Chapter = 02

KINEMATICS

MECHANICS

Definition:- It deals with the study of motion of objects.

Branches of Mechanics:- There are two main branches of Mechanics which are given below.

(1) Kinematics

(2) Dynamics

(1) Kinematics:-

Derivation and meaning:- The word Kinematics is derived from Greek word Kinema which means "Motion".

Definition:-

"Kinematics is the study of motion of an object without discussing the cause of motion**".**

Derivation and meaning:- The word dynamics is derived from Greek word dynamis which means "force or power".

Dynamics:-

Definition:- Dynamics is the study of motion of an object as well as discussing the cause of motion.

REST AND MOTION

Rest:-

Definition:-If a body does not change its position with respect to some observer with the passage of time it is said to be in a state of rest. OR

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

Examples: -

(i) A book lying on a table.

(ii) A student sitting on the chair in a classroom etc.

Motion:-

Definition:- If a body change its position with respect to some observer with the passage of time it is said to be in a state of motion. OR

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

Examples:-

(i) Flying of bird.

(ii) Rotation of a car wheel etc.

MOTION AND RELATIVE

Statement: - Rest and motion are relative.

Reason: - As position needs reference, therefore rest and motion also need specification of observer.

Explanation: -

A passenger sitting in a moving bus is at rest because he is not changing his position with respect to other passengers or objects in the bus. But to an observer outside the bus, the passengers and the objects inside the bus are in motion.

Conclusion:- As conclusion we find that Rest and motion are relative.

Position: - It is the location of object relative to some reference.

Types of Motion:- There are three types of motion which are given below.

(1)Translatory Motion

(2)Rotatory Motion

(3)Vibratory Motion

Translatory Motion:-

Definition:- In translatory motion, a body moves along a line without any rotation . The line may be straight or curve.

Examples:-

Types of trasnslatory Motion:- There are three types of translatory motion which are below.

(i) **Rectilinear Motion**:-

Definition:- The motion of a body along a straight path is known is known as rectilinear motion

Examples:-

(i) Motion of free falling bodies.

(ii) Flight of Aero planes in air etc.

(ii) **Curvilinear Motion**:-

Definition:- The motion of a body along a curve path is known as curvilinear motion.

Examples:-

(i)Motion of foot- ball kicked by foot- ball player.

(ii) Motion of cricket ball being hit for six etc.

(iii) Random Motion:-

Definition:- "The disordered or irregular motion of an object is called random motion".

For Example:-

(i) Flight of butterfly.

(ii) Flying of birds.

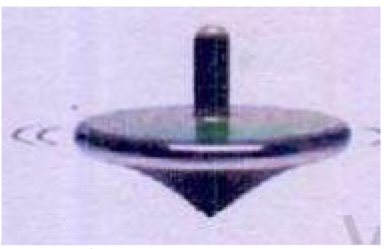
(iii) The motion of dust or smoke particles in the air.
(iv) Brownian motion of gas or liquid molecules etc.

(2) Rotatory Motion:-

Definition: - The spinning motion of a body about its axis is known as rotatory motion. **OR** The motion of a body as whole around a fixed axis is known as rotatory motion.

Examples:-

(i) The spinning of top about its own axis.
(ii) The rotation of wheel about its own axis.
(iii) The rotation of steering wheel about its own axis.



(3) **Vibratory Motion**:-

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

Examples:-

i. Vibratory motion of a child and a swing.
ii. Vibratory of pendulum of a clock.
iii.Vibratory of a children in a sea.



SCALARS AND VECTORS

Scalars OR Scalars Quantities:-
Definition:- Those physical quantities which can be completely described by only its magnitude (size) are known as scalars quantities.
Other Name:- They are also called " Non-Directional Quantities".
Explanation:-
(i) They have only magnitude.
(ii) They have no direction.
(iii)They can be added , subtracted , multiplied and divided by using ordinary algebra.
Examples:- speed , density , time, energy , charge , volume , power , temperature , electric current , electric resistance heat etc.

