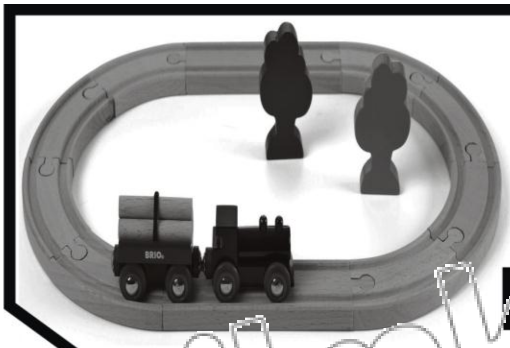

UNIT 2

KINEMATICS

2.1 REST AND MOTION
2.2 TYPES OF MOTION

LONG QUESTIONS

2.1 Q.1 Define rest and motion and explain them as relative quantities. ***(K.B)***

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

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

<u>Rest</u>:

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

<u>Surroundings</u>:

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

<u>Motion</u>:

"A body is said to be in motion, if it changes its position with respect to its surroundings**."**

<u>Relative Quantities</u>:

The state of rest or motion of a body is relative. For example, a passenger sitting in a 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 inside the bus are in motion because they are changing their positions.

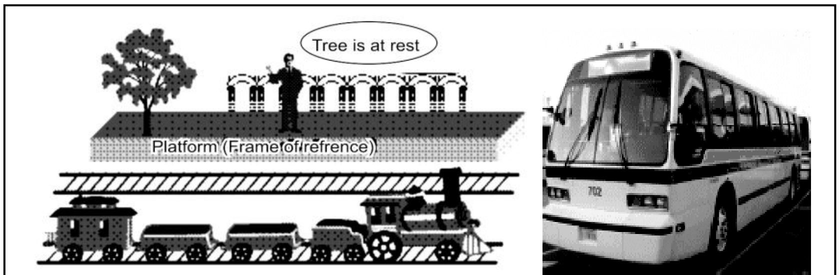

Figure: **<u>Rest and Motion are Relative Quantities</u>**

2.2 Q.1 Define Translatory motion and its types. ***(K.B)*** **(LHR 2011, 2012, 2013 GRW 2013, 2015)**

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

<u>Introduction</u>:

Everything in this universe is in motion. However different objects move differently. Some objects move along a straight line, some move in curved path, and some move in some other way.

<u>Definition</u>:

"In translational motion, a body moves along a line without any rotation. The line may be straight or curved."

<u>Examples</u>:

Following are some examples of translatory motion:

- Motion of a car in straight line
- Motion of electron around the nucleus
- Motion of gas molecules

- Aeroplane moving straight is in translational motion

Figure: Some Important Types of Translatory Motion
- **Translatory Motion of Car and Aeroplane**
- **Translatory Motion of A Child on Slide And Rider in Ferris Wheel**

TYPES OF TRANSLATORY MOTION

There are three types of translatory motion.

- Linear Motion **(LHR 2014)**
- Circular Motion
- Random Motion **(LHR 2013, 2014)**

LINEAR MOTION

Definition:

"Straight line motion of a body is known as its linear motion."

Examples:

Following are some examples of linear motion:

- The motion of freely falling bodies.
- Motion of a car on a straight and leveled road.
- Motion of aeroplanes flying straight in air.

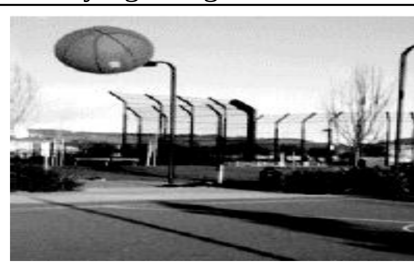

Figure: Linear Motion of A Ball Falling Down

CIRCULAR MOTION

Definition:

"The motion of an object in a circular path is known as circular motion."

Examples:

Some examples of circular motion are given below:

- A stone tied with string, when whirled, it will move along a circular path.
- A toy train moving on a circular track.
- Motion of individual particle of spinning top.
- Earth moving around the sun in solar system
- Motion of moon around the Earth.
- Motion of a bicycle or a car moving along circular road.
- Motion of a rider in Ferris wheel.

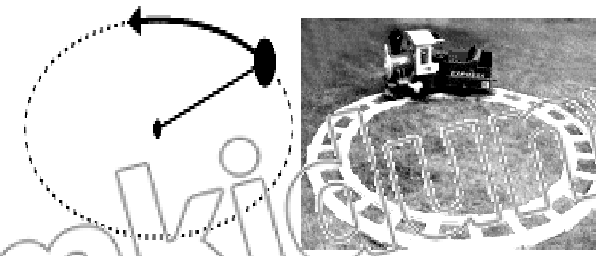

Figure: Circular Motion of Different Objects

RANDOM MOTION

Definition:

“The disordered or irregular motion of an object is called random motion.”

Examples:

- The motion of insects and birds.
- Brownian motion of gas or liquid molecules along a zig–zag path.
- Motion of dust or smoke particles in air

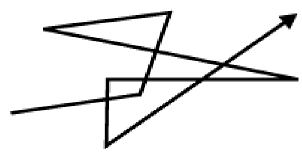

Figure: Random Motion of Gas Molecules is Called Brownian Motion

2.1, 2.2 SHORT QUESTIONS

Q.1 Define mechanics? Write its branches. ***(K.B)***

Ans: **MECHANICS**

Definition:

“The branch of physics in which we study motion of objects its causes and effects is called mechanics”

Branches of Mechanics:

There are two branches of mechanics

- Kinematics
- Dynamics

Kinematics: **(GRW 2015)**

“The branch of mechanics that deals with the study of motion of an object without discussing the cause of motion is called kinematics.”

Dynamics: **(GRW 2015)**

“The branch of mechanics that deals with the study of motion of an object and the cause of its motion is called dynamics.”

Q.2 Write about different types of motion. ***(K.B)***

Ans: **TYPES OF MOTION**

There are three types of motion:

- Translatory Motion
- Rotatory Motion
- Vibratory Motion

Translatory Motion:

"In translational motion, a body moves along a line without any rotation. The line may be straight or curved."

Examples:

Following are some examples of translatory motion:

- Motion of a car in straight line
- Motion of electron around the nucleus
- Motion of gas molecules

Types of Translatory Motion:

There are three types of translatory motion.

- Linear Motion
- Circular Motion
- Random Motion

Rotatory Motion: **(LHR 2013)**

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

Examples:

Following are some examples of rotatory motion:

- Motion of spinning top
- Motion of the Earth around its geographical axis
- Motion of wheel and steering wheel around its axis
- Motion of a ceiling electric fan
- Motion of Ferris wheel

Figure: Rotatory Motion of Various Objects

Vibratory Motion: **(LHR 2011, GRW 2015)**

"To and fro motion of a body about its mean position is known as vibratory motion."

Examples:

Some examples of vibratory motion are as follows:

- Motion of swing back and forth about its mean position
- Motion of pendulum of wall clock
- Motion of see – saw
- Motion of a body attached with a spring.
- Motion of hammer of ringing electric bell.
- Motion of string of a sitar
- Motion of a baby in a cradle moving to and fro

Figure: Vibratory Motion of Various Objects

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Q.3 Define Axis of rotation. ***(K.B)***

AXIS OF ROTATION

Definition:

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

Position:

In case of rotatory motion the Axis passes through the body while in case of circulatory motion the axis is present out-side the body.

Q.4 Differentiate between circular motion and rotatory motion. ***(K.B)*** **(GRW 2015)**

Ans: **DIFFERENTIATION**

Differences between circulatory and rotatory motion are as follows:

Circulatory Motion	Rotatory Motion
Definition	
• The motion of an object in a circular path is known as circular motion.	• The spinning motion of a body about its axis is called rotatory motion.
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 about is passing through the body itself.
Examples	
• Motion of earth around the sun. • Motion of individual particles of spinning top • Motion of rider in Ferris Wheel	• Motion of earth about its geographical axis. • Spinning motion of top • Motion of Ferris Wheel

Q.5 When a body is said to be at rest? ***(K.B)*** **(Mini exercise Pg. # 32)**

Ans: *Given on Page # 42*

Q.6 Give an example of a body that is at rest and is in motion at the same time. ***(K.B)*** **(Mini exercise Pg. # 32)**

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.7 Mention the type of motion in each of the following. ***(K.B)*** **(Mini exercise Pg. # 32)**

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

2.1, 2.2 MULTIPLE CHOICE QUESTIONS

1. **Study of motion of the bodies is known as: *(K.B)***
(A) Heat (B) Light
(C) Atomic physics (D) Mechanics

2. **Study of motion without discussing the cause of motion is called: *(K.B)***
(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: *(K.B)***
(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 state of: *(K.B)***
(A) Rest (B) Motion
(C) Uniform motion (D) Relative motion

5. **Rest and motion are : *(K.B)***
(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: *(K.B)*** **(LHR 2015)**
(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: *(K.B)*** **(GRW 2014, 2015)**
(A) Translatory (B) Vibratory
(C) Rotatory (D) None of these

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

9. **The spinning motion of individual particles of top is known as. *(K.B)*** **(LHR 2015)**
(A) Translatory motion (B) Vibratory motion
(C) Rotatory motion (D) Random motion

10. **The motion of rider in a Ferris wheel is: *(K.B)***
(A) Translatory motion (B) Vibratory motion
(C) Rotatory motion (D) None of these

11. **Which of the following is a vector quantity? *(K.B)***
(A) Speed (B) Distance
(C) Displacement (D) Power

12. **By dividing displacement of a moving body with time, we obtain: *(U.B)***
(A) Speed (B) Acceleration
(C) Velocity (D) Deceleration

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

2.3 SCALARS AND VECTORS
2.4 TERMS ASSOCIATED WITH MOTION

SHORT QUESTIONS

2.3 Q.1 Differentiate scalar and vector quantities. *(K.B+U.B+A.B)* **(LHR 2014, 2015, 2017)**

Ans: **DIFFERENTIATION**

Differences between scalar and vectors are as follows:

Scalar Quantities	Vector Quantities
Definition	
• Physical quantities which can be completely described by their magnitude only are called scalar quantities or simply Scalars	• Physical quantities which can be completely described by their magnitude along with their direction are called vector quantities or simply Vectors.
Addition/Subtraction	
• Scalar quantities can be added or subtracted by simple arithmetic rules because they have only numeric value with proper unit.	• Vector quantities can–not be added or subtracted by simple arithmetic rules because they have direction along with numeric value and proper unit. They need head to tail rule for this purpose
Examples	
• Mass, length, time speed, volume, area, energy etc.	• Velocity, force, displacement, momentum, torque etc.

