2 CHAPTER

KINEMATICS

LONG QUESTIONS

Q.1 Define Mechanics and discuss its types.

Ans:

MECHANICS

Mechanics is the branch of physics that deals with the motion of objects and the forces that change it.

Types:

Generally, mechanics is divided into two branches:

1. Kinematics
2. Dynamics

KINEMATICS:

Kinematics is the study of motion of objects without referring to forces.

Example:

In our everyday life, we observe many objects in motion. For example, cars, buses, bicycles, motorcycles moving on the roads, aero planes flying through air, water flowing in canals or some object falling from the table to the ground.

Dynamics:

Dynamics deals with forces and their effect on the motion of objects.

2.1 SCALARS AND VECTORS

LONG QUESTION

Q.1 Differentiate between scalars and vectors quantities.

SCALARS

Definition:

"Physical quantities which can be completely described only by its numerical magnitude (or size) with proper unit are termed as scalar quantities or simply scalars."

Example:

"Scalars quantities such as distance, speed, time, mass, energy, and temperature etc are scalar quantities."

consider a man travels a distance of 4.5km but its direction is not specified but only this magnitude is given so it is said to be scalar quantity similarly we say that time is a scalar quantity, because when we say that time measPurement is 30 s, here '30' is the numerical magnitude and 's' is proper unit. We do not need to state the direction of time.

Scalar quantities can be added, subtracted and multiplied by using ordinary rules of algebra. For example, if we took 5 s to reach the door of the classroom and another 20 s to reach the gate of school, the total time we took is (5 s +20 s) 25 seconds.

VECTOR

Definition:

"Physical quantities which require not only numerical magnitude (or size) with proper unit, but also the direction is termed as vector quantities or simply vectors."

Example:

"Vector quantities such as displacement, force, weight, velocity, acceleration, momentum, electric field strength, and gravitational field strength, require both numerical magnitude and direction."

When we refer to a vector quantity, we not only mention its numerical magnitude and unit, but also its direction. To fully describe a vector, its direction must be specified.

Since vector quantities are associated with direction, they cannot be added, subtracted, or multiplied using the usual rules of algebra.

SHORT QUESTION

Q.1 Differentiate scalar and vector quantities.

Ans:

DIFFERENTIATE

Differentiate between scalar and vector are as follows:

Scalar Quantities	Vector Quantities

Definition	
• "Physical quantities which can be completely described only by its numerical magnitude (or size) with proper unit are termed as scalar quantities or simply scalars."	• "Physical quantities which can be completely described by their magnitude (or size) along with their direction are called vector quantities or simply vectors."
EXAMPLE	
• Mass • Length • Time • Temperature	• Force • Momentum • Torque • displacement
Addictions/Subtraction	
• Scalar quantities can be added or subtracted by simply arithmetic rules because they have only numeric value with proper unit. • **Example:**	• Vector quantities cannot be added or subtracted by simply arithmetic rules because they have direction along with numeric value and proper unit. • **Example:**

MULTIPLE CHOICE QUESTIONS

1. Which one of the following is a vector quantity?
(A) Displacement (B) Speed
(C) Volume (D) Work

2. Which list contains only scalar quantities?
(A) Acceleration, displacement, velocity (B) Distance, force, speed
(C) Force, length time (D) Length, mass, speed

3. Which is a vector quantity?
(A) A mass of 2.0 kg (B) A temperature of – 10^{o}c
(C) A weight of 15N (D) An average speed of 20m/s

1.3 VECTOR REPRESENTATION

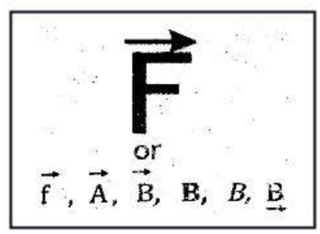
A vector quantity can be representative by two method.

- Symbolic method
- Graphical method

SHORT QUESTIONS

Q.1 What is representation of vector by symbolically?

Ans:



Definition:

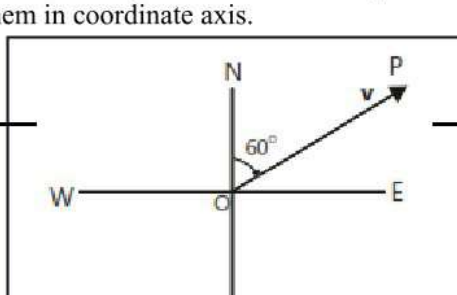
"Symbolically a vector can be represented by a letter either capital or small with a small arrow over it.

Example:

F and or A and B with an arrow over it.

Q.2 What is representation of vector by graphically?

Ans: Graphically a vector is represented by an arrow, the length of the arrow gives the magnitude with proper unit (under certain scale) and the arrow head points the direction of the vector. To use vectors, we place them in coordinate axis.



Q.3 Which step to represent a vector in coordinate system?

Ans: The following method is used to represent a vector

- Choose and draw a coordinate system.
- Select a suitable scale.
- Draw a line in the fixed direction. Cut the line equal to the magnitude of the vector according to the chosen scale.
- Put an arrow along the direction of the vector.

Q.4 Why vector quantities cannot be added and subtracted like scalar quantities?

Ans: **<u>ADDITION AND SUBTRACTION OF VECTORS</u>**

Scalar quantities can be described completely by magnitude only and can be added or subtracted by simple arithmetic rules. Vector quantities in addition to magnitude also need direction for their description. So, vectors cannot be added or subtracted by arithmetic rules due to direction.

Q.5 State Head to tail rule.

Ans: **<u>Statement:</u>**

To add a number of vectors, redraw their representative lines such that the head of one line coincides with the tail of the other. The resultant vector is given by a single vector which is directed from the tail of the first vector to the head of the last vector.

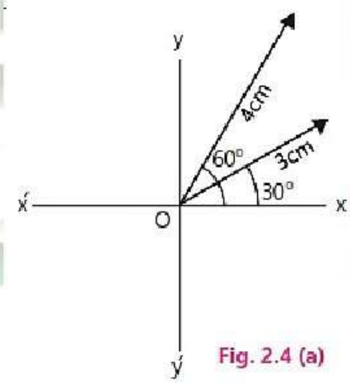


Fig. 2.4 (a)

Q.6 How are vector quantities important to us in our daily life?

Ans: **<u>IMPORTANCE OR VECTOR QUANTITIES</u>**

In order to locate a place from a reference point, we will have to describe the distance and direction of that place from reference point. Description of distance along with direction will make up a vector quantity. Hence by using vector quantities we can describe the position (or location) of bodies.

1.6.3 ADDING VECTOR QUANTITIES

SHORT QUESTION

Q.1 What is resultant of vector?

Ans: **<u>RESULTANT OF VECTOR</u>**

<u>Definition:</u>

"The process of combining two or more vectors to into a single vector (called as resultant vector) to determine their cumulated effect is termed as vector addition."

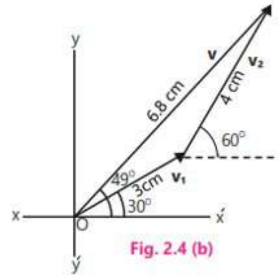


Fig. 2.4 (b)

Consider two vectors $\vec{A}$ (along x-axis) and $\vec{B}$ (along y-axis), which are perpendicular to each other. We can add the two vectors by placing vector $\vec{B}$ on head of vector $\vec{A}$, the resultant vector $\vec{R}$ will be obtained by joining tail of vector $\vec{A}$ with head of vector $\vec{B}$, as shown in figure 1.6.

MULTIPLE CHOICE QUESTIONS

1. The process of combining two or more vectors to into a single vector

(A) vector (B) scalar
(C) resultant vector (D) All of these

2.2 REST AND MOTION
2.3 TYPES OF MOTION

LONG QUESTIONS

Q.2 Define rest and motion and explain them as relative quantities.

Ans: **<u>REST AND MOTION</u>**

We see various things around us. Some of them are at rest while others are in motion

Rest:

"If with passage of time an object does not change its position with respect to its surrounding then it is at rest.**"**

Surroundings:

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

Motion:

"If with passage of time an object does change its position with respect to its surrounding then it is at motion.**"**

Relative Quantities:

When we look around us, we observe that many objects do not change their position. Thus, we consider them at the state of rest. For example, a bench in a park fixed under a tree is at rest as there is no change in its position with respect to us while standing near it with the passage of time. On the other hand, we also observe that many objects do change their position from one place to another. Hence, we consider them to be in the state of motion. For example, a car is in motion if there is change in its position with time.

POINT TO PONDER

Interestingly objects can be at rest and in motion at same time. It looks simple to distinguish the rest from motion, for example a car starts, it changes its position with reference to its surrounding, we say that car is moving.

However, we know that Earth is spinning on its axis, so the car along with its road is also in motion. Not only this but Earth is also moving around the sun and the sun along with the rest of the solar system are also moving through our milky way galaxy. Apart from this our galaxy is also traveling through space. How can we say that our car is at rest? This is why when we state an object to be at rest or motion, we specify it reference to some observer.

Q.3 Define Translatory motion and its types.

Ans: **<u>TRANSLATORY MOTION</u>**

<u>Introduction</u>:

We observe different types of motion in our daily life. A train moves almost along a straight line, the blades of a fan rotate about an axis, a swing vibrates about its mean position. Generally, there are three types of motion of bodies.

1. Translatory motion 2. Rotatory motion 3. Vibratory motion

<u>Definition</u>:

1. Translatory Motion

If the motion of a body is such that every particle of the body moves uniformly in the same direction, it is called translatory motion. For example, the motion of a train or a car is translatory motion (Fig.2.6). Translatory motion can be of three types:

Fig. 2.6 The motion of a train is translatory motion

(i) Linear Motion

If the body moves along a straight line, it is called linear motion. A freely falling body is the example of linear motion.

(ii) Random Motion

If the body moves along an irregular path (Fig. 2.7), the motion is called random motion.

(iii)Circular Motion

The motion of a body along a circle is called circular motion. If a ball tied to one end of a string is whirled, it moves along a circle. A Ferris wheel is also an example of circular motion (Fig.2.8).

2. Rotatory Motion:

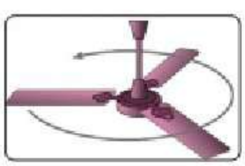
If each point of a body moves around a fixed point (axis), the motion of this body is called rotatory motion. For example, the motion of an electric fan and the drum of a washing machine dryer is rotatory motion (Fig.2.9). The motion of a top is also rotatory motion.

3. Vibratory Motion

When a body repeats its to and fro motion about a fixed position, the motion is called vibratory motion. The motion of a swing in a children park is vibratory motion (Fig. 2.10).

(a) Irregular path (b) The motion of bee is random motion
Fig. 2.7

Circular Motion
Fig. 2.8



Rotatory motion of a fan
Fig. 2.9

Fig. 2.10 Vibratory motion

SHORT QUESTIONS

Q.1 Define Axis of rotation?

AXIS OF ROTATION

Definition:

"An axis is a line around which a body rotates."

Q.2 Differentiate between circular motion and rotatory motion.