Vectors OR Vectors Quantities:-
Definition:- Those physical quantities which can be completely describes by its magnitude as well as direction are known as vectors quantities.
Other Name:- They are also called "Directional Quantities".
Explanation:-
(i) They have magnitude and direction.
(ii) For addition, subtraction , multiplication and division of vectors quantities special rules are needed.
Examples:- Velocity, weight, friction, acceleration, torque , momentum, force etc.

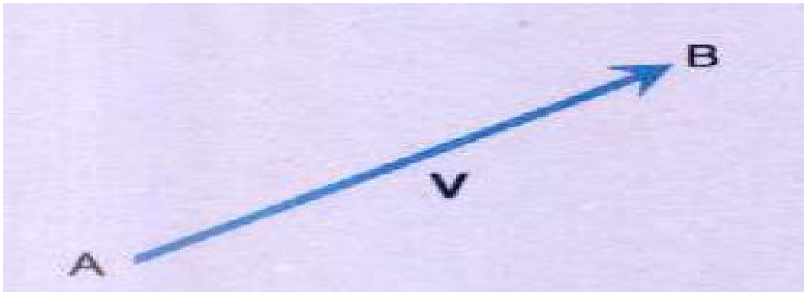
Representation of vectors:- Vectors can be represented by two ways which are given below.
(1) Symbolic Representation.
(2) Graphical Representation.

(1) **Symbolic Representation**:-
Definition:- Symbolically a vector is represented by a letter with an arrow head above or below or with bold face letters.
Explanation:- The symbolic representation of a vector "A" is :-$\vec{A}$, A , **A.**
Note:- We will use A in our text.
Mathematical Form:-

$$\vec{A} = |A| \hat{A}$$

Graphical Representation:-
Definition:- Graphically a vectors is represented by an arrow which drawn according to a scale.
Explanation:- The length of arrow gives the magnitude and the arrow head points the

direction of the vector. The starting point of the vector is called tail of the vector and ending point is called head of the vector as shown in figure.



CO-ORDINATE SYSTEM:-

Definition:- Lines drawn perpendicular at right to each other is known as Co-ordinates system.

Other Name:- It is also called rectangular Co-ordinate system.

Purpose:- It is used to represent vectors.

Types:- It has two types which are given below.

(1) Geographical Coordinates system.

(2) Cartesian Coordinates System.

Step to represent a vector in co-ordinate System:- The following method is used to represent a vector.

(1) Draw a co-ordinate system.

(2) Select a suitable scale.

(3)Draw a line in the specific direction.

(4)Cut the line equal to the magnitude of the vector according to the selected scale.

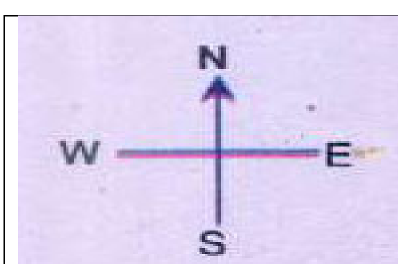
(5)Put an arrow in the direction of the vector.

Example:- A student traveled 100m from the school towards the east . Graphically it be represented as:

Solution:-

Steps:-

(i) Directional Map:-



(ii)Scale:- Let 10 km = 1cm then 100km = 10cm

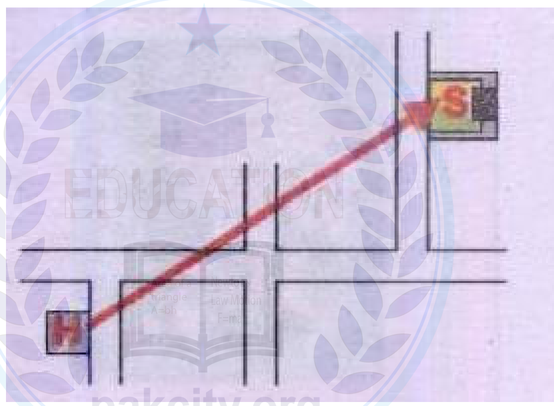
(iii)Line:-

(iv)Put arrow head:-

Position:-

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

For Example: - We want to describe the position of our school from home. Let the school be represented by "S" and home by "H". The position of our school from our home will be represented by a straight line HS in the direction from H to S.