2.3 Q.2 Define Magnitude. *(K.B)*

Ans: **MAGNITUDE**

Definition:

“The magnitude of a quantity means its numeric value with appropriate unit.**”**

Examples:

2.3 kg, 40s, 1.8m etc. represent magnitudes of different physical quantities.

2.3 Q.3 Justify the need of direction for a vector quantity. *(K.B)*

Ans: **NEED OF DIRECTION**

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

Example of Forces:

Consider a table as shown in figure below:

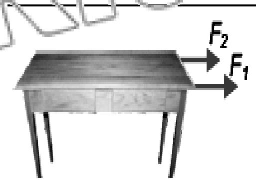


Figure: **Both Forces are Acting in The Same Direction**

Two forces $\mathbf{F_1}$ and $\mathbf{F_2}$ are acting on it. It will make lot of difference if the two forces act in opposite direction such as indicated in figure below:

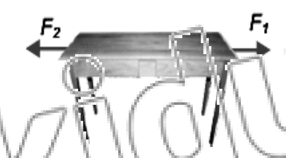


Figure: **Both Forces are Acting in The Opposite Directions**

Certainly the two situations differ from each other. They differ due to the direction of the forces acting on the table. Thus the description of a force would be incomplete if direction is not given. Similarly, when we say, we are walking at the rate of 3 kmh^{-1} towards north then we are talking about a vector.

2.3 Q.4 How a vector is represented? *(K.B)*

Ans: **REPRESENTATION OF VECTORS**

A vector quantity can be represented by two methods

- Symbolic Method
- Graphical Method

SYMBOLIC REPRESENTATION

To differentiate a vector from a scalar quantity we generally use bold letters to represent vector quantities. Such as **F**, **a**, **d** or a bar or arrow over their symbols such as $\vec{F}$, $\vec{a}$ and $\vec{d}$.

GRAPHICAL REPRESENTATION **(LHR 2014, GRW 2014)**

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

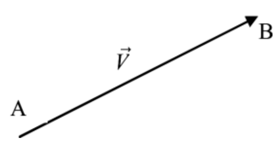


Figure: **Graphical Representation of Vector**

2.3 Q.5 Why vector quantities cannot be added and subtracted like scalar quantities? *(K.B)*
(Exercise 2.11)

Ans: **ADDITION AND SUBTRACTION OF VECTORS**

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.

2.3 Q.6 How are vector quantities important to us in our daily life? *(K.B+A.B)*

Ans: **IMPORTANCE OF VECTOR QUANTITIES**

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.

2.4 Q.1 What is Position? ***(K.B)+(U.B)*** **(GRW 2015)**

Ans: **POSITION**

Definition:

"The term position describes the location of a place or a point with respect to some reference point called origin**"**.

Quantity:

Position is a vector quantity. Change in position is called displacement.

Example:

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

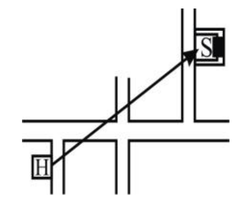


Figure: Position Vector

2.4 Q.2 Define Origin? ***(K.B)***

Ans: **ORIGIN**

Definition:

"The fixed point that is used as reference point to locate the position of an object or point is called origin.**"**

Origin is also termed as reference point and it is denoted by **"O**

2.4 Q.3 Differentiate Distance and displacement? ***(K.B)*** **(LHR 2017)**

Ans: **DIFFERENTIATION**

Differences between distance and displacement are as follows

Distance	Displacement
Definition	
• Length of path between two points is called distance between those points.	• The shortest distance between two points which has magnitude and direction is called displacement
Symbol	
• Distance is represented by **"S"**	• Displacement is denoted by " $\overline{d}$ "
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	
Consider a body that moves from point A to point B along the curved path. Join points A and B by a straight line. The straight line AB gives the distance which is the shortest between A and B. This shortest distance has magnitude d and direction from point A to B. This shortest distance d in a particular direction is called displacement. While any other length of path between A and B shows distance.	

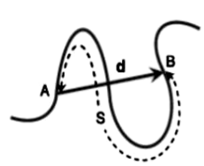


Figure: Distance S (dotted line) and displacement d (Arrow line) from points A to B

2.4 Q.4 Differentiate Speed and Velocity? *(K.B)+(U.B)+(A.B)*

Ans: **DIFFERENTIATION**

Differences between speed and velocity are as follows:

Speed	Velocity
Definition	
• The distance covered by an object in unit time is called speed	• The rate of displacement of a body is called its velocity.
Symbol	
• Speed is represented by "v"	• Displacement is denoted by "$\bar{v}$"
Quantity	
• Speed is a scalar quantity. Its S.I unit is metre per second **(ms^{-1})**	• Speed is a scalar quantity. Its S.I unit is metre per second **(ms^{-1})**
Formula	
• Speed= Distance covered/Total time $v = \frac{S}{t}$	• Velocity = $\frac{\text{displacement}}{\text{time taken}}$ $\vec{v} = \vec{d}/t$

2.4 Q.5 How to measure speed of different object? *(Conceptual base + A.B)*

Ans:

If a car travels between two points on a road, its average speed can be calculated like this.

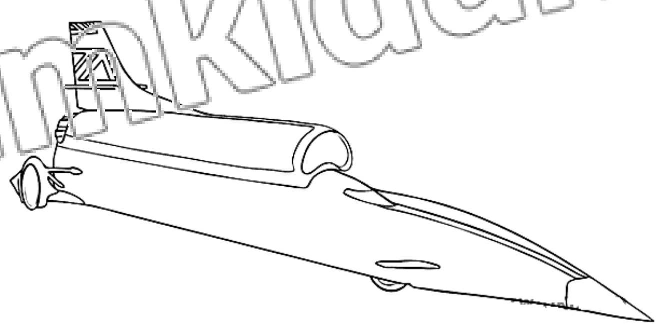
$$\text{average speed} = \frac{\text{distance moved}}{\text{time taken}}$$

On most journeys, the speed of a car varies, so the actual speed at any movement is usually different from the average speed. To find an actual speed, You need to discovered how far the car moves in the shortest time you can measure. For Example, If a car moves 0.20m in 0.01s:

$$\text{Speed} = \frac{0.20\,\text{m}}{0.01\text{s}} = 20\,\text{m/s}$$

2.4 Q.6 How the speed of thrust supersonic car record? *(Conceptual Base + A.B)*

Ans: Thrust supersonic car traveling fastest than sound. For speed records, car are timed over a measured distance (either One km or One mile). The speed is worked out for the average of two runs – down the course and then back again – so that the effect of wind cancelled out. Thrust SSC achieved a speed of 1,228 km/h and became the first land vehicle to officially break the sound barrier.



2.4 Q.7 How you will define the uniform speed? *(K.B+U.B)* **(GRW 2013)**

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."

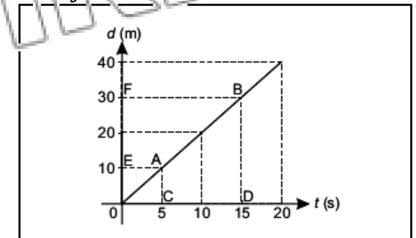


Figure: **Graph for Uniform Speed**

- In this case distance time graph will be a straight line inclined to time Axis.

2.4 Q.8 Define variable speed. *(K.B+U.B)*

Ans: **VARIABLE SPEEED**

Definition:

"If a body does not cover equal distances in equal intervals of time, however short the intervals may be, then the speed of the body is said to be variable.**"**

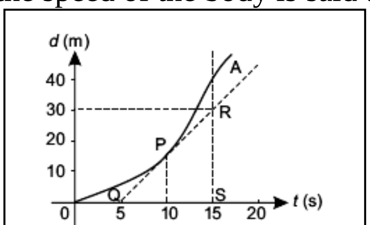
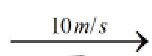


Figure: **Graph for Variable Speed**

- In this case distance time graph will not be a straight line

2.4 Q.9 Explain velocity in simple words. *(Conceptual Base + A.B)*

Ans: Velocity means the speed of something and its direction of travel. For example, a cyclist might have a velocity of 10 m/s due east. On paper this velocity can be shown using an arrow:



For motion in a straight line you can use a + or – to indicate direction.

For example:

+10 m/s (velocity of 10 m/s to the right)

-10 m/s (velocity of 10 m/s to the left)

2.4 Q.10 What do you know about uniform velocity? *(K.B)* **(GRW 2013, 2015)**

Ans: **UNIFORM VELOCITY**

Introduction:

In many cases the speed and direction of a body does not change. In such a case the body possesses uniform velocity. That is the velocity of a body during any interval of time has the same magnitude and direction.

Definition:

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

2.4 Q.11 Define variable velocity. ***(K.B)***

VARIABLE VELOCITY

Definition:

"If a body does not cover equal displacement in equal intervals of time, however short the intervals may be, then the velocity of the body is said to be variable.**"**

2.4 Q.12 A body is moving with uniform speed. Will its velocity be uniform? ***(K.B)***

Ans: **UNIFORM / VARIABLE VELOCITY**

A body moving with uniform speed may have either uniform or variable velocity.

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

Example 1

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

2.4 Q.13 Why a body moving along a circle with uniform speed has variable velocity? ***(K.B)***

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.

2.4 Q.14 Does speedometer of a car measure its velocity? ***(K.B+U.B)***

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.

2.4 Q.15 When does a body possess acceleration? ***(K.B)***

Ans: **ACCELERATION**

In many cases the velocity of a body changes due to a change either in its magnitude or direction or both. The change in the velocity of a body causes acceleration in it. If there is no change in the velocity of a body there will be no acceleration in it that is why a body moving with constant velocity does not have acceleration.

2.4 Q.16 What is meant by the acceleration? ***(K.B+U.B+A.B)*** **(LHR 2015, GRW 2017)**

Ans: **ACCELERATION**

Definition:

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

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 be $v_f - v_i$ in time t.