Ans:

DIFFERENTIATION

Differences between circulatory and rotatory motion are as follows:

Circulatory Motion	Rotatory Motion
Definition	
• "Circular motion is the translatory motion of an object in which it moves in a curved path."	• "If all points of a moving object move uniformly in the same direction, such that there is no change in the object's
Position of Axis	
• In circular motion the point about which a body goes around is outside the body.	• In rotatory motion the line around which a body moves
Examples	
• Motion of earth around the sun. • Motion of individual particles of spinning top	• Motion of earth about its geographical • Spinning motion of top

Q.3 When a body is said to be at rest?

Ans:

A BODY AT REST

"If with passage of time an object does not change its position then it is at rest."

Example:

A tree standing along a road is in the state of rest with respect to that road.

Q.4 Give an example of a body that is at rest and is in motion at the same time.

Ans:

REST AND IN MOTION AT SAME TIME

If a person is sitting in a moving 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.

Q.5 Mention the type of motion in each of the following.

Ans:

TYPES OF MOTION

Sr. #	Motion	Type
I	A ball moving vertically upward	Linear motion (Translatory motion)
ii	A child moving down a slide	Linear motion (Translatory motion)
iii	Movement of a player in a football ground	Random motion (Translatory motion)
iv	The flight of a butterfly	Random motion (Translatory motion)
V	An athlete running in a circular track	Circular motion (Translatory motion)
vi	The motion of a wheel	Rotatory motion
vii	The motion of a cradle	Vibratory motion

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 discussing the cause of motion is called:**
(A) Kinematics (B) Dynamics
(C) Heat (D) Motion

3. **If with passage of time an object does not change its position then it is at rest.**
(A) Rest (B) Motion
(C) Uniform motion (D) Relative motion

4. **If with passage of time an object do change its position then it is at motion.**
(A) Rest (B) Motion
(C) Uniform motion (D) Relative motion

5. **Rest and motion are:**
(A) Absolute states (B) Constant states
(C) Variable states (D) Relative states

6. **The spinning motion of a body about its axis is known as:**
(A)Translatory motion (B) Vibratory motion
(C) Rotatory motion (D)None of these

7. **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

8. **The motion of the string of a violin is:**
(A)Translatory (B) Vibratory
(C) Rotatory (D)None of these

9. **The spinning motion of individual particles of top is known as.**
(A)Translatory motion (B) Vibratory motion
(C) Rotatory motion (D) Random motion

10. **Motion in which every particle of a body has exactly the same motion is called_____.**
(A)Rotatory motion (B) Vibratory motion
(C)Translatory motion (D) None of these

11. **Causes day and night on the Earth:**
(A) Circular motion of the Earth (B) Vibratory motion of the Earth
(C) Rotatory motion of the Earth (D) Motion of the Sun

2.4 DISTANCE AND DISPLACEMENT
TERMS ASSOCIATED WITH MOTION

SHORT QUESTIONS

Q.1 Differentiate Distance and displacement?

Ans: **DIFFERENTIATION**

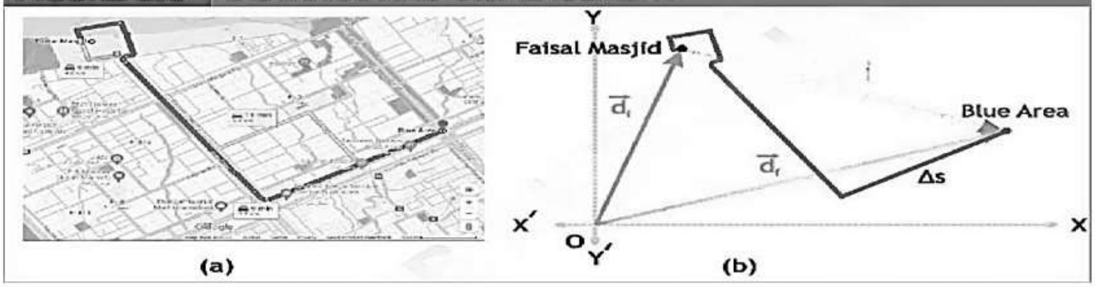
Differences between distance and displacement are as follows

The spinning motion of a body about its axis is known as:

Distance	Displacement
Definition	
• 'The length of path traveled between two positions is called distance.	• The shortest distance from initial position to final (or straight directed distance) is called displacement.
Symbol	
• Distance is usually denoted by Δx, Δr, Δs.	• Displacement is denoted by "$\vec{d}$"
Quantity	
• Distance is a scalar quantity. Its S.I unit is metre	• Displacement is a vector quantity. Its S.I unit is metre
Graphical Difference	

If we are at Faisal Masjid, Islamabad and we want to move to Blue area, Islamabad by searching on google map. We get a twisted path, showing us the way to reach our destination.

FIGURE 2.6 DISTANCE AND DISPLACEMENT



2.5 SPEED AND VELOCITY

LONG QUESTIONS

Q.1 Define speed and discuss its types.

Ans:

SPEED

Definition:

Distance covered in unit time is known as speed.

Formula:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Or $$V = \frac{\Delta s}{\Delta t}$$

Unit:

The S.I unit of speed is ms^{-1}

Quantity:

Speed is a scalar quantity.

Example:

An eagle dives to the ground along a 300 m path with an average speed of 60 m s^{-1}. How long does it take to cover this distance?

Total distance covered = S = 300 m Average speed = v = 60 m s^{-1}

Total time taken = t = ?

Using the equation

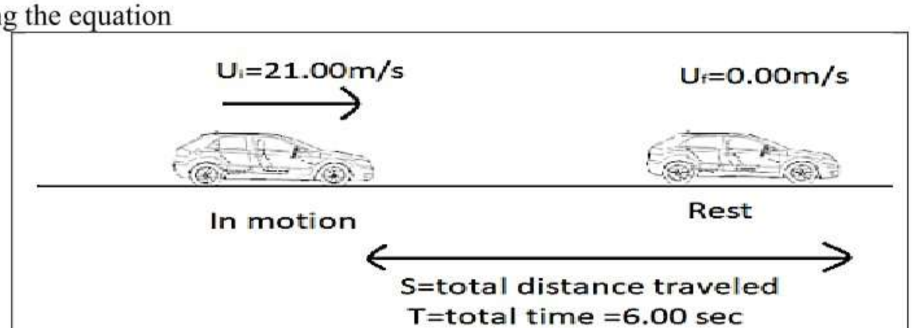


Fig 2.7 speed of a car

POINT TO PONDER

SOME INTERESTING SPEED FACTS

Who is the fastest man on earth? Yes, Usain Bolt. He finished a 100-metre sprint in just 9.58 seconds back in 2009. In that instance, his speed was 10.44 m/s or 37.58 km/h.

The slowest animal in the world, the crown goes to the 3-toed sloth. And, the average speed of them is about 0.00134112 m/s or 0.0048 km/h. You would have seen garden snails or turtles moves which is faster than this rate.

The fastest animal in the world is Peregrine Falcon, it can attain a maximum speed of up to 108.333 m/s or 390 km/h. Cheetah is the fastest animal in the land can reach a fastest speed of 33.33 m/s or 120 km/h.

A. <u>AVERAGE SPEED:</u>

If we calculate our speed over an entire trip, we are considering a large distance between two places and the total time that elapsed. The increases and decreases in speed would be averaged. The average speed is the total distance (s) covered in total time (t).

B. <u>INSTANTANEOUS SPEED</u>

We see sign boards on road reading, sharp turn ahead reduces speed 'speed limit 70 km/hr. Certainly this sign board does not refer to our average speed, but the speed at which we are moving at that particular instant of time. The speed at any specific instant of time is called the instantaneous speed.

C. <u>UNIFORM AND VARIABLE SPEED</u>

'If an object covers equal distances in equal intervals of time we say that the object is moving with uniform speed'. In uniform speed object does not get slower or faster and maintains the same speed.

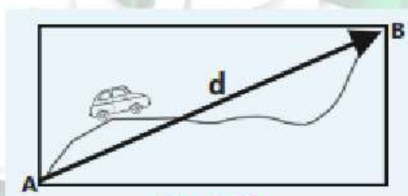


Fig. 2.11

Q.2 Define velocity and discuss its types.

Ans:

<u>VELOCITY</u>

<u>Definition:</u>

The net displacement from a body in unit time.

Mathematically

<u>Formula:</u>

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

Or $$V_{av} = \frac{d}{t}$$

Unit:

The S.I unit of Velocity is ms^{-1}

Quantity: Velocity is a vector quantity.

For Example:

For straight-line motion in one direction, speed and velocity have same magnitudes because the lengths of the distance and the displacement are the same. The distinction between them in this case is that a displacement direction must be specified for the velocity.

A. **AVERAGE VELOCITY:**

The average velocity is the total displacement $(\vec{d})$ covered in total time (t).

B. **INSTANTANEOUS VELOCITY**

If velocity is measured by keeping the time interval small, such velocity is termed as instantaneous velocity. To calculate velocity both the speed and direction for that moment of time need to be specified.

C. **UNIFORM AND VARIABLE VELOCITY** 'If an object covers equal displacements in equal intervals of time we say that the object is moving with uniform velocity. **Uniform velocity is the velocity that does not change otherwise it is called variable velocity.**

To produce variable velocity (a change in velocity), either the speed or the direction is changed (or both are changed). A satellite moving with a constant speed in a circular orbit around Earth does not have a constant velocity since its direction of movement is constantly changing.

SHORT QUESTIONS

Q.1 Difference between speed and velocity.

Ans: **DIFFERENTIATION**

Differences between speed and velocity are as follows:

Speed	Velocity
Definition	
• Distance covered in unit time is known as speed	• The net displacement from a body in unit time.
Symbol	
• Speed is represented by "v"	• Displacement is denoted by "$\vec{v}$"
Quantity	
• Speed is a scalar quantity.	• Speed is a scalar quantity.
Formula	
• Speed= Distance covered/Total time $V=\frac{s}{t}$	• Velocity $= \frac{\text{displacement}}{\text{time taken}}$ $V=\frac{d}{t}$

Q.4 How you will define the uniform speed?

Ans: **UNIFORM SPEED**

Definition:

"If the speed of a body does not vary and has the same value then the body is said to possess uniform speed.**"**

OR

"A body has uniform speed if it covers equal distances in equal intervals of time however short the interval may be."

Q.5 How you will define the Average speed?

Ans: **AVERAGE SPEED**

Definition:

If we calculate our speed over an entire trip, we are considering a large distance between two places and the total time that elapsed. The increases and decreases in speed would be averaged. The average speed is the total distance (s) covered in total time (t).

Q.6 How you will define the instantaneous speed?

Ans: **INSTANTANEOUS SPEED**

Definition:

We see sign boards on road reading, sharp turn ahead reduces speed 'speed limit 70 km/hr. Certainly this sign board does not refer to our average speed, but the speed at which we are moving at that particular instant of time. The speed at any specific instant of time is called the instantaneous speed.

Q.7 How you will define the Uniform velocity?

Ans: **UNIFORM VELOCITY**

Definition:

"If an object covers equal displacements in equal intervals of time we say that the object is moving with uniform velocity."

Q.8 How you will define the Average velocity?