Distance:-

Definition:-The length of path traveled between two positions is known as distance. **OR** The length of the actual followed by a body during its motion is known as distance.

Symbol:- It is denoted by S , ΔX , Δr , Δs , Δl , Δd.

Mathematical Form:- S = V t

Unit:- Its SI is meter (m).

Quantity:- It is a scalar quantity.

Nature:- It is a base quantity.

Displacement:-

Definition:-The shortest directed distance between two position is known as displacement. **OR** The shortest possible distance between any two points during motion of a body is known as displacement. **OR**

The distance in a straight line directed from one point to another point is known as displacement.

Symbol:- It is denoted by $\vec{S}$, $\overrightarrow{\Delta X}$, $\overrightarrow{\Delta r}$, $\overrightarrow{\Delta l}$, *or* $\overrightarrow{\Delta d}$.

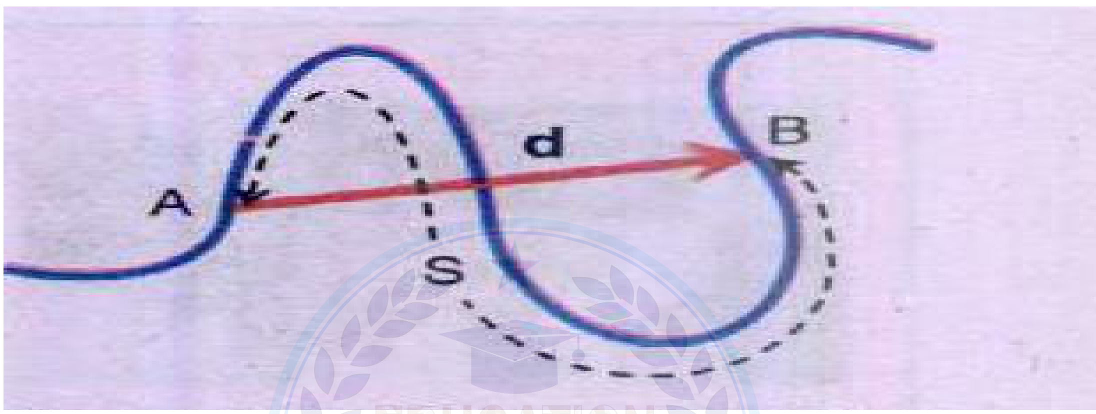
Mathematical form:- $\vec{S} = \vec{V}$ t

Unit:- Its SI unit is meter (m).

Quantity:- It is a vector quantity.

Nature:- It is a base quantity.

Figure (R):-



In figure (R):-

(i) The length of the curve path between the Points A and B is known as distance.

(ii) The length of straight line between the Points A and B is known as displacement.

Note:- The magnitude of distance and displacement is equal when a body moves on a straight path.

Difference between distance and displacement :-

Distance	Displacement
It is the length of path traveled between two positions.	It is the shortest directed distance between two position.
It is dented by S.	It is denoted by $\vec{S}$.
It is a scalar quantity.	It is a vector quantity.
It is always positive.	It may positive as well as negative.
It will never be decrease.	It may be decrease.
It cannot be zero.	It can be zero.

SPEED

Definition:- Measure of the distance covered with passage of time is known as speed. OR The distance covered by a body in unit time is known as speed.
Symbol:- It is denoted by "V".
Mathematical Form:-

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

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

Unit:- Its SI unit is meter per second (m/s or ms^{-1}).
Other Units:- kilometer per hour (km/ hr) .
Quantity:- It is a scalar quantity.
Nature:- It is a derived quantity.
Measurement:- It is measured with help of speedometer.
Purpose:- It gives information about the magnitude of motion only.
Types of speed:- There are four types of speed which are given below.
(i) Average speed
(ii) Instantaneous Speed
(iii) uniform Speed
(iv) variable Speed.