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

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

So,

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

Unit:

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

Quantity:

It is a vector quantity.

2.4 Q.17 Define uniform acceleration? *(K.B)* **(LHR 2017)**

Ans: **UNIFORM ACCELERATION**

We know,

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

Let the time t is divided into many smaller intervals of time. If the rate of change of velocity during all these intervals remains constant then the acceleration a also remains constant. Such a body is said to possess uniform acceleration.

Definition:

"A body has uniform acceleration if it has equal changes in velocity in equal intervals of time however short the interval maybe.**"**

2.4 Q.18 Define variable acceleration. *(K.B)*

Ans: **VARIABLE ACCELERATION**

If a body does not have 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.

2.4 Q.19 What is meant by positive acceleration and negative acceleration? *(K.B)*

(GRW2012, 2015)

Ans: **POSITIVE ACCELERATION**

If the velocity of the body is increasing then acceleration will be positive. The direction of positive acceleration is the same 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

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** or **deceleration.**

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.

2.4 Q.20 Can a body moving with constant velocity have acceleration? *(K.B)*

(LHR 2011, 2012, GRW 2017)

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.

2.4 Q.21 Can a body moving with certain velocity in the direction of east can have acceleration in the direction of west? *(K.B)*

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.

2.4 Q.22 Which is the fastest animal on the Earth? *(K.B)* **(Do you know Pg. # 35)**

Ans: **FASTEST ANIMAL**

The fastest animal on the Earth is Falcon that can fly at the speed of $200kmh^{-1}$.

2.4 Q.23 What is LIDAR GUN? *(K.B+A.B)* **(Do you know Pg. # 36)**

Ans: **LIDAR GUN**

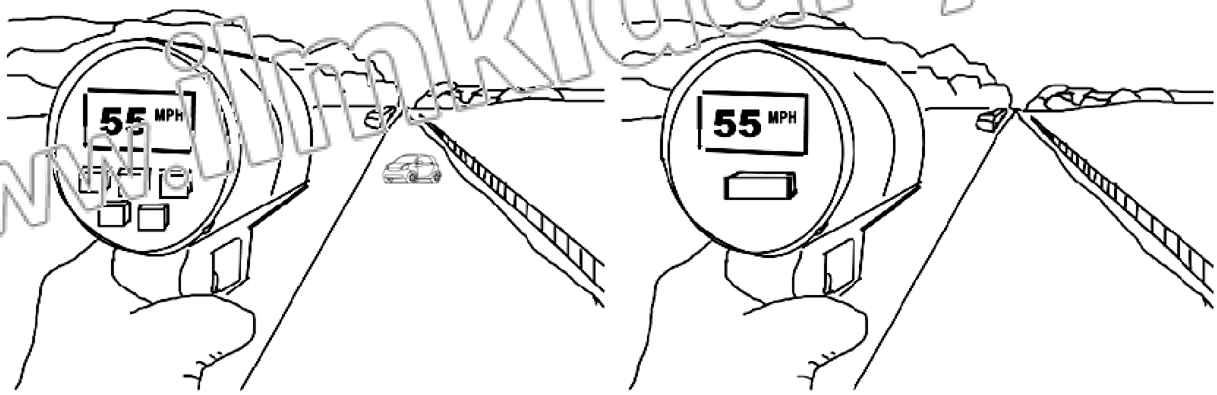


Figure 4

Figure: A LIDAR Gun

A LIDAR gun is light detection and ranging speed gun. It uses the time taken by laser pulse to make a series of measurements of a vehicle's distance from the gun. The data is then used to calculate the vehicle's speed. It is being used as motorway speed camera.

2.4 Q.24 What is terminal velocity? *(K.B)* **(Do you know Pg. # 36)**

Ans: **TERMINAL VELOCITY**

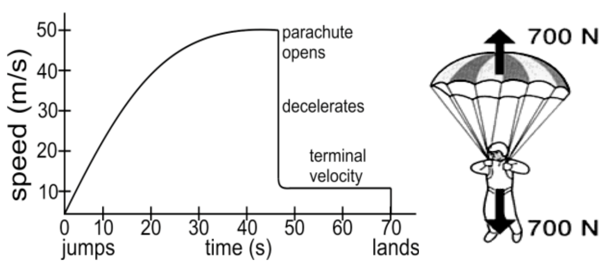


Figure: A Paratrooper Coming Down With Terminal Velocity

The constant velocity of a body falling down with in gravitational field is called terminal velocity. When a skydiver falls from a hovering helicopter, as her speed increases, the air resistance on her also increases. Eventually, it is enough to balance her weight, and she gains no more speed. She is at her **terminal velocity**. Typically, this is about 60 m/s, though the actual value depends on air conditions, as well as the size, shape, and weight of the skydiver.

When the skydiver opens her parachute, the extra area of material increases the air resistance, She loses speed rapidly until the forces are again in balance, at a greatly reduced terminal velocity.

2.4 Q.25 Why the car has rarely uniform acceleration but mostly non uniform?

Ans: A car is travelling along a straight road. If it has uniform acceleration, this means that its acceleration is steady (constant). In other words, it is gaining velocity at a steady rate. In practice, a car's acceleration is rarely steady. For less and less until it is zero. Also the car decelerates slightly during gear changes. If acceleration is not steady then it ins non-uniform.

EXAMPLE 2.1

Represent a force of 80 N acting towards North of East. *(U.B+A.B)*

Solution:

STEP # 1 **SPECIFICATION OF DIRECTIONS**

Draw two lines perpendicular to each other. Horizontal line represents East–West and vertical line represents North–South direction as shown in figure:

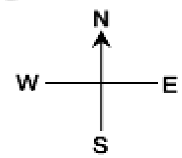


Figure: Specification of Directions

STEP # 2 **SELECTION OF SUITABLE SCALE**

Select a suitable scale to represent the given vector. In this case, we may take a scale which represents 20 N by 1 cm line.

STEP # 3 **DRAWING REPRESENTATIVE LINES**

Draw a line according to the scale in the direction of the vector. In this case, draw a line OA of length 4 cm along North–East.

STEP # 4 **SHOWING DIRECTION**

Put an arrow head at the end of the line. In this case, arrow head is at point A. Thus, the line OA will represent a vector i.e., the force of 80 N acting towards North–East.

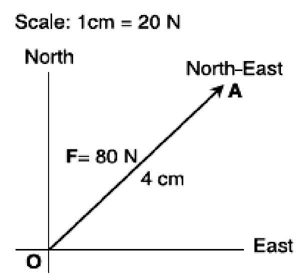


Figure: Representation of Vector

EXAMPLE 2.2

A sprinter completes its 100 metre race in 12s. Find its average speed. *(U.B+A.B)*

Solution:

Given Data:

Total distance = S = 100m

Total time taken = t = 12s

To Find:

Average speed = V_{av} = ?

Calculations:

Average speed = Total distance moved / Total time taken

$V_{av} = 100m/12s$

$V_{av} = 8.33ms^{-1}$

Result:

Hence, the average speed of the sprinter will be $8.33ms^{-1}$.

EXAMPLE 2.3

A cyclist completes half round of a circular track of radius 318 m in 1.5 minutes. Find its speed and velocity. ***(U.B+A.B)***

Solution:

We can easily deduce given data by drawing figure:

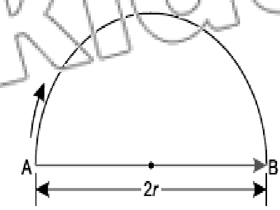


Figure: **Motion along half circle**

Given Data:

Radius of the circle = r = 318m

Distance covered by the sprinter = S = πr

$= (3.14)(318) = 999\text{m}$

Displacement covered by the sprinter = d = 2r

$= 2\,(318) = 636\text{m}$

Time taken by the sprinter = t = 1.5 minutes

$= 1.5\,(60) = 90\text{s}$

To Find:

Speed of the sprinter = v = ?

Velocity of the sprinter = $\vec{v}$ = ?

Calculations:

Speed= Distance covered/Total time

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

Putting values

$$v = 999/90 = 11.1\text{ms}^{-1}$$

Now we find velocity

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

$$\vec{v} = \vec{d}/t$$

Putting values

$$\vec{v} = 636/90 = 7.07\ \text{ms}^{-1}$$

Result:

Hence, the speed and velocity of sprinter will be 11.1ms^{-1} and 7.07 ms^{-1} respectively.

EXAMPLE 2.4

A car starts from rest. It velocity becomes 20ms^{-1} in 8 s. Find its acceleration. ***(U.B+A.B)***

Solution:

Given Data:

Initial velocity = $v_i = 0$
Final velocity = $v_f = 20\,ms^{-1}$
Time = t = 8s

To Find:

Accleceration = a = ?

Calculations:

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

Or $$a = \frac{20ms^{-1} - 0ms^{-1}}{8s} = 2.5ms^{-2}$$

Result:

Hence the acceleration of the car will be 2.5ms^{-2}.

EXAMPLE 2.5

Find the retardation produced when a car moving at a velocity of 30 ms^{-1} slow down uniformly to 15 ms^{-1} in 5s. ***(U.B+A.B)***

Solution:

Given data:

Initial velocity = $v_i = 30ms^{-1}$
Final velocity = $v_f = 15ms^{-1}$
Time = t = 3 s

To Find:

Retardation = –a = ?

Calculations:

We know

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

$$\text{Acceleration} = \frac{\text{Final velocity} - \text{Initial velocity}}{\text{time}}$$

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

$$a = \frac{15 - 30}{5}$$

$$a = -3ms^{-2}$$

Result:

Hence, the retardation in the body will be 3ms^{-2}.