Ans: **AVERAGE VELOCITY**

Definition:

"The average velocity is the total displacement $\left(\vec{d}\right)$ covered in total time (t)."

Q.9 How you will define the instantaneous velocity?

Ans: **INSTANTANEOUS VELOCITY**

Definition:

"If velocity is measured by keeping the time interval small, such velocity is termed as instantaneous velocity. To calculate velocity both the speed and direction for that moment of time need to be specified."

Q.10 How you will define the variable velocity?

Ans: **VARIABLE VELOCITY**

Definition:

"Uniform velocity is the velocity that does not change otherwise it is called variable velocity. To produce variable velocity (a change in velocity), either the speed or the direction is changed (or both are changed)."

For example:

A satellite moving with a constant speed in a circular orbit around Earth does not have a constant velocity since its direction of movement is constantly changing.

Q.11 Why a body moving along a circle with uniform speed has variable velocity?

Ans: **VARIABLE VELOCITY ALONG CIRCULAR PATH**

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.12 Does speedometer of a car measure its velocity?

Ans: **SPEED–O–METER**

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. It measures only speed.

2.6 ACCELERATION

LONG QUESTIONS

Q.1 Define acceleration and discuss its types.

ACCELERATION

Definition:

"Acceleration is defined as the time rate of change of velocity"

Formula:

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

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

Unit:

The SI unit of acceleration is ms^{-2}.

Quantity:

Acceleration is a vector quantity.

Types of Acceleration

- Positive acceleration
- Negative acceleration

POSITIVE ACCELERATION

Definition:

A positive acceleration means an increase in velocity with time.

Unit:

The SI unit of acceleration is ms^{-2}.

Quantity:

Acceleration is a vector quantity.

- acceleration

NEGATIVE ACCELERATION

Definition:

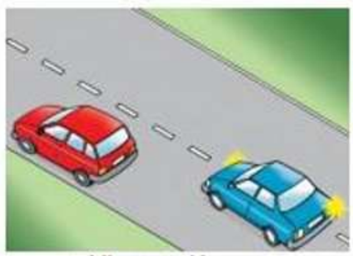
A negative acceleration means an decrease in velocity with time.

Unit:

The SI unit of acceleration is ms^{-2}.

Quantity:

Acceleration is a vector quantity.



While overtaking, a car accelerates to a greater velocity.
Fig. 2.12

Uniform Acceleration:

When an object is changing its velocity at the same rate each second, we call it uniform acceleration. A body has uniform acceleration if it has equal changes in velocity in equal intervals of time.

Non-uniform Acceleration:

Non-uniform acceleration occurs when an object's velocity changes, but this change is not steady over time. In simple terms, the rate at which the object's velocity changes is not the same throughout its movement. Acceleration, which is the measure of velocity change, is therefore not constant in non-uniform acceleration. Understanding non-uniform acceleration is important in physics to explain the movement of objects affected by changing forces. This is a common and practical situation since many real-life scenarios involve forces that vary over resulting in non-uniform acceleration.

SHORT QUESTIONS

Q.1 Define acceleration.

ACCELERATION

Definition:

"The measure of change in velocity ' $\Delta\vec{v}$ ' with the passage of time 'Δt' is called acceleration $\vec{a}$. (or) Time rate of change in velocity ' $\Delta\vec{v}$ ' is called acceleration ' $\vec{a}$ '."

Formula:

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

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

Unit:
The SI unit of acceleration is ms^{-2}.
Quantity:
Acceleration is a vector quantity.

Q.2 Define positive acceleration.

POSITIVE ACCELERATION

Definition:
A positive acceleration means an increase in velocity with time.
Unit:
The SI unit of acceleration is ms^{-2}.
Quantity:
Acceleration is a vector quantity.
acceleration

Q.3 Define negative acceleration.

NEGATIVE ACCELERATION

Definition:
A negative acceleration means a decrease in velocity with time.
Unit:
The SI unit of acceleration is ms^{-2}.
Quantity:
Acceleration is a vector quantity.

Q.4 Define uniform acceleration.

UNIFORM ACCELERATION

Definition:
When an object is changing its velocity at the same rate each second, we call it uniform acceleration. A body has uniform acceleration if it has equal changes in velocity in equal intervals of time.

Q.5 Can a body moving with constant velocity have acceleration?

Ans: **ZERO ACCELERATION**

No, a body moving with constant velocity will not have acceleration; 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. But in case of circular motion the body has some acceleration

Q.6 Can a body moving with certain velocity in the direction of east can have acceleration in the direction of west?

Ans: **DIRECTION OF ACCELERATION**

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.

MULTIPLE CHOICE QUESTIONS

1. Which one of the following is a vector quantity?
(A) Displacement (B) Speed
(C) Volume (D) Work

2. Which list contains only scalar quantities?
(A) Acceleration, displacement, velocity (B) Distance, force, speed
(C) Force, length, time (D) Length, mass, speed

3. Which is a vector quantity?
(A) A mass of 2.0 kg (B) A temperature of –10°c

(C) A weight of 15 N (D) An average speed of 20 m/s

4. Total length of a path between two points is known as:
(A) Velocity (B) Acceleration
(C) Speed (D) Distance

5. The shortest distance between two points is known as:
(A) Velocity (B) Displacement
(C) Speed (D) Distance

6. SI unit of speed is:
(A) ms^{-1} (B) mh^{-1}
(C) kms^{-1} (D) All of these

7. Speed is a:
(A) Vector quantity (B) Scalar quantity
(C) Both quantity (D) none of these

8. 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) Non uniform (D) All of these

9. The rate of displacement with respect to time is known as:
(A) Distance (B) Speed
(C) Velocity (D) Acceleration

10. 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

11. 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

12. The rate of change in position is called_________.
(A) Distance (B) Displacement
(C) Velocity (D) Acceleration

13. Usain bolt finished a 100-meter sprint in just 9.58 seconds back in 2009. What is speed?
(A) 10.44 m/s (B) 37.58 m/s
(C) 9.0 m/s (D) 36.9 m/s

14. A car traveling at 10 m/s accelerate uniformly at $2ms^{-2}$. What will be its velocity after 5 second?
(A) 10 m/s (B) 20 m/s
(C) 50 m/s (D) 40 m/s

15. Rate of change of velocity is known as:
(A) Distance (B) Speed
(C) Velocity (D) Acceleration

16. If the velocity of the body is increasing then its acceleration will be:
(A) Positive (B) Negative
(C) Uniform (D) Variable

17. If the velocity of the body is decreasing then its acceleration will be:
(A) Positive (B) Negative
(C) Uniform (D) Variable

18. If the velocity of a body is uniform then its acceleration will be:
(A) Positive (B) Negative

(C) Zero (D) Doubled

19. SI unit of acceleration is:
(A) ms^{-1} (B) kmh^{-1}
(C) kms^{-2} (D) ms^{-2}

20. 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

21. 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

22. If the direction of motion of body and acceleration are in same direction then acceleration will be:
(A) Uniform (B) Positive
(C) Negative (D) Zero

23. If the direction of motion of body and acceleration are in opposite direction then acceleration will be:
(A) Uniform (B) Positive
(C) Negative (D) Zero

24. The quantity which can be described by a number, with suitable unit only is called:
(A) Vector (B) Scalar
(C) Speed (D) Acceleration

25. The quantity which are described by magnitude as well as direction is called:
(A) Vector (B) Scalar
(C) Speed (D) Acceleration

26. 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

27. Velocity of a paratrooper coming down with constant velocity is also called:(F.B 2015) (K.B)
(A) Uniform acceleration (B) Variable velocity
(C) Terminal velocity (D) Instantaneous velocity

28. By which quantity should we divide acceleration in kmh^{-2} to get its value in ms^{-2}?
(A) 12960 (B) 1000
(C) 3600 (D) $(3600)^2$

2.7 GRAPHICAL ANALYSIS OF MOTION
DISTANCE –TIME GRAPH
SPEED TIME GRAPH

LONG QUESTIONS

Q.1 What do you know about graph? Write their use?

Ans:

GRAPH

Definition:

"Graph A graph is a pictorial diagram in the form of a straight line or a curve which shows the relationship between two physical quantities."

VARIABLES

Definition:

"The quantities between which a graph is plotted are called the variables."

TYPES OF VARIABLES

Dependent Variables:

The quantities whose values depend on other quantities are called dependent variables. While plotting a graph dependent variable is taken along vertical axis.

Example:

While driving a car distance covered depends on time so distance is a dependent variable

Independent Variable:

The quantity whose value of does not depend on other quantities are called the independent variables. While plotting a graph independent variable is taken along horizontal axis.

Example:

Time is an independent variable.

Uses of Graphs:

Graphs can be used to:

- Analyze motion of objects.
- Show year–wise growth/decline of export, month–wise rainfall, a patient's temperature record or runs per over scored by a team and so on.

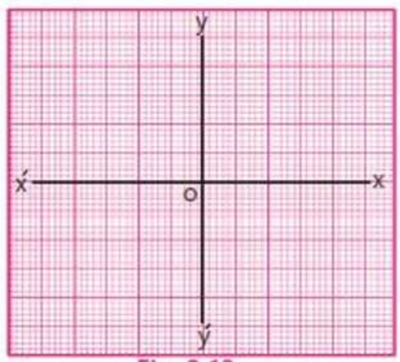


Fig. 2.13

Figure: Use of Graphs

Q.2 What is the slope (or gradient) of distance time curve give speed?

Ans: 2.6.1 DISTANCE-TIME GRAPH

The distance-time graph is plotted between distance (s) and time (t). The time is plotted along horizontal axis (x-axis) and distance is plotted along vertical axis (y-axis) as shown in figure 2.12 Distance time graph is always in the positive XY plane, as with passage of time, distance never goes to negative axis, irrespective of the direction of motion.

Distance-time graph shows the relation between distance S and time t taken by a moving body. Let a car be moving in a straight line on a motorway. Suppose that we measure its distance from starting point after every one minute, and record it in the table given below:

Time t(min)	0	1	2	3	4	5
Distance S(km)	0	1.2	2.4	3.6	4.8	6.0

Follow the steps given below to draw a graph on a centimeter graph paper:

i. Take time t along x-axis and distance S along y-axis.

ii. Select suitable scales (1 minute = 1 cm) along x-axis and (1.2 km =1 cm) along y-axis. The graph paper shown here is not to the scale.

iii. Mark the values of each big division along x and y axes according to the scale.

iv. Plot all pairs of values of time and distance by marking points on the graph paper.

v. Join all the plotted points to obtain a best straight line as shown in Fig. 2.14. From the table, we can observe that car has covered equal distance in equal intervals of time. This shows that the car moves with uniform speed. Therefore, a straight line graph between time and distance represents motion with uniform speed. Now consider another journey of the car as recorded in the table given below:

Time t(min)	0	1	2	3	4	5
Distance S(km)	0	0.240	0.960	2.160	3.840	6.000

Table shows that speed goes on increasing in equal intervals of time. This is very obvious from the graph as shown in Fig. 2.15. The graph line is curved upward.
This is the case when the body (car) is moving with certain acceleration.

