}$

RequiredRetardation produced in car = $a = ?$ Distance traveled by the car = $S_2 = ?$ **Solution**

From first equation of motion, we have

$$v_f = v_i + at$$

By putting the values, we have

$$0 = 40 + a \times 10$$

$$-40 = a \times 10$$

So

$$a = \frac{-40}{10}$$

$$a = -4 \text{ ms}^{-2}$$

Now from second equation of motion, we have

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

By putting the values, we have

$$S_2 = 40 \times 10 + \frac{1}{2} (-4) \times (10)^2$$

$$S_2 = 400 - 2 \times 100$$

$$S_2 = 400 - 200$$

$$S_2 = 200 \text{ m}$$

So Total distance moved by car = $S = S_1 + S_2 = 200 \text{ m} + 200 \text{ m} = 400 \text{ m}$ **Result**Total distance moved by car = $S = 400 \text{ m}$

- 2.6 A train from rest with an acceleration of 0.5 ms^{-2} . Find its speed in kmh^{-1} , when it has moved through 100 m.

Given DataAcceleration of the train = $a = 0.5 \text{ ms}^{-2}$ Initial velocity of the train = $v_i = 0 \text{ ms}^{-1}$ Distance moved by train = $S = 100 \text{ m}$ **Required**Final speed in $\text{kmh}^{-1} = v_f = ?$ **Solution**

From third equation of motion, we have

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

by putting the values, we have

$$2 \times 0.5 \times 100 = v_f^2 - (0)^2$$

$$100 = v_f^2$$

by taking square root on both sides, we have

$$\sqrt{100} = v_f^2$$

$$\text{So } v_f = 10 \text{ ms}^{-1}$$

In kmh^{-1}

$$v_f = \frac{100 \times 3600}{1000}$$

$$v_f = 36 \text{ kmh}^{-1}$$

ResultFinal speed in $\text{kmh}^{-1} = v_f = 36 \text{ kmh}^{-1}$

- 2.7 A train starting from rest accelerates uniformly and attains a velocity 48 kmh^{-1} in 2 minutes. It travels at speed for 5 minutes. Finally, it moves with uniform retardation and is stopped after 3 minutes. Find the total distance traveled by the train.

Solution

Total Distance traveled

$$= \text{area under the graph (trapezium OABC)}$$

$$= \frac{1}{2}(\text{sum of parallel sides}) \times \text{height}$$

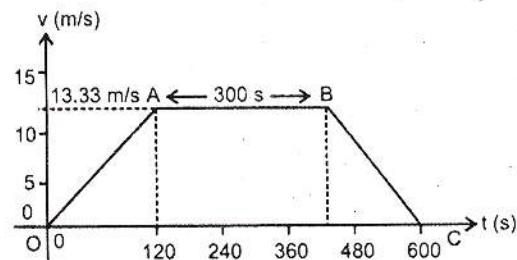
$$= \frac{1}{2}(600 + 300) \times 13.33$$

$$= \frac{1}{2}(900) \times 13.33$$

$$= 450 \times 13.33$$

$$= 5998.5$$

$$= 5999 \text{ m} = 6000 \text{ m}$$



Result

- 2.8 A cricket ball is hit vertically upwards and returns to ground 6 s later. Calculate

- Maximum height, reached by the ball.
- Initial velocity of the ball.

Given Data

$$\text{Final velocity of the ball} = v_f = 0 \text{ ms}^{-1}$$

$$\text{Gravitational acceleration} = g = 10 \text{ ms}^{-2}$$

$$\text{Time in which ball return to ground} = t = 6 \text{ s}$$

Required

$$\text{Maximum height reached by ball} = h = ?$$

$$\text{Initial velocity of the ball} = v_i = ?$$

Solution

As the ball moves with uniform acceleration in vertical motion, so time taken by the ball in both directions will be same.

Total time taken to return the ground = Time taken upwards + Time taken downwards

6s = Time taken upwards + Time taken downwards

As Time taken upwards = Time taken downwards

Total time taken to return the ground = $2 \times$ Time taken upwards

$$\text{So Time taken upwards} = 6\text{s}/2 = 3 \text{ s}$$

From first equation of motion, we have

$$v_f = v_i + gt$$

By putting the values, we have

$$0 = v_i + (-10) \times 3$$

$$0 = v_i - 30$$

So $v_i = 30 \text{ ms}^{-1}$

Now from second equation of motion, we have

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

By putting the values, we have

$$S = 30 \times 3 + \frac{1}{2} \times (-10) \times (3)^2$$

$$S = 90 - 5 \times 9$$

$$S = 45 \text{ m}$$

Result

Maximum height reached by ball = $h = 45 \text{ m}$

Initial velocity of the ball = $v_i = 30 \text{ ms}^{-1}$

- 2.9 When brakes are applied, the speed of a train decreases from 96 kmh^{-1} to 48 kmh^{-1} in 800 m . How much further will the train move before coming to rest? (Assuming the retardation to be constant)**

Given Data

$$\text{Initial velocity of train} = v_i = 96 \text{ kmh}^{-1} = 26.67 \text{ ms}^{-1}$$

$$\text{Final velocity of train} = v_f = 48 \text{ kmh}^{-1} = 13.33 \text{ ms}^{-1}$$

$$\text{Distance covered by train} = 800 \text{ m}$$

Required

$$\text{Retardation of the train} = a = ?$$

Solution

From third equation of motion, we have

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

By putting the values, we have

$$2 \times a \times 800 = (13.33)^2 - (26.67)^2$$

$$1600 \times a = 177.7 - 711.29$$

$$1600 \times a = -533.6$$

$$a = -0.33 \text{ ms}^{-2}$$

Given Data

$$\text{Initial velocity of train} = v_i = 48 \text{ kmh}^{-1}$$

$$\text{Final velocity of train} = v_f = 0 \text{ ms}^{-1}$$

$$\text{retardation of train} = a = -0.33 \text{ ms}^{-2}$$

Required

$$\text{Distance covered by train} = S = ?$$

Solution

From third equation of motion, we have

$$\underline{2aS = v_f^2 - v_i^2}$$

By putting the values, we have

$$2 \times (-0.33) \times S = (0)^2 - (13.33)^2$$

$$-0.66 \times S = -177.7$$

$$S = \frac{-177.7}{-0.66}$$

$$= 269 \text{ m}$$

Result

The train will move by 269m before coming to rest

- 2.10 In the above problem, find the time taken by the train to stop after the application of the brakes.

Given Data

$$\text{Initial velocity of train} = v_i = 96 \text{ kmh}^{-1} = 26.67 \text{ ms}^{-1}$$

$$\text{Final velocity of train} = v_f = 0 \text{ ms}^{-1}$$

$$\text{retardation of train} = a = -0.33 \text{ ms}^{-2}$$

Required

$$\text{Time taken by the train} = t = ?$$

Solution

From first equation of motion, we have

$$v_f = v_i + at$$

By putting the values, we have

$$0 = 26.67 + (-0.33) \times t$$

$$-26.67 = -0.33 \times t$$

$$t = \frac{-26.67}{-0.33}$$

$$t = 80 \text{ s}$$

Result

$$\text{Time taken by the train} = t = 80 \text{ s}$$