2.3, 2.4 MULTIPLE CHOICE QUESTIONS

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

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

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

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

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

6. 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: *(K.B)*
(A) Uniform (B) Variable
(C) Non uniform (D) All of these

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

8. If the speed and direction of the moving body does not change with time then its velocity is said to be: *(K.B)*
(A) Uniform (B) Variable
(C) Constant (D) All of these

9. If the speed or direction of the moving body changes with time then its velocity is said to be: *(K.B)*
(A) Uniform (B) Variable
(C) Constant (D) All of these

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

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

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

13. If the velocity of a body is uniform then its acceleration will be: *(K.B)*
(A) Positive (B) Negative
(C) Zero (D) Doubled

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

15. If velocity of a body changes equally in equal intervals of time then its acceleration will be: *(K.B)*

(A) Uniform (B) Variable
(C) Constant (D) Relative

16. The velocity and acceleration of a body moving with uniform speed in a circular path will be: *(K.B)*

(A) In the same direction (B) In the opposite direction
(C) Mutually perpendicular (D) Equal

17. If the direction of motion of body and acceleration are in same direction then acceleration will be: *(K.B)*

(A) Uniform (B) Positive
(C) Negative (D) Zero

18. If the direction of motion of body and acceleration are in opposite direction then acceleration will be: *(K.B)*

(A) Uniform (B) Positive
(C) Negative (D) Zero

19. The quantity which can be described by a number, with suitable unit only is called: *(K.B)*

(A) Vector (B) Scalar
(C) Speed (D) Acceleration

20. The quantity which are described by magnitude as well as direction is called: *(K.B)*

(A) Vector (B) Scalar
(C) Speed (D) Acceleration

21. If a car is moving with uniform speed in a circle then its velocity will be: *(K.B+U.B)*

(A) Uniform (B) Variable
(C) Zero (D) None of the above

22. Speed of falcon is: *(K.B)*

(A) 100 kmh^{-1} (B) 200 mh^{-1}
(C) 70 kmh^{-1} (D) 200 kmh^{-1}

23. Speed of cheetah*(K.B)*

(A) 100 kmh^{-1} (B) 200 mh^{-1}
(C) 70 kmh^{-1} (D) 200 $kmah^{-1}$

24. Velocity of a paratrooper coming down with constant velocity is also called: *(K.B)*

(A) Uniform acceleration (B) Variable velocity
(C) Terminal velocity (D) Instantaneous velocity

25. By which quantity should we divide acceleration in kmh^{-2} to get its value in ms^{-2}? *(U.B)*

(A) 12960 (B) 1000
(C) 3600 (D) $(3600)^2$

2.5 GRAPHICAL ANALYSIS OF MOTION

LONG QUESTIONS

2.5 Q.1 What do you know about graph? Write their use? *(K.B+U.B+A.B)*

Ans: **GRAPH**

Definition:

"Graph is a pictorial way of presenting the information about the relation between various 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.

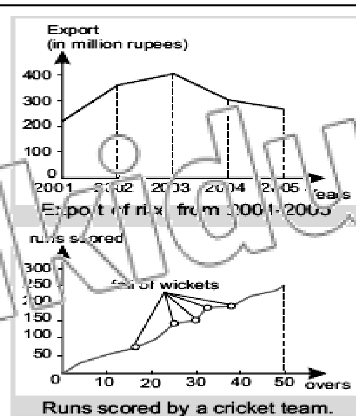


Figure: Use of Graphs

2.5 Q.2 Explain Distance – time Graph. ***(K.B+U.B+A.B)***

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.

Explanation:

Distance time graphs for different bodies are given below:

OBJECT AT REST

Definition:

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

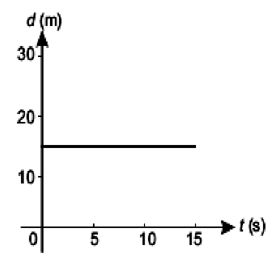


Figure: **Distance Time Graph For Body At Rest**

In the case the distance moved by the object with time is zero. That is, the object is at rest. Thus, a horizontal line parallel to time axis on a distance–time graph shows that speed of the object is zero.

OBJECT MOVING WITH CONSTANT SPEED

Definition:

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

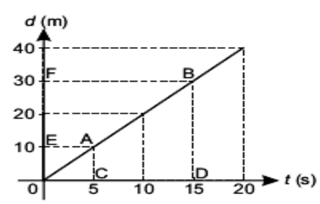
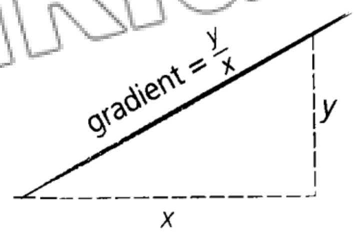


Figure: **Distance Time Graph For Uniform Speed**

- In this case distance time graph will be a straight line inclined to time Axis.

Gradient:

On a graph, the line's rise on the vertical scale divided by its rise on the horizontal scale is called the **gradient**, as shown on below.



- Consider two points A and B on the graph its slope or gradient gives the speed of the object as:

$$\text{Speed of the object} = \text{Slope or gradient of line AB}$$

$$= \frac{\text{distance EF}}{\text{time CD}} = \frac{y}{x}$$

$$= \frac{20\text{m}}{10\text{s}} = 2\,\text{ms}^{-1}$$

- On a straight-line graph, the gradient has the same value wherever you measure y and x.
- On distance time graph, the gradient of the line is numerically equal to the speed.

OBJECT MOVING WITH VARIABLE SPEED

Definition:

"If a body does not cover equal distances in equal intervals of time, however short the intervals may be, then the speed of the body is said to be variable.**"**

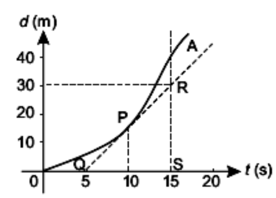


Figure: Distance Time Graph For Variable Speed

- In this case distance time graph will not be a straight line
- The slope of the curve at any point can be found from the slope of the tangent at that point. For example:

$$\text{Slope of the tangent at P} = \frac{RS}{QS}$$

$$= \frac{30\text{m}}{10\text{s}} = 3\text{ms}^{-1}$$

Thus speed of the object at point P is 3ms^{-1}. The speed is higher at instants where slope is greater and speed is zero at instants where slope is horizontal.

2.5 Q.2 Explain speed time graph. ***(K.B+U.B+A.B)***

Ans: **SPEED TIME GRAPH**

"The graph that shows the relationship between speed of an object and time taken by it, is called speed time graph.**"**

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

Explanation:

Speed time graph different situations are given below:

SPEED TIME GRAPH FOR CONSTANT SPEED

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

Q.3 How term distance and displacement are interchangeable in a graph? ***(C.B)***

Ans: displacement is distance in a particular direction. Where there is no change in the direction of motion means motion in a straight line, a displacement time graph looks the same as the distance time graph that is why displacement and distance are interchangeable.

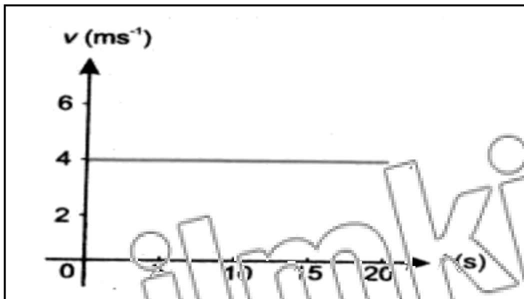
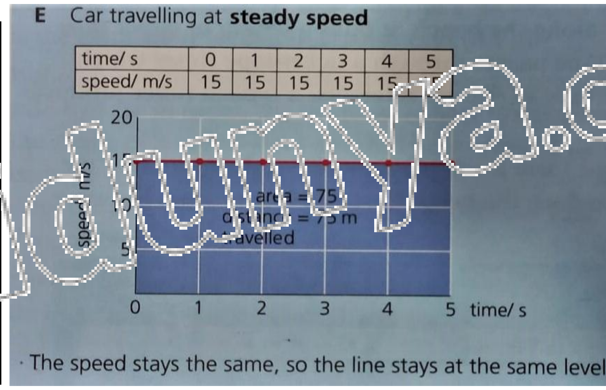


Figure: Speed Time Graph For Constant Speed (4ms⁻¹)



SPEED TIME GRAPH FOR UNIFORM ACCELERATION

Definition:

"A body has uniform acceleration if it has equal changes in velocity in equal intervals of time however short the interval maybe.**"**

Let the speed of an object be changing uniformly. In such a case speed is changing at constant rate.

Thus its speed–time graph would be a straight line such as shown in figure below:

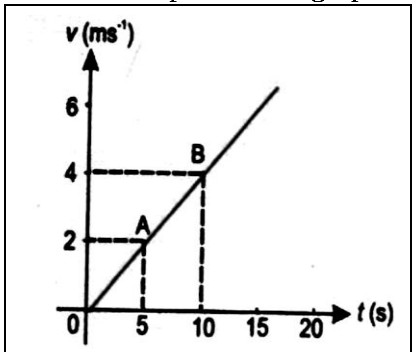
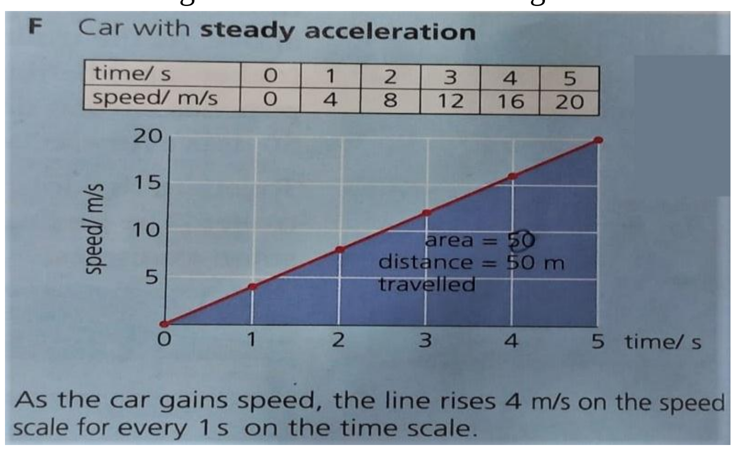


Figure: Speed Time Graph For Uniform Acceleration



A straight line means that the object is moving with uniform acceleration. Slope of the line gives the magnitude of its acceleration.

On a speed-time graph, the gradient of the line is numerically equal to the acceleration.

DISTANCE TRAVELLED BY A MOVING OBJECT

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

2.5 SHORT QUESTIONS

Q.1 How can we find distance from speed time graph? ***(C.B)***

Ans: **TO FIND DISTANCE**

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

Q.2 How the term velocity and speed are interchangeable in graph? ***(C.B)***

Ans: Velocity is speed in a particular direction. Where there is no change in the direction of motion means motion in a straight line, a Velocity time graph looks the same as the speed time graph that is why velocity and speed are interchangeable.