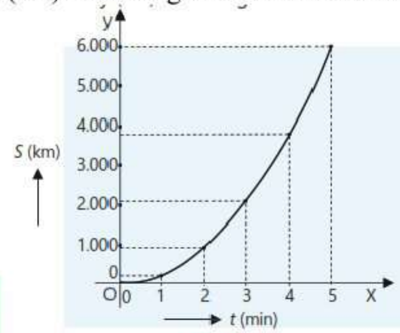


Fig. 2.15

Q.3 Explain Distance – time Graph.

Ans:

DISTANCE TIME GRAPH

It is useful to represent the motion of objects using graphs. The terms distance and displacement are used interchangeably when the motion is in a straight line. Similarly, if the motion is in a straight line then speed and velocity are also used interchangeably. In a distance–time graph, time is taken along horizontal axis while vertical axis shows the distance covered by the object.

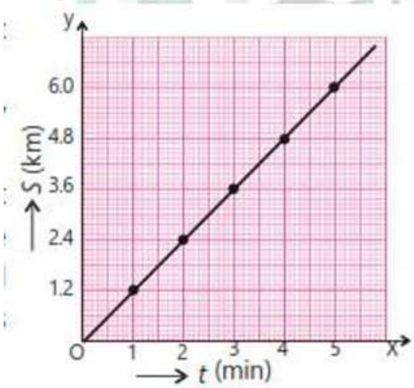


Fig. 2.14

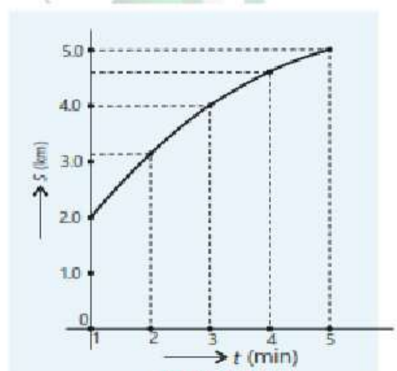


Fig. 2.16

Now consider another case.

Time t(min)	0	1	2	3	4	5
Distance S(km)	1.2	1.2	1.2	1.2	1.2	1.2

Graph line is horizontal in this case (Fig 2.17). It shows that the distance covered by the car does not change with change in time. It means that the car is not moving; it is at rest.

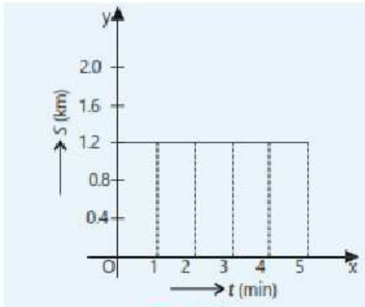


Fig. 2.17

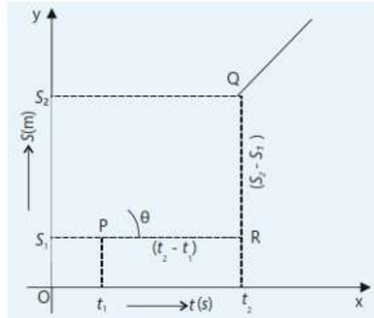


Fig. 2.18

Speed-Time Graph

Suppose we can note the speed of the same car after every one second and record it in the table given below, we can draw the graph between speed v versus time t. This is called speed-time graph.

Time t(min)	0	1	2	3	4	5
Distance S(km)	0	8	16	24	32	40

Take t along x-axis and v along y-axis. Scale can be selected as 1 s = 1 cm (x-axis) and speed 10 m s−1
= 1 cm along y-axis.

Shape of the graph is shown in Fig. 2.19· It is a straight line rising upward. This shows that speed increases by the same amount after every one second. This is a motion with uniform acceleration. It is also evident from the table.

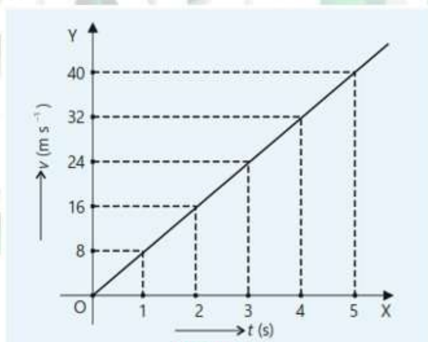


Fig. 2.19

Now consider another case. The observations are recorded in the table given below:

Time t(s)	0	1	2	3	4	5
Speed $V(ms^{-1})$	20	20	20	20	20	20

In this case, graph line is horizontal (Fig. 2.20) parallel to time x- axis. It shows that speed does not change with change in time. This is a motion with constant speed.

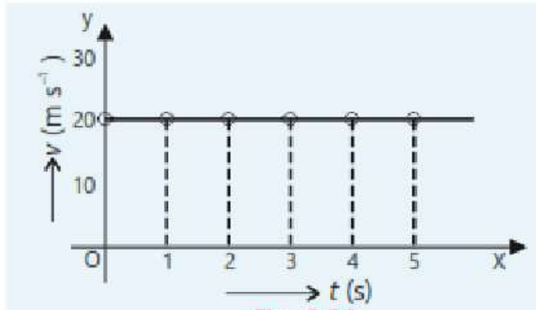


Fig. 2.20

Gradient of a Speed-Time Graph

Now consider the speed-time graph (Fig. 2.21). The speeds at times t_1 and t_2 are v_1 and v_2 respectively. The change in speed in a time interval $(t_2 - t_1)$ is $(v_2 - v_1)$.
Therefore,

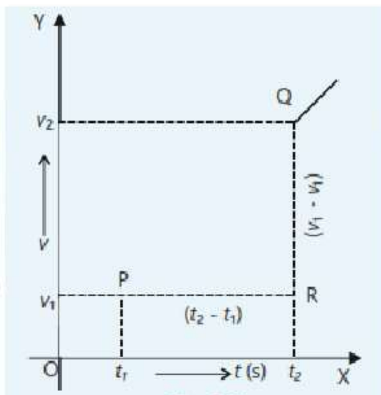


Fig. 2.21

This shows that when a car moves with constant acceleration, the velocity-time graph is a straight line which rises through same height for equal intervals of time.
Graph of Fig. 2.19 is redrawn in Fig. 2.22 to find its slope. The speed v_1 at time t_1 is the same as speed v_2 at time t_2, hence, the change in speed is also zero.

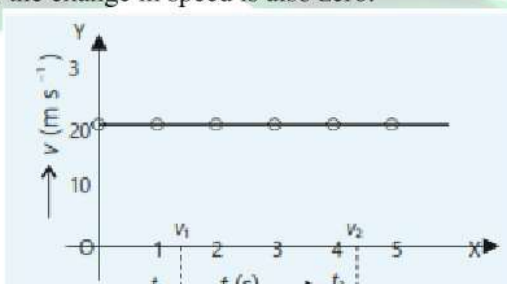


Fig. 2.22

When the speed of the object is constant, the speed-time graph is a horizontal straight line parallel to time axis.
This shows that the acceleration of this motion is zero. It is the motion without the change in speed.

2.11 Area Under Speed-Time Graph

The distance moved by an object can also be determined by using its speed-time graph. For example, figure 2.23 shows that the object is moving with constant speed v. For a time-interval t, the distance covered by the object
as given by Eq. 2.1 is $v \times t$.

This distance can also be found by calculating the area under the speed-time graph. The area under the graph for time interval t is the area of rectangle of sides t and v. This area is shown shaded in Fig.2.23 and is equal to $v \times t$. Thus, area under speed-time graph up to the time axis is numerically equal to the distance covered by the object in time t.

Now consider another example shown in Fig. 2.24. Here, the speed of the object increases uniformly from 0 to v in time t. The average speed is given by

Distance covered = average speed × time = $1/2\ v \times t$. If we calculate the area under speed-time graph, it is equal to the area of the right-angled triangle shown shaded in Fig. 2.24. The base of the triangle is equal to t and the perpendicular is equal to v. Area of a triangle = 1/2 (perpendicular × base) = $1/2\ (v \times t)$

We see that this area is numerically equal to the distance covered by the object during the time interval t. Therefore, we can say that:

The area under the speed-time graph up to the time axis is numerically equal to the distance covered by the object.

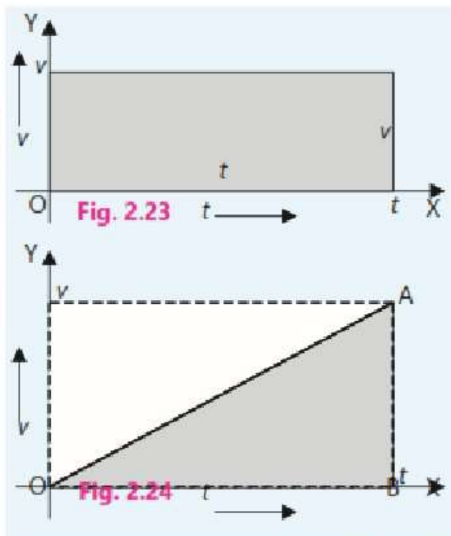


Fig. 2.23

Fig. 2.24

SHORT QUESTIONS

Q.1 How can we find distance from speed time graph?

Ans: **TO FIND DISTANCE**

We can find distance from speed time graph by finding total area under the graph because in speed time graph total area under the graph shows total distance covered by the body.

MULTIPLE CHOICE QUESTIONS

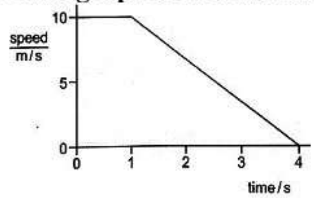
1. The slope of straight line in distance time graph gives the magnitude of:
(A) Force (B) Displacement
(C)Speed (D) Acceleration

2. The slope of straight line in speed time graph gives the magnitude of:
(A) Force (B) Displacement
(C) Torque (D) Acceleration

3. Area under the speed time graph shows:
(A) Force (B) Displacement
(C)Distance (D) Acceleration

4. In distance time graph time is taken along:
(A)X–axis (B)Can be taken along any axis
(C)Y–axis (D) Vertical axis

5. The diagram shows the speed-time graph of the motion of a car for four seconds.



What is the distance travelled by the car in the four seconds?

(A) 15 m (B) 25 m

(C) 30 m (D) 40 m

2.12 SOLVING PROBLEMS FOR MOTION UNDER GRAVITY

SHORT QUESTIONS

Q.1 What are the conditions for equations of motions?

Ans: While applying these equations, the following assumptions are made:

(i) Motion is always considered along a straight line

(ii) Only the magnitudes of vector quantities are used

(iii) Acceleration is assumed to be uniform.

(iv) The direction of initial velocity is taken as positive. Other quantities which are in the direction of initial velocity are taken as positive. The quantities in the direction opposite to the initial velocity are taken as negative.

Q.2 What are the equations of Motion?

Ans: The three equations of motion are as follows:

1) $v_f = v_i + at$

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

3) $2as = v_f^{\,2} - v_i^{\,2}$

2.12 SOLVING PROBLEMS FOR MOTION UNDER GRAVITY
2.13 FREE FALL ACCELERATION

LONG QUESTION

Q.1 Write a note on free fall Acceleration.