(i)Average Speed:-
Definition:- The total distance covered divided by the total time taken is known as average speed.
Symbol:- It is denoted by <V> or V_{av} .
Mathematical Form:-

$$\text{Average Speed} = \frac{Total\ distance}{Total\ Time}$$

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

Unit: - Its SI unit is m/s.
Quantity: - It is a scalar quantity.
Nature:- It is a derived quantity.

(ii) Instantaneous Speed:-
Definition:- The speed of a body at a certain instant of time is known as instantaneous speed.
Symbol:- It is denoted by " V_{inst}".
Mathematical Form:-

$$V_{inst} = Limit_{\Delta t \to 0} \frac{\Delta S}{\Delta t}$$

Unit:- Its SI unit is m/s.
Quantity:- It is a scalar quantity.
Nature:- It is a derived quantity.
Explanation:- Let we are sitting in the a car and we look at the speedometer. The speedometer shows 100 km/h speed. This speed of the car is known as instantaneous speed at this particular instant.
Note:- The average speed and instantaneous speed becomes equal when the body is moving with uniform speed.
(iii)Uniform Speed:-
Definition:- If a body covers equal distances in equal intervals of time is known as uniform speed.

(iv) Variable Speed: -
Definition:- If a body covers unequal distances in equal intervals of time is known as variable speed.

VELOCITY

Definition:- The rate of displacement of a body is known as velocity. OR
Measure of displacement covered with the passage of time is known as Velocity.
Symbol:- It is denoted by V.
Mathematical Form:-

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

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

Unit:- Its SI unit is meter per second (m/s or ms^{-1}).
Quantity:- It is a vector quantity.
Nature:- It is a derived quantity.
Purpose:- It gives information about the magnitude of motion only.
Types of Velocity:-

1. Average Velocity.
2. Instantaneous Velocity.
3. Uniform Velocity.
4. Variable Velocity.

(1)**Average Velocity**:-
Definition:- The total displacement covered divided by the total time taken is known as average velocity.

Symbol:- It is denoted by <V> or V_{av} .

Mathematical Form:-

$$\text{Average Velocity} = \frac{Total\ displacement}{Total\ Time}$$

$$<\vec{V}> = \frac{\vec{S}}{t}$$

Unit: - Its SI unit is m/s.

Quantity: - It is a vector quantity.

Nature:- It is a derived quantity.

Instantaneous Velocity:-

Definition:- The velocity of a body at a certain instant of time is known as instantaneous velocity.

Symbol:- It is denoted by "$\overrightarrow{V_{inst}}$".

Mathematical Form:-

$$\overrightarrow{V_{inst}} = Limit_{\Delta t \to 0} \frac{\overrightarrow{\Delta S}}{\Delta t}$$

Unit:- Its SI unit is m/s.

Quantity:- It is a vector quantity.

Nature:- It is a derived quantity.

(iii)Uniform Velocity:-

Definition:- If a body covers equal displacement in equal intervals of time is known as uniform velocity.

(iv) Variable Velocity: -

Definition:- If a body covers unequal displacement in equal intervals of time is known as variable velocity.

ACCLERATION

Definition:- The rate of change of velocity of a body is known as acceleration. OR
The measure of change in velocity with the passage of time is known as acceleration. OR
The time rate of change of velocity is known as acceleration.

Symbol:- It is denoted by $\vec{a}$.

Mathematical Form:- $\text{Acceleration} = \frac{Change\ in\ velocity}{Time\ taken}$

$$\vec{a} = \frac{\Delta V}{\Delta t} \quad \text{OR} \quad \vec{a} = \frac{V_f - V_i}{\Delta t}$$

$$\Delta V = V_f - V_i$$

Unit:- Its SI unit is meter per second square (m/s^2 or ms^{-2}).

Quantity:- It is a vector quantity.

Nature:- It is a derived quantity.

Types of Acceleration:-

1. Average Acceleration.
2. Instantaneous Acceleration.
3. Positive Acceleration.
4. Negative acceleration.
5. Variable Velocity.
6. Uniform acceleration.

(1) **Average Acceleration**:-

Definition:-The total change in velocity divided by total time taken is known as average acceleration.