EXAMPLE 2.6

Below figure shows the distance–time graph of a moving car. ***(U.B + A.B)***

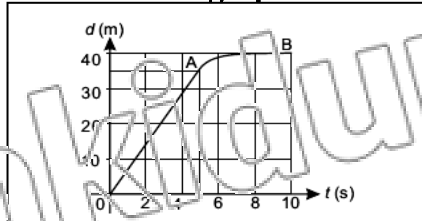


Figure: **Distance Time Graph for Car**

From the graph, find

(a) The distance car has travelled.

(b) The speed during the first five seconds.

(c) Average speed of the car.

(d) Speed during the last 5 seconds. **(Example 2.6)**

Solution:

(a) Total distance travelled = 40 m

(b) Distance travelled during first 5s is 35 m

$$\therefore \quad \text{Speed} = \frac{35\text{m}}{5\text{s}}$$
$$= 7\text{ms}^{-1}$$

(c) Average speed $= \frac{40\text{m}}{10\text{s}}$
$$= 4\text{ms}^{-1}$$

(d) Distance moved during the last 5 s = 5 m

$$\therefore \ \text{Speed} = \frac{5\text{m}}{5\text{s}} = 1\text{ms}^{-1}$$

Result:

- **Car has travelled 40 m**
- **Speed during the 15 s is 7ms^{-1}**
- **Average speed of the car is 4ms^{-1}**
- **Speed during last 5 s is 5ms^{-1}**

EXAMPLE 2.7

Find the acceleration from speed–time graph shown in figure given below: ***(U.B + A.B)***

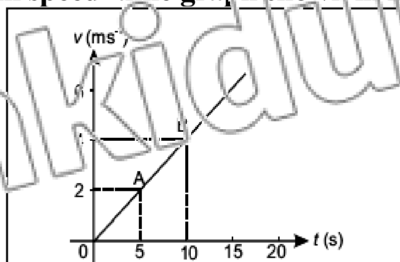


Figure: **Speed Time Graph For Finding Acceleration**

Solution:

On the graph in above figure, point A gives speed of the object as 2 ms^{-1} after 5 s and point B gives speed of the object as 4 ms^{-1} after 10 s.

As Acceleration = slope of AB

Where slope = change in velocity / time interval

$$\therefore \quad \text{acceleration} = \frac{4ms^{-1} - 2ms^{-1}}{10s - 5s}$$

$$= \frac{2ms^{-1}}{5s} = 0.4ms^{-2}$$

Result:

In above speed time graph acceleration of the body is $4ms^{-2}$.

EXAMPLE 2.8

Find the acceleration from speed–time graph shown in figure below: ***(U.B + A.B)***

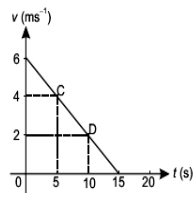


Figure: **Graph of An Object Moving With Uniform Deceleration**

Solution:

In above figure the graph shows that the speed of the object is decreasing with time. The speed after 5s is 4 ms–1 and it becomes 2ms–1after 10 s.

As acceleration = slope of CD

$$= \frac{2ms^{-1} - 4ms^{-1}}{10s - 5s}$$

$$= -\frac{2ms^{-1}}{5s} = -0.4ms^{-2}$$

Result:

Above graph shows that the deceleration of the body is $0.4ms^{-2}$.

EXAMPLE 2.9

A car moves in a straight line. The speed–time graph of its motion is shown in figure below: ***(U.B + A.B)***

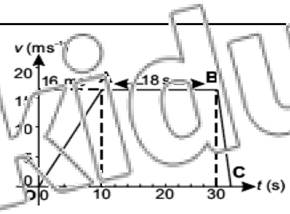


Figure: **Speed time graph of a car during 30 s**

From the graph, Find:

(a) Its acceleration during the first 10 seconds.

(b) Its deceleration during the last 2 seconds.

(c) Total distance travelled.

(d) Average speed of the car during its journey.

Solution:

(a) Acceleration during the first 10 seconds,

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

$$=\frac{16ms^{-1}-0ms^{-1}}{10s}=1.6ms^{-2}$$

(b) Acceleration during the last 2 seconds,

$$=\frac{0ms^{-1}-16ms^{-1}}{2s}$$

$$=-8ms^{-2}$$

(c) Total distance travelled = area under the graph (trapezium OABC)

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

$$=\frac{1}{2}(18s+30s)\times(16ms^{-1})$$

$$=\frac{1}{2}(48s)\times(16ms^{-1})$$

$$=384m$$

(d) $$\text{Average speed}=\frac{\text{Total distance covered}}{\text{Time taken}}$$

$$=\frac{384m}{30s}=12.8ms^{-1}$$

Result:

Above graph shows that:
- **(a) The acceleration of the body during the first 10 seconds is 1.6 ms^{-2}**
- **(b) Its deceleration during the last 2 seconds is - 8 ms^{-2}**
- **(c) Total distance travelled by the car is 384m**
- **(d) Average speed of the car during its journey remained as 12.8 ms^{-1}**

2.5 MULTIPLE CHOICE QUESTIONS

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

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

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

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

2.6 EQUATIONS OF MOTION

LONG QUESTIONS

2.6 Q.1 Derive first equation of motion using speed time graph.

OR Prove that $v_f = v_i + at$ *(K.B+U.B+A.B)* **(GRW 2013)**

<u>FIRST EQUATION OF MOTION</u>

Consider a body is 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.

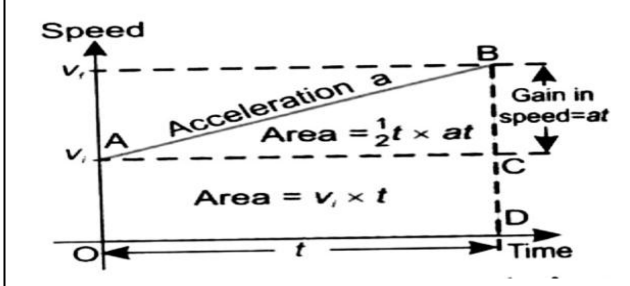


Figure: **<u>Speed Time Graph For Uniform Acceleration</u>**

<u>In this case</u>:

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

We know that slope of line in speed–time graph gives the magnitude of acceleration.

$$\therefore \text{ Acceleration} = \frac{BC}{AC}$$

$$a = \frac{BC}{AC}$$

As AC = OD and BC = BD – CD

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

As $BD = v_f$

$CD = v_i$

$OD = t$

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

Or $at = v_f - v_i$

Therefore, $v_f = v_i + at$

This is called first equation of motion.

<u>Conclusion</u>:

First equation of motion shows the relationship between final velocity "v_f", initial velocity "v_i", acceleration "a" and time taken "t" of a body moving in a straight line with uniform acceleration.

2.6 Q.2 Derive second equation of motion using speed–time graph. **(LHR 2012, 2013)**

OR Prove that $S = v_i t + \frac{1}{2} at^2$ *(K.B+U.B+A.B)*

SECOND EQUATION OF MOTION

Consider a body is 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.

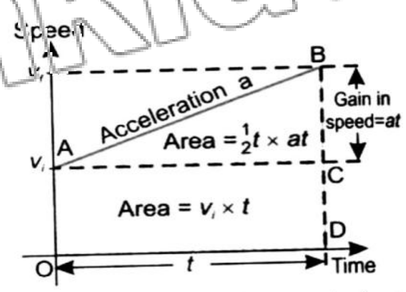


Figure: Speed Time Graph For Uniform Acceleration

In this case:

The total distance **"S"** travelled by the body is equal to the total area of the under the speed time graph. i.e.

Total Distance Covered = Area of the rectangle OACD + Area of the triangle ABC

Area of the rectangle OACD = (width × length)

$= OA \times OD$

$= v_i \times t$ ………… (i)

Area of the triangle ABC $= \frac{1}{2}$ (width × length)

$= \frac{1}{2}(BC \times AC)$

$= \frac{1}{2}(BC \times OD)$

$= \frac{1}{2} at \times t$

$= \frac{1}{2} at^2$ ————————(ii)

Adding (i) and (ii)

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

This is called Second equation of motion.

Conclusion:

Second equation of motion shows the relationship between distance covered "S" , initial velocity "v_i" , time taken "t" and acceleration "a" of a body moving in a straight line with uniform acceleration.

2.6 Q.3 Derive third equation of motion using speed–time graph.

OR Prove that $2aS = v_f^2 - v_i^2$ *(K.B+U.B+A.B)*

Ans: **<u>THIRD EQUATION OF MOTION</u>**

Consider a body is 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.

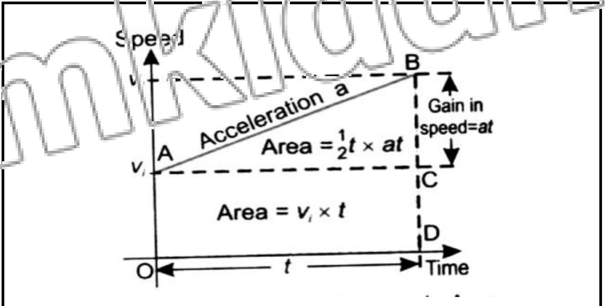


Figure: <u>Speed Time Graph for Uniform Acceleration</u>

<u>In this case</u>:

The total distance **"S"** travelled by the body is equal to the total area of trapezium OABD under the graph.

$$\text{Area of trapezium OABD} = \frac{1}{2}[\text{sum of parallel sides}]\begin{bmatrix}\text{Perpendicular distance}\\ \text{between parallel sides}\end{bmatrix}$$

$$S = \frac{1}{2}(BD + OA)(OD)$$

Or $$2S = (BD + OA)(OD)$$

Multiplying both sides by $\frac{BC}{OD}$, we get

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

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

As (BC = BD–CD)

As $\left(\frac{BC}{OD} = a\right)$

$$2aS = (BD + OA)(BD - CD)$$

As $BD = v_f$

$OA = v_i$

$BD = v_f$

$CD = v_i$

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

$$2aS = (v_f + v_i)(v_f - v_i)$$

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

This is called Third equation of motion.

<u>Conclusion</u>:

Third equation of motion shows the relationship between distance covered "S", initial velocity "v_i", time taken "t" and acceleration "a" of a body moving in a straight line with uniform acceleration.