Ans: **Definition:**

When a body is falling freely under the action of gravity of the Earth, the acceleration acting on it is the gravitational acceleration and is denoted by ***g***.

Direction:

The direction of gravitational acceleration is always downwards. Its value is 9.8ms², but for convenience we shall use the value of ***g*** as 10ms².

Explanation:

Since the freely falling bodies move vertically downwards in a straight line with uniform acceleration g, so the three equations of motion can be applied to the motion of such bodies. While applying equations of motion, the acceleration a is replaced by **g.**

Equations of Motion under the action of Gravity:

The three equations of motion under the action of gravity are as follows:

$$v_f = v_i + gt$$

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

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

Rules for Gravitational Acceleration:

It should be remembered that while using these equations, the following points should be kept in mind:

(i) If a body is released from some height to fall

freely, its initial velocity ***v*** will be taken as zero.

(ii) The gravitational acceleration ***g*** will be taken as

positive in the downward direction. All other quantities will also be taken as positive in the downward direction. The quantities in the direction opposite to the acceleration will be taken as negative.

(iii) If a body is thrown vertically upward, the value of ***g*** will be negative and the final velocity will be zero at the highest point.

STUDENTS LEARNING OBJECTIVE

MULTIPLE CHOICE QUESTIONS

1. A person A sitting in a bus says that he is at rest but an observer B standing on the road says that A is moving. The right person is:

(A) Person B (B) Person A

(C) Both persons A and B (D) None of these

2. A body has translatory motion if it moves along a:

(a) straight line (b) circle

(c) line without rotation (d) curved path

3. If an object is moving with constant speed then its distance–time graph will be a straight line.

(a) along time–axis (b) along distance–axis

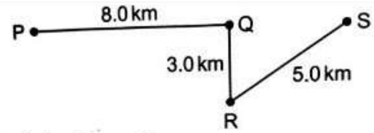
(c) parallel to time–axis (d) inclined to time–axis

4. A boy pushes a table 2 m and then pushes the same table 2.6 m. What is the total displacement covered by the table?

(A) 2.3 m (B) 4.6 m

(C) 3.2m (D) Can not be measured accurately fromthis data

5. A lorry takes 15 minutes to travel along the path PQRS.



What is the average speed of the lorry?

(A) 4.0 km/h (B) 22 km/h

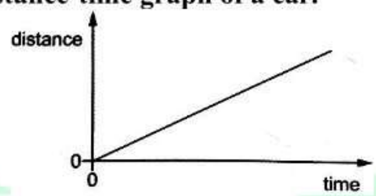
(C) 48 km/h (D) 64 km/h

6. **A car starts from rest and gains a velocity of 22 ms^{-1} in 11 seconds. The acceleration of car will be:**

(A) $2ms^{-2}$ (B) $20ms^{-2}$

(C) $22ms^{-2}$ (D) Zero

7. **The diagram shows the distance-time graph of a car.**

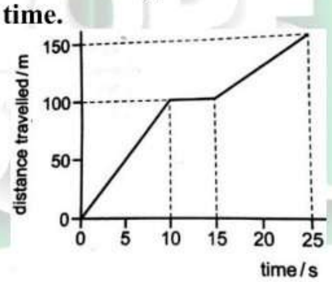


The car is travelling along a straight road up a hill.
Which quantity for the car is constant and greater than zero?

(A) Acceleration (B) Gravitational potential energy

(C) Kinetic energy (D) Resultant force

8. **A cyclist takes a ride lasting 25 s. the diagram shows how her distance travelled form the starting position varies with time.**



What is her average speed for the whole ride?

(A) 6.0 m/s (B) 7.5 m/s

(C) 10.0 m/s (D) 11.0 m/s

9. **An object falls from rest through the air, its velocity increases until if which quantity increases until its terminal velocity is reached?**

(A) Acceleration (B) Air resistance

(C) Resultant force (D) Weight

10. **A sky diver falls from rest through the air and reaches terminal velocity.**
What is the acceleration of the sky diver during his fall?

(A) Constant at 0 m/s^2 (B) Constant at 10 m/s^2

(C) Starting at 0 m/s^2 and increasing to 10 m/s^2 (D) Starting at 10 m/s^2 and decreasing to 0 m/s^2

11. **A car is moving with 100 kmh^{-1} towards north along a straight road. It means its velocity is:**

(A) Zero (B) $100kmh^{-1}$

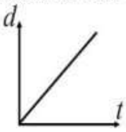
(C) $100kmh^{-1}$ north (D) $100kmh^{-1}$ south

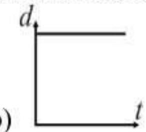
12. **A bus is travelling towards south on a straight road. It covers 80 metre distance during each 5 seconds. The uniform speed of the bus is 16 ms^{-1}. Its uniform velocity will be:**

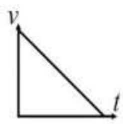
(A) Can not be calculated (B) $16ms^{-1}$

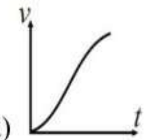
(C) Zero (D) $16 ms^{-1}$ south

13. Which of the following graphs is representing uniform acceleration?

(a) 

(b) 

(c) 

(d) 

14. By dividing displacement of a moving body with time, we obtain:

(a) speed (b) acceleration

(c) velocity (d) deceleration

15. A ball is thrown vertically upward. It velocity at the highest point is:

(a) $-10 ms^{-2}$ (b) zero

(c) $10 ms^{-2}$ (d) none of these

16. A change in position is called:

(a) speed (b) velocity

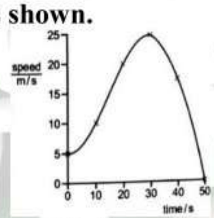
(c) displacement (d) distance

17. A train is moving at a speed of $36 kmh^{-1}$. Its speed expressed in ms^{-1} is:

(a) $10 ms^{-1}$ (b) $20 ms^{-1}$

(c) $25 ms^{-1}$ (d) $30 ms^{-1}$

18. The speed-time graph for a car is shown.

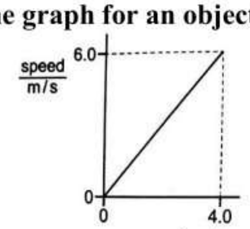


What is the acceleration of the car at 30 s?

(A) 0 (B) $\frac{25-5}{30} m/s^2$

(C) $\frac{25}{30} m/s^2$ (D) $\frac{25}{50} m/s^2$

19. The diagram shows a speed-time graph for an object moving with uniform acceleration.



What is the distance travelled in the first 4.0 s?

(A) 0.67 m (B) 1.5 m

(C) 12 m (D) 24 m

STUDENTS LEARNING OBJECTIVE

SHORT QUESTIONS

Q.1 Can a body at rest be regarded in a state of motion? Give example.

Ans: **REST AND MOTION ARE RELATIVE**

Rest and motion are relative quantities, so a body at rest can be regarded in a state of motion. For example, a person sitting in a train is at rest with respect to an observer in the train but this person is in motion for the observer standing outside the train.

Q.2 Can displacement be greater than distance?

Ans: No, because the displacement of an object can be either equal to or less than the distance travelled by the object.

Q.3 Can Distance and displacement be equal?

Ans: Yes, distance and displacement will be equal in one directional straight-line motion. This is because the length of the path travelled is the magnitude of the displacement or the distance.

Q.4 Is the distance covered by the body may be greater than the magnitude of displacement?

Ans: **DISTANCE AND DISPLACEMENT**

Yes, the distance covered by a body may be greater than the displacement.

Example:

When an object is moving in a closed path its distance covered is greater than the displacement at the end of observed time. **For example,** a man moves in a closed path ABCD. He starts from point A and after time "**t**" he reaches at same points in this case displacement of the man will be zero but distances will be of 16m. As shown in the figure:

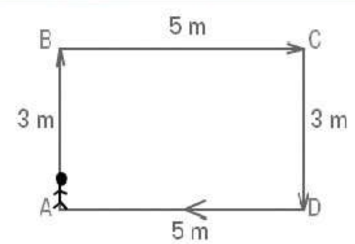


Figure: Distance is greater than displacement

Q.5 Is it possible that displacement is zero but not the distance?

Ans: **ZERO DISPLACEMENT**

Yes, it is possible that displacement is zero but not the distance.

Example:

When an object moves in a closed path and complete one round trip its displacement become zero while the distance covered is not zero. **For example,** a man moves in a closed path ABCD. He starts from point A and after time "**t**" he reaches at same points in this case displacement of the man will be zero but distances will be of 16m. As shown in the figure:

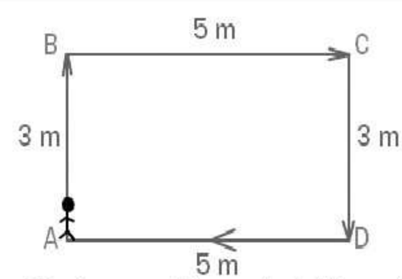


Figure: Displacement is zero but distance is of 16 m

Q.6 Under what condition displacement are equal to the distance?

Ans: **DISTANCE AND DISPLACEMENT**

The length of path between two points is called distance while the shortest distance between two points is called displacement. As shown in the figure

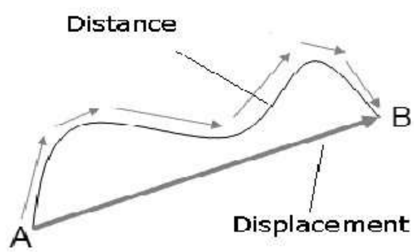


Figure: Distance and Displacement

The displacement and distance covered is equal if and only if the body is moving in a straight line.

Q.7 Can a body have acceleration with zero velocity?

Ans:

ACCELERATION

A body has no acceleration with zero velocity. Because acceleration produces when the velocity of the body changes. As

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

If velocity of a body is zero it means velocity is constant and not changing so acceleration is Zero.

Q.8 Can the speed of a body be negative?

Ans:

NEGATIVE SPEED

Distance covered by a body in unit time is called speed.

Speed= Distance covered/Total time

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

No the speed of the body cannot be negative because it is a scalar quantity and scalar quantities can never be negative.

Q.9 Is it possible to accelerate an object without speeding it up or slowing it up or slowing it down?

Ans: Yes, an object can be accelerated without speeding up or slowing down. We know that acceleration is referred as the rate of change of velocity and the velocity is the speed in a particular direction and is a vector quantity. So, if the velocity can either changes its speed or direction there is some acceleration.

Q.10 Is it possible that velocity of an object be in a direction other than the direction of acceleration?

Ans:

DIRECTION OF VELOCITY

Yes the velocity of a body can be in a direction other than acceleration. **For example** When a body moves in a circle, the direction of linear velocity is tangent to the circle while the acceleration is directed towards the centre of the circle.

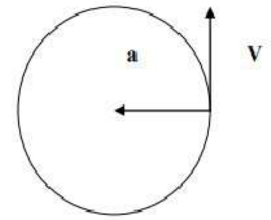


Figure: Motion of A Body in Circular Path

Q.11 Give an example of an accelerated body moving with a uniform speed.

Ans: The motion of a body in a circle with uniform speed have an acceleration due to change in the direction of velocity called centripetal acceleration.