Symbol:- It is denoted by $<\vec{a}>$ OR $\overrightarrow{a_{ave}}$.

Mathematical Form:- $<\vec{a}> = \frac{\overrightarrow{\Delta V}}{\Delta t}$

Unit: - Its SI unit is m/s.

Quantity: - It is a vector quantity.

Nature:- It is a derived quantity.

(2) **Instantaneous Acceleration**:-

Definition:- The acceleration of a body at a certain instant of time is known as Instantaneous Acceleration.

Symbol:- It is denoted by $\overrightarrow{a_{inst}}$.

Mathematical Form:- $\overrightarrow{a_{inst}} = Limit_{\Delta t \to 0} \frac{\overrightarrow{\Delta V}}{\Delta t}$

Unit: - Its SI unit is m/s.

Quantity: - It is a vector quantity.

Nature:- It is a derived quantity.

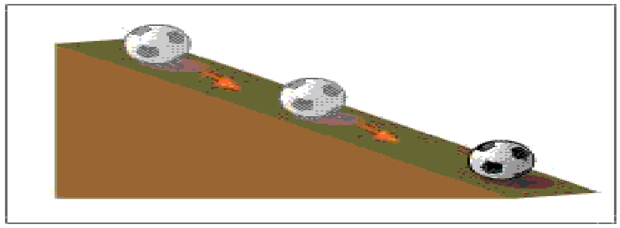
(3) **Positive Acceleration**:-

Definition:- If the magnitude of velocity increases with respect to time then acceleration is known as positive acceleration.

Examples:-

(i) A car starts from rest and its speed increases along a straight line with respect to time then the acceleration of the is said to possess positive acceleration.

(ii) A ball rolling down on an inclined plane is an example of positive acceleration.



(4)**Negative Acceleration**:-

Definition:- If the magnitude of velocity decreases with respect to time then acceleration is known as negative acceleration.

Other Name:- It is also called Deceleration or Retardation.

Examples:-

(i) If a car is moving with a certain speed and then applies brakes with retarding the speed then the acceleration is negative.

(ii)Ball rolling upward on an inclined plane is an example of negative acceleration.

(5).Uniform Acceleration:- A body is said to have uniform acceleration if its average and instantaneous acceleration becomes equal.

(6). **Variable Acceleration:-** It the magnitude of velocity changing irregularly with time then the acceleration is known as variable acceleration.

GRAPH:-

Definition:-"Graph is a pictorial way of presenting information about the relation between various quantities". OR

It is an effective way for showing the relationship between two physical quantities.

Explanation:- Graph contains horizontal and vertical lines at equal distances and coordinates system to show relationship in various quantities.

Variables:-The quantities between which a graph is plotted are called the variables.

Independent and Dependent Variables: -

Independent Variables: - It is a quantity which can be changed with our wishes.

Dependent Variables:- It is a quantity which changes due to the change in the independent variable.

Slope of Graph:-

Definition:- The slope of the graph means vertical co-ordinate difference divided by horizontal co-ordinate difference.

Calculation of slop of graph:- The slope of the graph in Cartesian co-ordinate system can be calculated as.

(1) Pick two points P_1 and P_2.

(2) Determine the co-ordinates $P_1(x_1,y_1)$ and $P_2(x_2,y_2)$, by drawing perpendicular on x and y-axis from both points.

(3) Determine the difference x-co-ordinates $x= x_2-x_1$ and y-coordinates $y=y_2-y_1$.

(4) Dividing the difference in y-coordinates by difference in x-coordinates gives slop.

Mathematically: - Slop = $\frac{\Delta Y}{\Delta X} = \frac{y_{2}-y_{1}}{x_{2}-x_{1}}$

DISTANCE-TIME GRAPH: -

Definition:- The graph which shows the relation between distance and time is known as distance time graph. OR

The graph plotted between distance (s) and time (t) is known as distance – time graph.

Purpose:- The slope of distance time curve only gives speed.

Explanation:- In this case

(i) Time (t) is taken along x-axis.