2.6 SHORT QUESTIONS

Q.1. What are equations of motion? ***(K.B+U.B+A.B)***

Ans: **EQUATIONS OF MOTION**

There are three basic equations of motion of bodies moving with uniform acceleration. These equations relate initial velocity **vi**, final velocity vf, acceleration **a**, time **t** and distance **s** covered by a moving body. In these equations of motion we suppose the motion of a body is along a straight line. Hence, we consider only the magnitude of displacements, velocities, and acceleration along straight line. For rectilinear motion equations of motion are as follows:

$$v_f = v_i + at$$

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

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

Q.2. Write formulae to find area rectangle, triangle and trapezium. ***(U.B+A.B)***

Ans: **FORMULAE**

Formulae for the areas of different shapes are given below:

Area of the rectangle = (width x length)

Area of the triangle ABC = $\frac{1}{2}$ (width x length)

$$\text{Area of trapezium OABD} = \frac{1}{2}[\text{sum of parallel sides}]\begin{bmatrix}\text{Perpendicular distance} \\ \text{between parallel sides}\end{bmatrix}$$

Q.3. How to convert ms^{-2} to kmh^{-2}? ***(U.B+A.B)***

Ans: **ms^{-2} TO kmh^{-2}**

To convert ms^{-2} to kmh^{-2} multiply acceleration in ms^{-2} by {(3600x3600)/1000} = 12960 to get its value in kmh^{-2}

Q.4. How to convert kmh^{-2} to ms^{-2}? ***(U.B+A.B)***

Ans: **kmh^{-2} TO ms^{-2}**

Divide acceleration in kmh^{-2} by 12960 to get its value in ms^{-2}.

Q.5. How to convert ms^{-1} into kmh^{-1}? ***(U.B+A.B)***

Ans: **ms^{-1} TO kmh^{-1}**

$1\ ms^{-1} = 0.001\ km \times 3600\ h^{-1}$

$= 3.6\ kmh^{-1}$

Multiply speed in ms^{-1} by 3.6 to get speed in kmh^{-1}

<u>For example</u>:

$$20ms^{-1} = 20\times3.6\ kmh^{-1}$$

$$= 72\ kmh^{-1}$$

Q.6. How to convert kmh^{-1} to ms^{-1} ***(U.B+A.B)***

$1\ kmh^{-1}$ $= \frac{1000m}{60\times60s} = \frac{10}{36}\ ms^{-1}$

Thus multiply speed in kmh^{-1} by $\frac{10}{36}$ to get speed in ms^{-1} **e.g.,**

$50\ kmh^{-1}$ = $50\times\frac{10}{36}\ ms^{-1}$

$= 13.88\ ms^{-1}$

EXAMPLE 2.10

A car travelling at $10ms^{-1}$ accelerates uniformly at $2ms^{-2}$. Calculate its velocity after 5 s. *(U.B+A.B)*

Solution:

Given Data:

Initial velocity = v_i = $10ms^{-1}$
Acceleration = a = $2ms^{-2}$
Time = t = 5 s

To Find:

Final velocity = v_f = ?

Calculations:

We know

$$v_f = v_i + at$$

Putting the values

$$v_f = (10) + (2)(5)$$
$$v_f = 10 + 10$$
$$v_f = 20\ ms^{-1}$$

Result:

The velocity of the car after 5 s is $20ms^{-1}$.

EXAMPLE 2.11

A train slows down from 80 kmh^{-1} with a uniform retardation of 2 ms^{-2}. How long will it take to attain a speed of 20 kmh^{-1}? *(U.B+A.B)*

Solution:

Given Data:

Initial velocity = v_i = 80 kmh^{-1}

$$= \frac{80 \times 1000m}{60 \times 60s}$$

$$= 22.2ms^{-1}$$

Final velocity = v_f = 20 kmh^{-1}

$$= \frac{20 \times 1000m}{60 \times 60s} = 5.6ms^{-1}$$

Acceleration = a = $-2ms^{-2}$

To Find:

Time taken = t =?

Calculations:

We know

$$v_f = v_i + at$$

Putting the values

$$5.6 = (22.2) + (-2)(t)$$
$$5.6 - 22.2 = -2t$$
$$-16.6 = -2t$$
$$t = 16.6 / 2$$
$$t = 8.3\ s$$

Result:

The train will take 8.3s to attain the required speed

EXAMPLE 2.12

A bicycle accelerates at 1 ms^{-2} from an initial velocity of 4 ms^{-1} for 10 s. Find the distance moved by it during this interval of time. ***(U.B+A.B)***

Solution:

Given Data:

Acceleration = a = 1ms^{-2}

Initial velocity = v_i = 4ms^{-1}

Time = t = 10s

To Find:

Distance moved = S = ?

Calculations:

We know

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

Putting values

$S = (4)(10) + \frac{1}{2}(1)(10)^2$

$S = 40 + 50$

$S = 90m$

Result:

The bicycle will move 90 metres in 10s

EXAMPLE 2.13

A car travels with a velocity of 5 ms^{-1}. It then accelerates uniformly and travels a distance of 50 m. If the velocity reached is 15 ms^{-1}, find the acceleration and the time to travel this distance. ***(U.B+A.B)***

Solution:

Given Data:

Initial Velocity = v_i = 5 ms^{-1}

Final Velocity = v_f = 15 ms^{-1}

Distance = S = 50m

To Find:

Acceleration = a =?

Time to travel the distance = t =?

Calculations:

We use 3rd equation of motion for finding acceleration

$2aS = v_f^2 - vi^2$

$2a(50) = (15)^2 - (5)^2$

$100a = 225 - 25$

$100a = 200$

$a = 200/100$

$a = 2ms^{-2}$

We can find time to travel by using 1st equation of motion

As $v_f = v_i + at$

Putting the values

$(15) = (5) + (2)$

$15 - 5 = 2t$

$10 = 2t$

$t = 10/2$

$t = 5$ s

Result:

The acceleration of the car is 2 ms^{-2} and it takes 5 seconds to travel 50 m distance.

2.6 MULTIPLE CHOICE QUESTIONS

1. **In equations of motion, motion will always be taken: *(K.B)***
(A) Circular line (B) Straight line
(C) Elliptical line (D) irregular line

2. **In equations of motion, Acceleration will always be: *(K.B)***
(A) Uniform (B) Variable
(C) Positive (D) Negative

3. **In equations of motion, initial velocity will be taken as: *(K.B)***
(A) Uniform (B) Variable
(C) Positive (D) Negative

4. **In speed time graph, sketched for deriving equations of motion "at" is: *(K.B)***
(A) Gain in speed (B) Variable
(C) Momentum (D) Final velocity

5. **Equations of motion are: *(K.B)***
(A) 1 (B) 2
(C) 3 (D) 4

6. **50 kmh^{-1} = *(U.B+A.B)*** **(Useful Information Pg. # 47)**
(A) 13.88 ms^{-1} (B) 5000 ms^{-1}
(C) 30 ms^{-1} (D) 500 ms^{-1}

7. **72 kmh^{-1} = *(U.B+A.B)*** **(Useful Information Pg. # 47)**
(A) 13.88 ms^{-1} (B) 5000 ms^{-1}
(C) 20 ms^{-1} (D) 500 ms^{-1}

8. **1ms^{-1}= *(U.B+A.B)*** **(Useful Information Pg. # 47)**
(A) 100 kmh^{-1} (B) 200 mh^{-1}
(C) 3.6 kmh^{-1} (D) 36 kmh^{-1}

9. **To get speed in ms^{-1}, we multiply speed in kmh^{-1} by: *(U.B+A.B)*** **(Useful Information Pg. # 47)**
(A) 36/10 (B) 200
(C) 10/36 (D) 36

10. **54 kmh^{-1} into ms^{-1} *(U.B+A.B)*** **(LHR 2017)**
(A) 5 ms^{-1} (B) 15 ms^{-1}
(C) 10 ms^{-1} (D) 20 ms^{-1}

2.7 MOTION OF FREE FALLING BODIES

LONG QUESTIONS

Q.1. What do you know about gravitational acceleration? *(K.B+U.B+A.B)* **(LHR 2011)**

Ans: **<u>GRAVITATIONAL ACCELERATION</u>**

Definition:

"The uniform acceleration of free falling bodies under the action of force of gravity is called gravitational acceleration.**"**

Discovery:

Galileo was the first scientist to notice that all the free falling objects have the same acceleration independent of their masses. He dropped various objects of different masses from the leaning tower of Pisa. He noticed that all of them reach the ground at the same time.

Explanation:

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 10 ms^{-2}. For bodies falling vertically downward 'g' is positive and for bodies moving vertically upward 'g' is negative.

2.7 SHORT QUESTIONS

Q.1. How can we use equations of motion for bodies, which are falling freely under the gravity? *(A.B)*

Ans: **FREE FALLING BODIES**

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,

$$v_f = v_i + gt$$

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

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

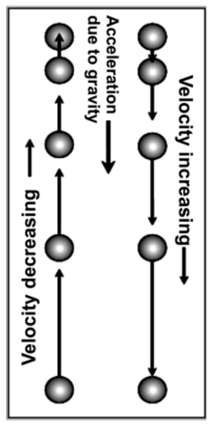


Figure: Acceleration of Free Falling Bodies

Q.2. What are the points kept in mind when bodies are moving freely under gravity? *(K.B)*

Ans: **FOR DOWNWARD MOTION**

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

FOR UPWARD MOTION

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

Q.3. When a body is thrown vertically upward, its velocity at the highest point is zero. Why? *(K.B)*

Ans: **VELOCITY AT HIGHTEST POINT**

When a body is thrown vertically upward, it moves against the force of attraction of the Earth. It slows down gradually and on reaching the highest point it comes to rest. That is why the velocity of a body becomes zero at the highest point.

EXAMPLE 2.14

A stone is dropped from the top of a tower. The stone hits the ground after 5 seconds. Find: ***(U.B+A.B)***

(a) The height of the tower

(b) The velocity with which the stone hits the ground.

Solution:

Given Data:

Initial velocity = $v_i = 0$

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

Time = t = 5 s

To Find:

Height of tower = S = h = ?

Final Velocity = v_f = ?