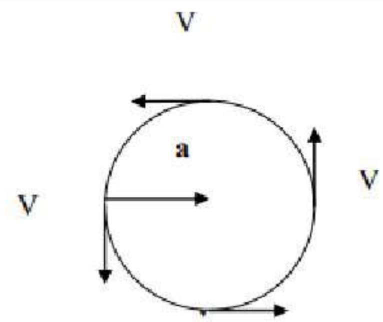


Figure: Motion of A Body in Circular Path

Q.12 When the velocity time graph is a straight line parallel to time axis, what can you say about its acceleration.

Ans: **ACCELERATION FROM GRAPH**

If the velocity time graph is a straight line parallel to time axis it means velocity is constant. When the velocity of the body is constant its acceleration will be zero because acceleration is equal to the rate of change of velocity.

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

Q.13 How do riders in a Ferris wheel possess translatory motion but not circular motion?

Ans: **MOTION OF RIDER**

Riders in a Ferris wheel move in a circle without rotation therefore motion of rider in Ferris wheel is translatory not rotatory.

Q.14 A ball is thrown vertically upward with an initial speed of 5m/s. What will be its speed when it returns to its starting point? (in the absence of air resistance)

Ans: **SPEED AT STARTING POINT**

The body returns to its starting point with the same speed of 5m/s in the absence of air resistance.

Q.15 A bus travel 15Km towards west makes U-turn back travel a further distance of 10Km, find (a) Distance traveled (b) Its displacement

Ans: **Solution:**

Given data:

First distance covered = S_1 = 15Km

Second distance covered = S_2 = 10Km

To Find:

a) Total Distance travelled = S =?

b) Total Displacement covered= d = ?

Calculations:

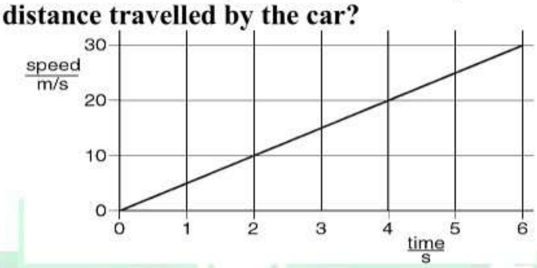
First we find total distance covered

S = S 1+ S 2
S = 15+10
S =25Km
Now we find Net Displacement
d = d2 –d1
d = 15 -10
d = 5Km ---- towards east of starting point.

Result:

Distance Travelled by the bus is 25km while its displacement is 5km towards east.

Q.16 A car starts from rest and is uniformly accelerated to a speed of 30m/s in 6 s. Have a look on the graph and find distance travelled by the car?



Ans: **Solution:**

In this case total Distance travelled by the car is equal to Total Area under the speed Time graph:
S = Area of a triangle
S= ½ (Length ×Width)
S= ½ (6×30)
S = ½(180)
S= 90 m

Result:

Distance travelled by the car is 90m.

Q.17 Define slope of a graph.

Ans: **SLOPE**

In mathematics, the **slope** or **gradient** of a line is a number that describes both the direction and the steepness of the line. Slope is often denoted by the letter m.
Slope is calculated by finding the ratio of the "vertical change" to the "horizontal change" between (any) two distinct points on a line. Sometimes the ratio is expressed as a quotient ("rise over run"), giving the same number for every two distinct points on the same line.
In mathematical language, the slope m of the line is:

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

SUMMARY	
Position	Position is the distance and direction of a body from a fixed reference point.
Distance	Distance is the length of a path traveled by an object
Displacement	Displacement is the shortest distance from the initial and final position of a body.

Speed	Speed is time rate of change of distance and is a scalar quantity.
Velocity	Velocity is the time rate of change of displacement and is a vector quantity
Acceleration	Gradient of distance-time graph gives speed of the body
Gradient of speed-time graph	Gradient of speed-time graph gives acceleration of the body.
Area under the speed-time graph	Area under the speed-time graph gives distance travelled by the body.

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

2.1 Encircle the correct answer from the given choices.

1. The numerical ratio of displacement to distance is:

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

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

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

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

(a) 5m **(b) 10m**
(c) 50m (d)100m

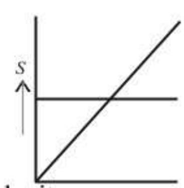
4. A body accelerates from rest to a velocity of 144 km h^{-1} in 20 seconds. Then the distance covered by it is:

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

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

(a) 1s **(b) 2s** (c) 4s (d) 16s

6. The displacement time graphs of two objects A and B are shown in the figure. Point out the true statement from the following:



(a) The velocity of A is greater than B.
(b) The velocity of A is less than B.
(c) The velocity of A is equal to that of B.
(d) The graph gives no information in this regard.

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

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

8. Gradient of the speed-time graph is equal to:

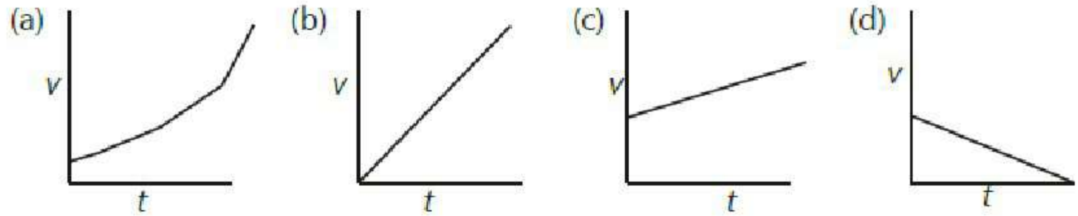
(a) speed (b) velocity
(c) acceleration (d) distance covered

9. Gradient of the distance-time graph is equal to the:

(a) speed (b) velocity

(c) distance covered (d) acceleration

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



SHORT QUESTIONS

2.1 Define scalar and vector quantities.

Ans:

Sclar Quantities	Vector Quantities
Definition	
• "Physical quantities which can be completely described only by its numerical magnitude (or size) with proper unit are termed as scalar quantities or simply scalars."	• "Physical quantities which can be completely described by their magnitude (or size) along with their direction are called vector quantities or simply vectors."
Addictions/Subtraction	
• Scalar quantities can be added or subtracted by simply arithmetic rules because they have only numeric value with proper unit.	• Vector quantities cannot be added or subtracted by simply arithmetic rules because they have direction along with numeric value and proper unit.

2.2 Give 5 examples each for scalar and vector quantities.

Ans: **Examples of Scalars:**

- Work
- Power
- Time
- Mass
- Speed

Examples of Vectors:

- Force
- Momentum
- Acceleration
- Velocity
- Displacement

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

Ans: **Statement:**

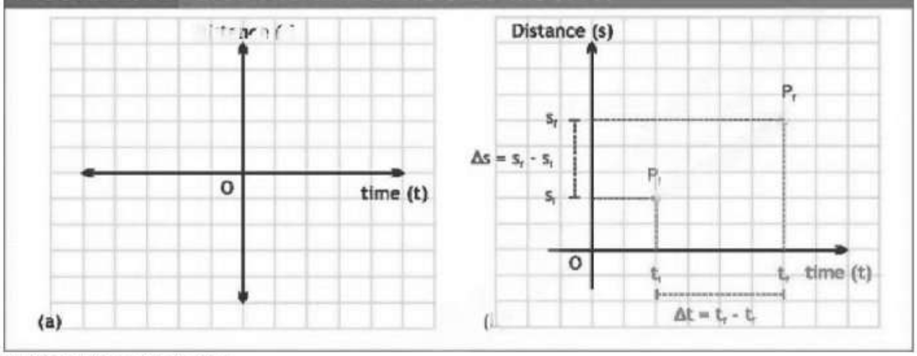
To add a number of vectors, redraw their representative lines such that the head of one line co insides with the tail of the other. The resultant vector is given by a single vector which is directed from the tail of the first vector to the head of the last vector.

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

Ans: DISTANCE-TIME GRAPH

The distance-time graph is plotted between distance (s) and time (t). The time is plotted along horizontal axis (x-axis) and distance is plotted along vertical axis (y-axis) as shown in figure 2.12 (a). Distance time graph is always in the positive XY plane, as with passage of time, distance never goes to negative axis, irrespective of the direction of motion.

FIGURE 2.12 GRAPHICAL ANALYSIS OF MOTION



SPEED TIME GRAPH

"Speed-time graph is the graph plotted between speed (v) and time (t). In this graphical analysis the speed is plotted along vertical axis (y-axis) and time along horizontal axis (x- axis).

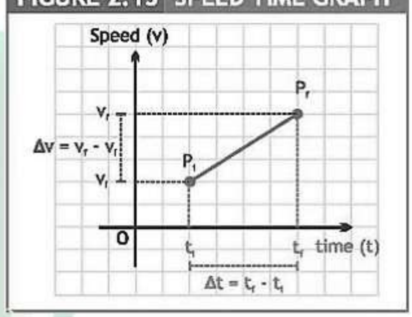
Speed time graph serve two purposes. Slope of the graph gives magnitude of acceleration.

Area under the graph gives distance traveled.

The slope of speed time curve gives magnitude of acceleration.

As discussed in the graph for the distance graph, the slope of velocity time graph gives by definition the magnitude (value) of acceleration"

FIGURE 2.13 SPEED TIME GRAPH



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

Ans: No, a heavier object will not fall faster than a lighter object.

In the context of objects falling near Earth's surface, both heavy and light objects experience the same constant acceleration due to gravity, which is approximately 9.8 m/s^2, 29.8ms^2, 9.8m/s^2 (assuming air resistance is negligible). This constant acceleration applies to all objects, regardless of their mass.

The confusion often arises because, in everyday experience, heavier objects sometimes seem to fall faster due to air resistance. However, in a vacuum, where air resistance is absent, all objects, regardless of their mass, will fall at the same rate.

This was famously demonstrated by Galileo, who showed that, in the absence of air resistance, a feather and a stone dropped from the same height would hit the ground at the same time.

Thus, the acceleration due to gravity is the same for both light and heavy objects, and mass does not affect the rate of falling in free fall.

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

Ans: When vectors are written in scalar notation, the direction is clearly specified through unit vectors, components, or angles.

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

Ans: May or may not be

If a body moves in a straight line at constant speed, its velocity remains uniform because both the speed and direction are constant.

If the body moves in a curved path at constant speed, its velocity will not be uniform because although the speed is constant, the direction of motion is changing at each point along the curve. This means the velocity is changing due to the change in direction.

2.8 Is it possible for a body to have acceleration? When moving with:

1) Constant velocity

2) Constant speed

Ans: **<u>Constant velocity:</u>**

No, it is not possible for a body moving with constant velocity to have acceleration.

<u>Constant speed:</u>

May or may not be

If a body moves in a straight line at constant speed, its velocity remains uniform because both the speed and direction are constant.

If the body moves in a curved path at constant speed, its velocity will not be uniform because although the speed is constant, the direction of motion is changing at each point along the curve. This means the velocity is changing due to the change in direction.

CONSTRUCTED RESPONSE QUESTIONS

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

Ans: Distance and displacement are two different things. If the object moving in a straight line then its distance and displacement will be same in magnitude but when the object moving in a circular path then its distance and displacement will be different.

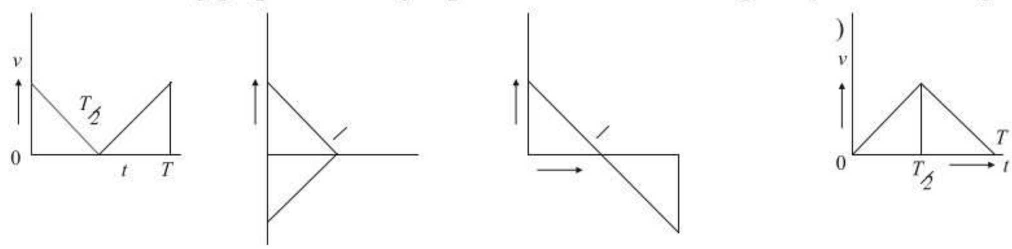
2.2 When a bullet is fired, its velocity with which it leaves the barrel is called the muzzle velocity of the gun. The muzzle velocity of one gun with a longer barrel is lesser than that of another gun with a shorter barrel. In which gun is the acceleration of the bullet larger? Explain your answer.

Ans: The acceleration of the bullet is larger in the gun with the shorter barrel, assuming that the higher muzzle velocity of the shorter-barrel gun is the result of a higher acceleration. The shorter barrel limits the time and distance over which the bullet can accelerate, so the gun with the shorter barrel requires a larger force and therefore a larger acceleration to achieve the higher muzzle velocity.

2.3 For a complete trip, average velocity was calculated. Its value came out to be positive. Is it possible that its instantaneous velocity at any time during the trip had the negative value? Give justification of your answer.

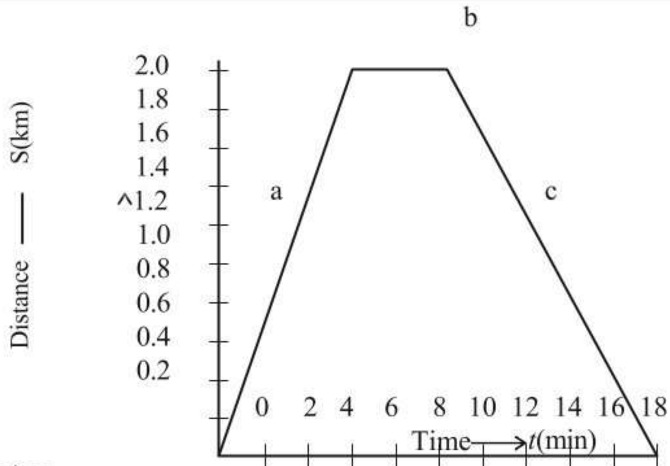
Ans: No, it is not possible because instantaneous velocity at any time during the trip can never be negative.

2.4 A ball is thrown vertically upward with velocity *v*. It returns to the ground in time *T*. Which of the following graphs correctly represents the motion? Explain your reasoning.



Ans: Graph **A** is the correct representation of this case because, when we throw the ball vertically upward its velocity goes on decreasing and at the highest point its velocity becomes zero. While returning to the ground its velocity will increase due the gravitational pull.

2.5 The figure given below shows the distance-time graph for the travel of a cyclist. Find the velocities for the segments a, b and c.



Ans: **Velocity at a:**

$$velocity = \frac{distance}{time}$$

$$v = \frac{2}{6} = 0.333 km m^{-1}$$

Velocity at b:

At point b the velocity of the body is zero because the body is at rest.

Velocity at c:

$$v = \frac{2}{8} = 0.25 km m^{-1}$$

2.6 Is it possible that the velocity of an object is zero at an instant of time, but its acceleration is not zero? If yes, give an example of such a case.

Ans: Yes, it is possible for an object's velocity to be zero at an instant of time while its acceleration is not zero. This can occur when the object changes direction or is at a turning point, where the velocity is momentarily zero but the acceleration is still acting.

Example:

When the ball reaches the highest point (its maximum height), its velocity is zero at that instant because it momentarily stops before reversing direction.

However, acceleration is not zero. The ball is still under the influence of gravity, which is pulling it downward with a constant acceleration of **g**.

COMPREHENSIVE QUESTIONS

2.1 How a vector can be represented graphically? Explain.

Ans: Graphically a vector is represented by an arrow, the length of the arrow gives the magnitude with proper unit (under certain scale) and the arrow head points the direction of the vector. To use vectors, we place them in coordinate axis.

2.2 Differentiate between:

- **Rest and motion**
- **Speed and velocity**

Ans: **Rest:**

"If with passage of time an object does not change its position then it is at rest.**"**

Surroundings:

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

Motion:

"If with passage of time an object does change its position then it is at motion."

Relative Quantities:

When we look around us, we observe that many objects do not change their position. Thus, we consider them at the state of rest. For example, a bench in a park fixed under a tree is at rest as there is no change in its position with respect to us while standing near it with the passage of time. On the other hand, we also observe that many objects do change their position from one place to another. Hence, we consider them to be in the state of motion. For example, a car is in motion if there is change in its position with time.

DIFFERENTIATION

Differences between speed and velocity are as follows:

Speed	Velocity
Definition	
• Distance covered in unit time is known as speed	• The net displacement from a body in unit time.
Symbol	
• Speed is represented by "v"	• Displacement is denoted by "$\vec{v}$"
Quantity	
• Speed is a scalar quantity.	• Speed is a scalar quantity.
Formula	
• Speed= Distance covered/Total time $V=\frac{\Delta s}{\Delta t}$	• Velocity $=\frac{\text{displacement}}{\text{time taken}}$ $V=\frac{\Delta \vec{d}}{\Delta t}$

2.4 Explain the difference between distance and displacement.

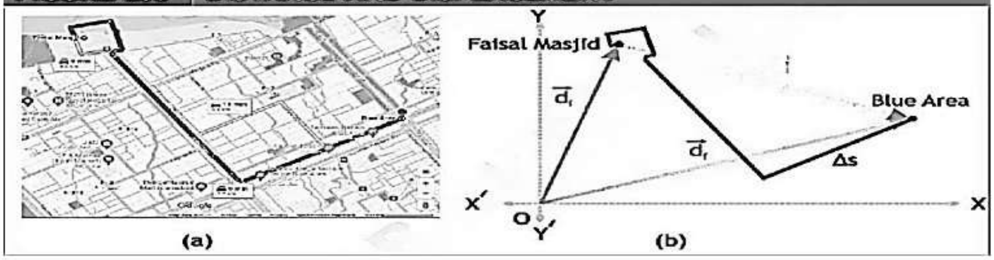
Ans:

Distance	Displacement
Definition	
• 'The length of path traveled between two positions is called distance.	• The shortest distance from initial position to final (or straight directed distance) is called displacement.
Symbol	
• Distance is usually denoted by Δx, Δr, Δs.	• Displacement is denoted by "$\vec{d}$"
Quantity	
• Distance is a scalar quantity. Its S.I unit is metre	• Displacement is a vector quantity. Its S.I unit is metre

Graphical Difference

If we are at Faisal Masjid, Islamabad and we want to move to Blue area, Islamabad by searching on google map. We get a twisted path, showing us the way to reach our destination.

FIGURE 2.6 | DISTANCE AND DISPLACEMENT



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

Ans:

The gradient is the measure of slope of a line. Consider the distance-time graph of uniform speed again. Select any two values of time *t1* and *t2*. Draw two vertical dotted lines at *t1* and *t2* on x-axis. These lines meet the graph at points P and Q. From these points draw horizontal lines to meet y-axis at *S1* and *S2* respectively as shown in Fig.2.18.

Distance covered in this time interval is $S_2 - S_1 = S$

Time taken $t_2 - t_1 = t$

The slope or gradient of the graph is the measure of tangent θ of the triangle RPQ:

$$Slope = \frac{RQ}{PR}$$

$$Slope = \frac{S_2 - S_1}{t_2 - t_1} = \frac{S}{t}$$

From Eq. (2.1), $\frac{S}{t} = v_a$, the average speed during the time interval *t*.

Figure 2.17 shows that $\frac{S}{t} = \tan\theta =$ Slope of graph line, therefore,

Gradient of the distance-Time graph is equal to the average speed of the body.

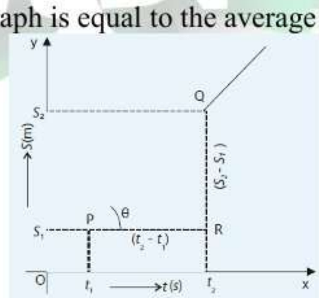


Fig. 2.18

Now consider the speed-time graph (Fig. 2.21). The speeds at times t_1 and t_2 are v_1 and v_2 respectively. The change in speed in a time interval $(t_2 - t_1)$ is $(v_2 - v_1)$.

Therefore,

$$Slope = \frac{Change\ in\ speed}{Total\ time\ taken}$$

$$or\ Slope = \frac{(v_2 - v_1)}{(t_2 - t_1)}$$

$$Slope = \frac{\Delta v}{t}$$

But $\frac{\Delta v}{t} = a$, the average acceleration.

Hence

Gradient of the speed-Time graph is equal to the average acceleration of the body.

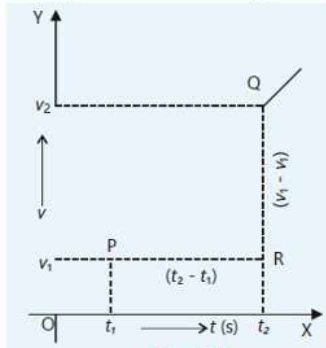


Fig. 2.21

This shows that when a car moves with constant acceleration, the velocity-time graph is a straight line which rises through same height for equal intervals of time.

Graph of Fig. 2.19 is redrawn in Fig. 2.22 to find its slope. The speed v_1 at time t_1 is the same as speed v_2 at time t_2, hence, the change in speed is also zero.

2.6 Prove that the area under speed-time graph is equal to the distance covered by an object.

Ans: **<u>Area under speed time graphs represents the distance travelled:</u>**

If the motion of a body represented by the speed time graph is symmetric shape then the area can be calculated using appropriate formula for geometrical shapes.