Calculations:

We can find height of the tower by using 2nd equation of motion

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

By putting values

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

$$h = 0 + 125$$

$$h = 125 \text{ m}$$

We can find final velocity of the stone by using 3rd equation of motion

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

By putting values

$$2(10)(125) = v_f^2 - 0$$

$$v_f^2 = 2500$$

Taking square root on both sides

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

Result:

The height of the tower is 125 metres and it will hit the ground with a velocity of 50 ms-1.

EXAMPLE 2.15

A boy throws a ball vertically up. It returns to the ground after 5 seconds. Find

(a) The maximum height reached by the ball.

(b) The velocity with which the ball is thrown up. ***(U.B+A.B)*** **(LHR 2017)**

Solution:

Given data:

Gravitational acceleration = g = $-10ms^{-2}$ (As the ball is moving upward)

Time for up and down motion = t_o = 5 s

Velocity at maximum height = $v_f = 0$

To Find:

Maximum height reached by the ball = h = ?

The velocity with which the ball is thrown up = v_i = ?

Calculations:

For finding initial velocity first we have to find time to reach maximum height that is Half of total time of flight (t_o)

So Time to reach maximum height = ½ t_o

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

$t = 2.5$ s

Now by using 1st equation of motion we can find initial velocity

We know

$v_f = v_i + at$

Putting the values

$0 = v_i + (-10)(2.5)$

$0 = v_i - 25$

$v_i = 25ms^{-1}$

By using 3rd equation of motion we can find maximum height reached by the ball

We know

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

By putting values

$2(-10)h = 0 - (25)^2$

$-20\ h = -625$

$h = 625/20$

$h = 31.25$ m

Result:

The ball was thrown up with a speed of 25 ms^{-1} and the maximum height to which the ball rises is 31.25 m.

Q.4. Prove that Put the heavy and lighter bodies have same value of gravitational acceleration as they fall freely from certain hight? *(C.B + A.B)*

Ans:

mass of heavy body = M

mass of lighter body = m

$$\text{Fore of gravity on heavy body} = F_1 = \frac{GM_eM}{R^2}$$

$$\text{Fore of gravity on lighter body} = F_2 = \frac{GM_em}{R^2}$$

$$\text{Gravitational accelration on heavy body} = \frac{F_1}{M} = \frac{GM_e}{R^2} = 9.8ms^{-2}$$

$$\text{Gravitational accelration on lighter body} = \frac{F_2}{m} = \frac{GM_e}{R^2} = 9.8ms^{-2}$$

Hence proved the gravitational acceleration is same for bodies of different mass

2.7 MULTIPLE CHOICE QUESTIONS

1. **Series of experiments on free fall of heavy bodies was performed by: *(K.B)***

(A) Newton (B) Einstein

(C) Galileo (D) Al–Kundi

2. **When a body is falling freely under the gravity then in equations of motion 'a' is replaced by: *(K.B)***

(A) m (B) d

(C) S (D) g

3. If a body is falling under the gravity then its initial velocity will be: *(K.B)*

(A) Positive (B) Negative
(C) Uniform (D) Zero

4. If a body is falling under the gravity then its gravitational acceleration will be: *(K.B)*

(A) Positive (B) Negative
(C) Increasing (D) Zero

5. If a body is thrown vertically upward then its final velocity will be: *(K.B)*

(A) Positive (B) Negative
(C) Uniform (D) Zero

6. If a body is thrown upward, then its gravitational acceleration will be: *(K.B)*

(A) Positive (B) Negative
(C) Increasing (D) Zero

7. Value of g depends on: *(K.B)s*

(A) Mass (B) Speed
(C) Size (D) Height

MCQ'S ANSWER KEY (TOPIC WISE)

2.1 INTRODUCTION TO PHYSICS

2.2 TYPES OF MOTION

1	2	3	4	5	6	7	8	9	10	11	12
D	A	A	B	D	C	B	B	A	A	C	C
13											
C											

2.3 SCALARS AND VECTORS

2.4 TERMS ASSOCIATED WITH MOTION

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

2.5 GRAPHICAL ANALYSIS OF MOTION

1	2	3	4
C	D	C	A

2.6 EQUATIONS OF MOTION

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

2.7 MOTION OF FREE FALLING BODIES

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

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

2.1 Encircle the correct answer from the given choices. *(K.B)*

i. A body has translatory motion if it moves along a: **(GRW 2017)**

(a) straight line (b) circle
(c) line without rotation (d) curved path

ii. The motion of a body around an axis is called: *(K.B)* **(LHR 2015)**

(a) circular motion (b) rotatory motion
(c) vibratory motion (d) random motion

iii. Which of the following is a vector quantity? *(K.B)*

(a) speed (b) distance
(c) displacement (d) power

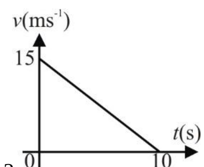
iv. If an object is moving with constant speed then its distance–time graph will be a straight line. *(U.B)*

(a) along time–axis (b) along distance–axis
(c) parallel to time–axis (d) inclined to time–axis

v. A straight line parallel to time–axis on a distance–time graph tells that the object is: *(K.B+U.B)*

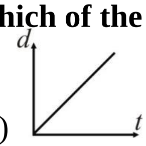
(a) moving with constant speed (b) at rest
(c) moving with variable speed (d) in motion

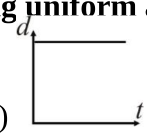
vi. The speed–time graph of a car is shown in the figure, which of the following statement is true? *(U.B)*

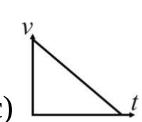


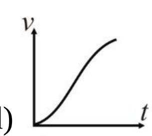
(a) car has an acceleration of 1.5 ms^{-2} (b) car has constant speed of 7.5ms^{-1}
(c) distance travelled by the car is 75 m (d) average speed of the car is 15 ms^{-1}

vii. Which of the following graphs is representing uniform acceleration? *(U.B)* **(LHR 2015)**

(a) 

(b) 

(c) 

(d) 

viii. By dividing displacement of a moving body with time, we obtain: *(K.B)*

(a) speed (b) acceleration
(c) velocity (d) deceleration

ix. A ball is thrown vertically upward. Its velocity at the highest point is: *(K.B)*

(a) –10 ms^{-2} (b) zero
(c) 10 ms^{-2} (d) none of these

x. A change in position is called: *(K.B)*

(a) speed (b) velocity
(c) displacement (d) distance

xi. A train is moving at a speed of 36kmh^{-1}. Its speed expressed in ms^{-1} is:*(A.B)* **(GRW 2015)**

(a) 10 ms^{-1} (b) 20 ms^{-1}
(c) 25 ms^{-1} (d) 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.B)*
(a) 31. 25 m (b) 250 m
(c) 500 m (d) 5000 m

ANSWER KEY

i	ii	iii	iv	v	vi	vii	viii	ix	x	xi	xii
c	b	c	d	b	c	c	c	b	c	a	b

2.2 Explain translatory motion and give examples of various types of translatory motion.
Ans: See Q.2 Long Question TOPIC 2.2

2.3 Differentiate between the following:
(i) Rest and motion
(ii) Circular motion and rotatory motion
(iii) Distance and displacement **(GRW 2014)**
(iv) Speed and velocity **(LHR 2013, 2015)**
(v) Scalars and vectors **(GRW 2013, LHR 2014, 2015, 2107)**

(i) Difference between Rest and Motion
(ii) Circular motion and rotatory motion.
(iii) Difference between Distance and Displacement.
(iv) Difference between Speed and Velocity
(v) Difference between Linear and Random motion.
(vi) Difference between scalar and vector.

2.4 Define the terms speed, velocity, and acceleration. **(GRW 2013, LHR 2015)**

2.5 Can a body moving at a constant speed have acceleration? **(LHR 2014)**
Ans: **CONSTANT SPEED AND ACCELERATION**
A body moving with constant speed may or may not have acceleration.
- It will not have acceleration if the body is moving with constant speed in a straight line that will be case of constant velocity.

That body can have acceleration if its direction of motion changes continuously. For example a body moving with constant speed in a circular path has acceleration.

2.6 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.

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?

2.8 What would be the shape of speed – time graph of a body moving with variable speed? **(LHR 2013, 2014, 2015)**
Ans: Long question Q. 2 Topic 2.5

2.9 Which of the following can be obtained from speed – time graph of a body?
(i) Initial speed **(ii) Final Speed**
(iii) Distance covered in time t **(iv) Acceleration of motion**
Ans: **INFORMATION FROM SPEED TIME GRAPH**
All the given quantities can be obtained from speed–time graph.

2.10 How can vector quantities be represented graphically? **(LHR 2014, GRW 2014)**
Ans: Short question Q. 4 Topic 2.3 & 2.4

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

Ans: **ADDITION AND SUBTRACTION**

Scalar quantities can be described completely by magnitude only and can be added or subtracted by simple arithmetical 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.

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

Ans: **IMPORTANCE OF VECTOR QUANTITIES**

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.

2.13 Derive equations of motion for uniformly accelerated rectilinear motion.

Ans: See Long Questions TOPIC 2.6

2.14 Sketch a velocity – time graph for the motion of the body. Calculate total distance covered by the body.

DISTANCE FROM VELOCITY TIME GRAPH

Solution:

Given Data:

Velocity time graph for the calculation of total distance is given below?

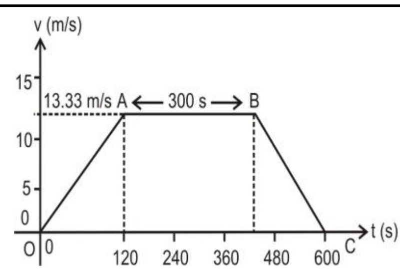


Figure: Speed Time Graph For Finding Total Distance Covered

To Find:

Total distance covered=?

Calculations:

By using the given values we plot a graph shown in figure.

Velocity = 48 kmh^{-1}

Velocity = $\frac{48 \times 1000}{1000}$

Velocity = 13.33 ms^{-1}

Time taken = 2 minutes

= 2(60)

= 120 s

Again time taken = 5 minutes

= 5(60)

= 300 s

Again time taken = 3 minutes

= 3(60)

= 180 s

We know that area under speed–time graph represents the distance covered by the object.

∴ Total distance covered = Area of trapezium OABC

$S = \frac{1}{2}$ (Sum of parallel sides) (Perpendicular distance between parallel sides)

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

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

S= 6000 m

Result:

Total distance covered by the body has been found by finding total area under speed time graph that is equal to 6000m

NUMERICAL PROBLEMS *(U.B+A.B)*

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

Solution:

Given Data:

Velocity of train = V_{av} = 36 kmh^{-1} = $\frac{36\times1000}{3600}$ = 10 ms^{-1}

Time taken = t = 10 s

To Find:

Distance travelled by train = S = ?

Calculations:

As we know that

$S = V_{av} \times t$

By putting the values, we have

S = 10 x 10

S = 100 m

Result:

Hence, the distance travelled by train will be 100 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?

Solution:

Given Data:

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

Distance covered by train = S = 1 km = 1000 m

Time taken by train = t = 100 s

To Find:

Speed of train after 100 s = v_f = ?

Calculations:

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

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

By putting the values, we have

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

$$1000 = ½ \times a \times 10000$$
$$1000 = a \times 5000$$
$$a = \frac{1000}{5000}$$
So, $a = 0.2\ ms^{-2}$

Now from first equation of motion, we have

$$v_f = v_i + at$$

by putting the values, we have

$$v_f = 0 + 0.2 \times 100$$
$$v_f = 20\ ms^{-1}$$

Result:

Hence, the speed of train at the end of 100 s, will be 20 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 travelled during this time and the final velocity of the car.

Solution:

Given Data:

Velocity of the car = v_i = 10 ms^{-1}

Acceleration of the car = a = 0.2 ms^{-2}

Time taken by car = t = 0.5 min. = 0.5 x 60 = 30 s

To Find:

(a) Distance traveled by car = S = ?

(b) Final velocity of the car = v_f = ?

Calculations:

As we know that

$$S = v_i t + ½ at^2$$

By putting the values, we have

$$S = 10 \times 30 + ½ \times 0.2 \times (30)^2$$
$$S = 300 + 0.1 \times 900$$
$$S = 300 + 90$$
$$S = 390\ m$$

(b) Now, by using first equation of motion, we have

$$v_f = v_i + at$$
$$v_f = 10 + (0.2)(30) = 10 + 6$$
$$v_f = 16\ ms^{-1}$$

Result:

Hence, the distance travelled and final velocity of the car will be 390 m and 16 ms^{-1} respectively.

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?

Solution:

Given Data:

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

Time to reach the maximum height = t = 3 s

Gravitational acceleration = g = –10 ms^{-2}

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

To Find:

Maximum height reached by the ball = h = ?

Calculations:

From second equation of motion in vertical motion, we have

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

by putting the values, we have

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

$h = 90 - 5 \times 9 \Rightarrow h = 90 - 45 \Rightarrow h = 45$ 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 s + 3s

Total time taken to return the ground = 6 s

Result:

Hence, the maximum height reached by the ball will be 45 m and total time taken to return the ground will be 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 declaration. Find

i) declaration

ii) total distance traveled by the car

Solution:

Given Data:

For uniform motion:

Uniform velocity = v_{av} = 40ms^{-1}

Time for uniform velocity = t =5s

When brakes are applied

Initial velocity = v_i = 40ms^{-1}

Final Velocity = v_f = 0

Time for being stop = t =10s

To Find:

(i) Deceleration = – a = ?

(ii) Distance traveled by the car = S = ?

Calculations

(i) We know

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

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

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

Putting values

$$a = \frac{0-40}{10} \Rightarrow a = -4ms^{-2}$$

ii) We can find total distance covered in two steps

Step 1 for Uniform Motion:

As we know that

$S = v_{av} \times t$

By putting the values, we have

$S = 40 \times 5$

$S = 200$ m

Step 2 for Deceleration:

As we know that

$S = v_i t + ½ at^2$

By putting the values, we have

$S = (40)(10) + ½(-4)(10)^2$

$S = 400 - 200$

$S = 200m$

Total distance travelled during the journey = 200m+200m
=400m

Result:

Hence, the deceleration in the car will be 4 ms^{-2} and total distance travelled by the car during the journey will be 400 m.

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

Solution:

Given Data:

Acceleration of the train = a = 0.5 ms^{-2}

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

Distance moved by train = S = 100 m

To Find:

Final speed in kmh^{-1} = v_f = ?

Calculations:

From third equation of motion, we have

$2aS = vf^2 - vi^2$

by putting the values, we have

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

$100 = vf^2$

by taking square root on both sides, we have

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

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

Speed In kmh^{-1}

$$v_f = \frac{10 \times 3600}{1000} = 36 kmh^{-1}$$

Result:

Hence, the final speed of train in kmh^{-1} will be 36 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:

Given Data:

Velocity = v = 48 kmh^{-1}

Velocity = v = $\frac{48 \times 1000}{3600} = 13.33 ms^{-1}$

Time taken = t = 2 minutes = 2(60) = 120 s

Again time taken = t = 5 minutes = 5(60) = 300 s

Again time taken = t = 3 minutes = 3(60) = 180 s

To Find:

Total distance covered = S = ?

Calculations:

By using the given values we can plot a graph shown in figure:

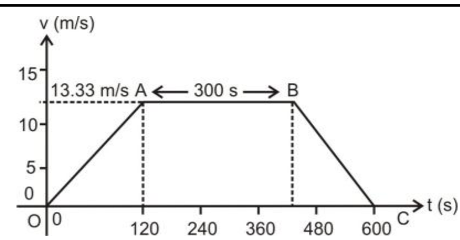


Figure: **Speed Time Graph For Finding Total Distance Covered**

We know that area under speed–time graph represents the distance covered by the object.

$\therefore$ Total distance covered = Area of trapezium OABC

$$S = \frac{1}{2} \text{(Sum of parallel sides) (Perpendicular distance between parallel sides)}$$

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

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

S = 6000 m

Result:

Hence, total distance covered by the brain has been found by finding total area under the graph line in speed time graph and that will be equal to 6000m.

2.8 A cricket ball is hit vertically upwards and returns to ground 6 s later. Calculate
(i) Maximum height, reached by the ball.
(ii) Initial velocity of the ball.

Solution:

Given Data:

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

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

Time in which ball return to ground = $t = 6$ s

To Find:

Maximum height reached by ball = h = ?

Initial velocity of the ball = v_i = ?

Calculations:

We know that for ball thrown vertically upward in air

Time taken by ball to reach maximum height = Time taken by ball to reach ground from maximum height

∴ time taken by ball to reach maximum height = t = 3 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 $$v_i = 30\ ms^{-1}$$

Now from second equation of motion, we have

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

By putting the values, we have

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

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

$$S = 45\ m$$

Result:

Hence, the maximum height reached by ball will be 45 m and initial velocity of the ball will be 30 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)

Solution:

Given Data :

Initial velocity of train = $v_i = 96\ kmh^{-1} = \frac{96 \times 1000}{3600} = \frac{80}{3} ms^{-1} = 26.67 ms^{-1}$

Final velocity of train = $v_f = 48\ kmh^{-1} = \frac{48 \times 1000}{3600} = \frac{40}{3} ms^{-1} = 13.33 ms^{-1}$

Distance covered by train = 800 m

To Find:

Distance covered by the train before coming to rest = S = ?

Calculations:

First we have to find

Retardation of the train = –a = ?

From third equation of motion, we have

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

By putting the values, we have

$$2\ a\ (800) = (13.33)^2 - (26.67)^2$$
$$1600\ a = 177.69 - 711.29$$
$$1600\ a = -533.6$$
$$a = -533.6 / 1600$$
$$a = -0.33\ ms^{-2}$$

Again For over all motion till trains stops

Initial velocity of train = $v_i = 48\ kmh^{-1} = \frac{40}{3} ms^{-1} = 13.33 ms^{-1}$

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

Retardation of train = a = – 0.333 ms^{-2}

From third equation of motion, we have

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

By putting the values, we have

$$2\ (-0.333)\ S = (0)^2 - (13.33)^2$$
$$-0.66\ 6S = -(177.69)$$
$$S = 177.69/0.66$$
$$S = 266.8\ m$$

Result:

> **Hence, the distance moved by the train before coming to rest will be 266.8 m.**

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

Solution:

Given Data:

Initial velocity of train = $v_i = 96\ kmh^{-1} = \frac{96 \times 1000}{3600} = \frac{80}{3} ms^{-1} = 26.67 ms^{-1}$

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

Acceleration = a = $-0.333 ms^{-2}$

To Find:

Time taken by the train = t = ?

Calculations:

From first equation of motion, we have

$$v_f = v_i + at$$

By putting the values, we have

$$0 = 26.67 + (-0.333)\ t$$
$$-26.67 = -(0.333)\ t$$
$$t = 26.67/ 0.333$$
$$t = 80s$$

Result:

> **Hence, the time taken by the train to stop after the application of the brakes will be 80 s.**

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. **(6×1=6)**

1. Motion of individual particle of spinning top is:

(A) Circular motion (B) Rotatory motion
(C) Vibratory motion (D) Random motion

2. One metre per second is equal to:

(A) 3.6 kmh^{-1} (B) $\frac{1}{3.6}kmh^{-1}$
(C) 6.3 kmh^{-1} (D) $\frac{1}{6.3}kmh^{-1}$

3. 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

4. A sprinter completes its 100 metre race in 12s, it's average speed will be:

(A) 100 ms^{-1} (B) 12 ms^{-1}
(C) 8 ms^{-1} (D) 8.33 ms^{-1}

5. Motion of a rider in Ferris wheel is:

(A) Translatory motion (B) Rotatory motion
(C) Random motion (D) Vibratory motion

6. 0.002070 has number of significant figures:

(A) 3 (B) 4
(C) 5 (D) 2

Q.2 Give short answers to following questions. **(5×2=10)**

i. A truck covers a distance of 360 km in 5 hours. Find its speed in metre per second.
ii. A body is moving with uniform velocity. What will be its acceleration?
iii. Under what conditions the distance and displacement between two points will be equal?
iv. Can a body moving at a constant speed have acceleration?
v. Find the retardation produced, when a car moving at the speed of 30ms^{-1} slows down uniformly to 15 ms^{-1} in 5s.

Q.3 Answer the following questions in detail. **(4+5=9)**

a) Define gravitational acceleration. Write a note on the motion of freely falling bodies.
b) A stone is dropped from the top of a tower. The stone hits the ground after 5 seconds. Find:
(i) The height of the tower
(ii) The velocity with which the stone hits the ground

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.