For example, consider the figure in which the speed time graph of the object in motions represented by a rectangle. The area of rectangle is

$$\text{Area} = \text{width} \times \text{length}$$

$$\text{Area} = v \times t$$

The distance by average speed is given by equation is also. $s = vt$

Thus the area under speed time graphs represent the distance travelled. Similarly consider the figure in which the speed time graph of the object in motion is represented by a triangle. The area of triangle is

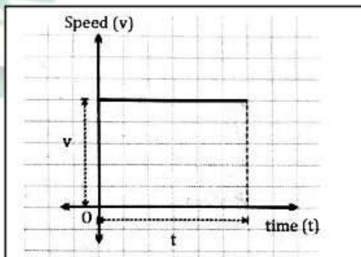


Figure:<u>Triangular Area</u>

$$\text{Area} = \frac{1}{2}\text{width} \times \text{length}$$

$$Area = \frac{1}{2} v \times t$$

The distance by average speed is given by equation it is again. $s = \frac{1}{2}vt$

2.7 How equations of motion can be applied to the bodies moving under the action of gravity?

Ans: **<u>Equations of Motion under the action of Gravity</u>**:

The three equations of motion under the action of gravity are as follows:

$$v_f = v_i + gt$$

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

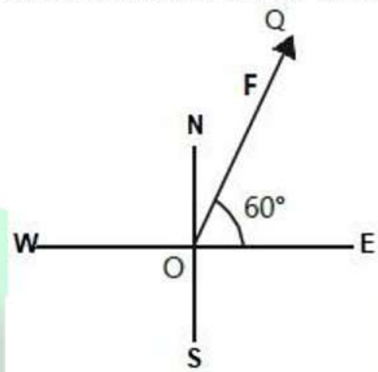
$$2gh = v_f^{\,2} - v_i^{\,2}$$

NUMERICAL PROBLEMS

2.1 Draw the representative lines of the following vectors:
(a) A velocity of 400 ms^{-1} making an angle of 60^o with x-axis.
(b) A force of 50 N making an angle of 120^o with x-axis:

Solution:

(i) Draw two mutually perpendicular lines indicating N, S, E& W.
(ii) Select a suitable scale. If 100 ms^{-1} = 1cm, then 300 ms-1 are represented by 3cm line.
(iii) Draw 3 cm line OP at a angle of 60^o starting from N towards E.
(iv) Make an arrow head at the end of line OP. The OP is the vector v.



Solution:

Draw a force vector F having magnitude of 350 N and acting at an angle of 60° with x-axis
(i) Draw horizontal and vertical lines to represent x-axis and y-axis as shown in Fig. 2.3.
(ii) Scale: If 100 N = 1 cm. then 350 N3.5 cm.
(iii) Draw 3.5 cm line OQ at an angle of 60^o with x-axis
(iv) Make an arrow head at the end of the line OQ. The OQ is the vector F

2.2 A car is moving with an average speed of 72 km h^{-1}. How much time will it take to cover a distance of 360 km? (5 h)

Given Data

Speed of car = T^2 kmh^{-1}
Distance = S = 360 km

To Find:

Time = t = ?

Solution:

Formula:

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

By applying the values

$$t = \frac{360}{72} \rightarrow \boxed{5hour}$$

Result:

Time taken for the car will be 5 hours

2.3 A truck starts from rest. It reaches a velocity of 90 km h^{-1} in 50 seconds. Find its average acceleration. ($0.5m\ s^{-2}$)

Given Data:

Initial velocity $v_i = 0ms^{-1}$

Final velocity $v_f = 90kmh^{-1} \Rightarrow \dfrac{90\times1000}{3600} \Rightarrow 25ms^{-1}$

Time taken = t = 50 seconds

To Find:

Average Acceleration = a_{ac} = ?

Solution

Formula:

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

By putting values

$$a_{av} = \frac{25-0}{50} \Rightarrow \frac{25}{50} \Rightarrow 0.5ms^{-2}$$

Result:

Average acceleration of truck will be 0.5ms

2.4 A car passes a green traffic signal while moving with a velocity of $5m\ s^{-1}$. It then accelerates to $1.5m\ s^{-2}$. What is the velocity of car after 5 seconds?($12.5m\ s^{-1}$)

Given Data:

Initial velocity of car = v_i = 5 ms^{-1}.
Acceleration = a_{ac} = 1.5 ms^{-2}
Time = t = 5 sec.

To Find:

Final velocity of car = v_f= ?

Solution:

Formula:

$$v_f = v_i + a_{ac}t$$

By putting values

$$v_f = 5 + (1.5)(5)$$

$$v_f = 5 + 7.5 \Rightarrow \boxed{12.5ms^{-1}}$$

Result:

Final velocity of the car will be 12.5 ms^{-1}.

2.5 A motorcycle initially travelling at 18 km h^{-1} accelerates at constant rate of $2m\ s^{-2}$ How far will the motorcycle go in 10 seconds? (150 m)

Given Data:

Initial velocity $= v_i = 18kmh^{-1} = \dfrac{18\times1000}{3600} \Rightarrow 5ms^{-1}$

Acceleration = a = 2 ms^{-2}
Time = t = 10 sec

To Find:

Distance travelled = S = ?

Solution:
Formula:

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

$$S = (5)(10)^2 = \frac{1}{\cancel{2}}(\cancel{2})(10)^2$$

$$S = 50 + 100 \Rightarrow \boxed{150m}$$

Result:

Distance travelled by the motorcycle will be 150m.

2.6 A wagon is moving on the road with a velocity of 54km h^{-1}. Brakes are applied suddenly. The wagon covers a distance of 25 m before stopping. Determine the acceleration of the wagon. (-4.5m s^{-2})

Given Data:

Initial velocity $= v_i = 54kmh^{-1}$

$$= \frac{54 \times 1000}{3600} \Rightarrow 15ms^{-1}$$

Final velocity $= v_f = 0ms^{-1}$

Distance travelled = S = 25m

To Find:

Acceleration = a = ?

Solution:
Formula:

$$S = \frac{v_i + v_f}{2} \times t \Rightarrow t = \frac{25}{v_i + v_f}$$

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

$$t = \frac{2(25)}{15+0} \Rightarrow \frac{50}{15} \Rightarrow \boxed{3.3333\,\text{sec}}$$

Now,

$$a = \frac{0-15}{3.3333} \Rightarrow \frac{-15}{3.3333} \Rightarrow \boxed{-4.5ms^{-2}}$$

Result:

Acceleration of the wagen before coming to rest will be -4.5ms^{-2}.

2.7 A stone is dropped from a height of 45 m. How long will it take to reach the ground? What will be its velocity just before hitting the ground? (3s, 30m, s^{-1})

Given Data:

Height = h = 45 m
Initial velocity = vi = 0 ms-1
Gravitational acceleration = g = 10ms^{-2}

To Find:

Time of stone to reach the ground = t = ?
Final velocity = v_f= ?

Solution

Formula:

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

$$2gh = vf^2 - vi^2$$

By applying values

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

$$45 = (0)t + \frac{1}{\cancel{2}}\left(\cancel{10}^5\right)t^2$$

$$45 = 0 + 5\left(t^2\right)$$

$$45 = (5)t^2$$

$$^9\cancel{45} = t^2$$

$$\sqrt{t^2} = \sqrt{9}$$

$$\boxed{t = 3\sec}$$

Now,

$$2gh = v_f^{\,2} - v_i^{\,2}$$

$$2(10)(45) = vf^2 - (0)^2$$

$$900 = vf^2 - 0$$

$$\sqrt{vf^2} = \sqrt{900}$$

$$\boxed{v_f = 30ms^{-1}}$$

Result:

Time taken by the stone to hit the greed will 5sec and its final velocity will be 30 ms^{-1}.

2.8 A car travels 10 km with an average velocity of 20m s^{-1}. Then it travels in the same direction through a diversion at an average velocity of 4m s^{-1} for the next 0.8 km. Determine the average velocity of the car for the total journey (15.4m s prime1)

Given Data:

Distance travelled = S1 = 10 km ⇒ 10,000m
Distance travelled after dividsion = S2 = 0.8km = 0.8 × 1000m = 800
Average velocity = v = 20 ms^{-1}.
Velocity after divesion = v = 4ms^{-1}.

To Find:

Average velocity of total journey = V_{av}= ?

Solution

Formula:

$$S = S_1 + S_2$$

$$t_1 = \frac{S_1}{v_1}$$

$$t_2 = \frac{S_2}{V_2}$$

$$t = t + t^2$$

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

By applying values

$$S = 10,000m + 800m \Rightarrow 10,800m$$

$$t_1 = \frac{10,000}{20} \Rightarrow 500\sec$$

$$t_2 = \frac{600}{4} \Rightarrow 200\sec$$

$$t = 500 + 200 \Rightarrow 700\sec$$

$$v_{av} = \frac{10800}{700} \Rightarrow \boxed{15.4ms^{-1}}$$

Result:

Average velocity of total journey will be 15.4 ms^{-1}.

2.9 A ball is dropped from the top of a tower. The ball reaches the ground in 5 seconds. Find the height of the tower and the velocity of the ball with which it strikes the ground. (125m 0.5m s prime prime)

Given Data:

Time to reach the ground = t = 5 sec
Acceleration due to gravity = g = 10ms^{-2}
Initial velocity = V_i = 0ms^{-1}

To Find:

Height of tower = h = ?
Velocity of ball with which it strikes the ground = V_f = ?

Solution:

By using 2nd equation of motion

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

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

$$h = (0) + (5)(25)$$

$$h = 5(25)$$

$$h = 125m$$

Now, for finding "final velocity" we will use 1st equation of motion:

$$v_f = v_i + gt$$

$$v_f = (0) + (10)(5)$$

$$v_f = 0 + 50$$

$$v_f = 50ms^{-1}$$

Result:

(i) Height of tower is 125m
(ii) Velocity of ball with which it strikes the ground is 50 ms^{-1}.

2.10 A cricket ball is hit so that it travels straight up in the air. An observer notes that it took 3 seconds to reach the highest point. What was the initial velocity of the ball? If the ball was hit 1 m above the ground, how high did it rise from the ground?

($30m\ s^{-1}$, 46 m)

Given Data:

Time = t = 3 sec
Gravitational acceleration = g = -10ms-2
Final velocity = $v_f = 0\ ms^{-1}$.

To Find:

Initial velocity = v = ?
Maximum height = h = ?

Solution:

Formula:

$$vf = vi + gt$$

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

$$\text{Total height} = h+1$$

By applying values

$$vf = vi + gt$$

$$0 = vi + (-10)(3)$$

$$0 = vi - 30$$

$$30 = vi$$

$$\boxed{vi = 30ms^{-1}}$$

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

$$h = (30)(3) + \frac{1}{2}(-10)^5(3)^2$$

$$h = 90 - 5(9) \Rightarrow 90 - 45 \Rightarrow 45m$$

$$\text{Total height} = 45 + 1 \Rightarrow 46m$$

Result:

Initial velocity of the ball will be $30ms^{-1}$ and its maximum height be 46 m.

2.1 INTRODUCTION TO PHYSICS

2.2 TYPES OF MOTION

1	2	3	4	5	6	7	8	9	10	11
D	A	A	B	D	C	B	B	A	C	C

2.2 DISTANCE AND DISPLACEMENT

2.3 SPEED AND VELOCITY

2.4 ACCELERATION

1	2	3	4	5	6	7	8	9	10
A	D	C	D	B	A	B	A	C	A
11	12	13	14	15	16	17	18	19	20
B	C	A	B	D	A	B	C	D	A
21	22	23	24	25	26	27	28		
C	B	C	B	A	B	C	A		

2.5 MOTION OF FREE-FALLING BODIES

1	2	3	4	5	6	7
C	D	D	A	D	B	D

2.6 GRAPHICAL ANALYSIS OF MOTION

1	2	3	4	5	6	7
C	D	C	A	B	C	D

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

ANSWER KEY

1	2	3	4	5	6	7	8	9	10
D	A	B	B	B	A	D	C	A	