(ii) While distance (s) is taken along y-axis.

(iii) The slope of s-t graph gives information about the speed of a body.

Examples:- Consider a body covers 100m distance in 10 sec , the slope of distance time graph will give speed.

$$\text{Speed} = \text{Slope} = \frac{\Delta S}{\Delta t} = \frac{S_f - S_i}{t_f - t_i} = \frac{100-0}{10-0} = \frac{100}{10} = 10\text{ m/s}$$

Speed = V = 10 m/s

Graphical Interpretation of distance-time graph OR **Distance- time graph**:-

(1) No Motion OR zero speed:- Time is passing and no change in the distance is seen. Its means the body is at rest. Since there is no slope so the speed is zero.

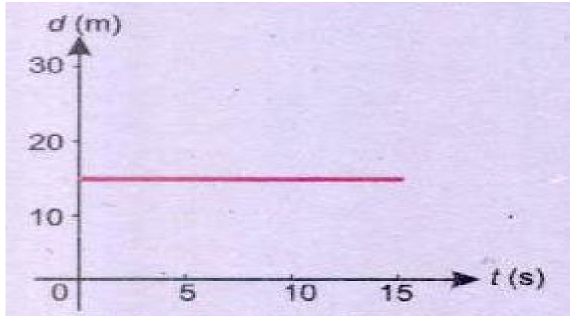


Figure : Distance-time graph when the object is at rest.

(2) <u>Uniform Speed</u>:- The distance is increasing linearly with time. The slop is constant therefore object is moving with uniform speed.

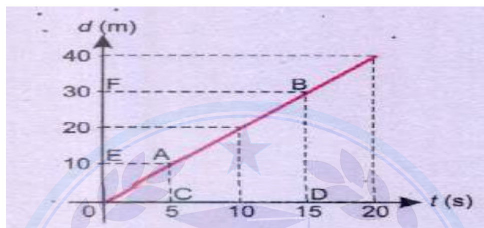


Figure : Distance-time graph showing constant speed.

(3) <u>Variable Speed</u>:- The distance is changing non-linearly with time (spiking down).The slope is changing therefore object is moving with variable speed.

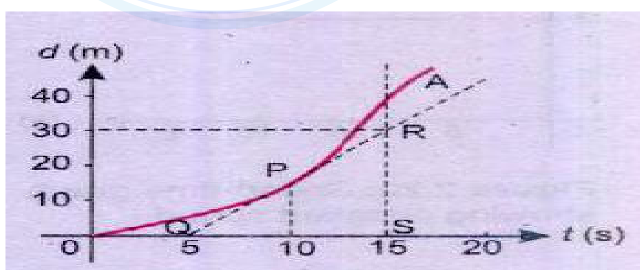


Figure 2.20: Distance-time graph showing variable speed.

<u>Speed- time graph: </u>-

<u>Definition</u>:- The graph which shows the relation between the speed and time is known as velocity time graph. OR

The graph which is plotted between speed and time is speed-time graph.

Explanation:- In this case

(i)Time (t) is taken along x-axis.
(ii) While distance (s) is taken along y-axis.
(iii) The slope of V- t graph gives information about the acceleration of a body.
Purpose of speed-time graph:-It is useful for two purposes:-
(i)Slop or gradient of the graph magnitude of acceleration.
(ii) Area under the graph gives distance traveled.

Note:-The speed is higher at instants when slope is greater, speed is zero at instants when slope is horizontal.

Show that Slop or gradient of speed-time graph gives us magnitude of acceleration

Consider the motion of the object which speeds up from 0 m/s to 8 m/s in 4s , the slope of the speed-time graph will give the magnitude of acceleration which can be written as

$$\text{Slope} = \frac{\Delta V}{\Delta t} = \frac{V_f - V_i}{t_f - t_i} \quad \text{.................. (i)}$$

As we know that $\frac{V_f - V_i}{t_f - t_i}$ = Acceleration = $\vec{a}$ Then equation (i) becomes

$$\text{Slope} = \vec{a} = \frac{V_f - V_i}{t_f - t_i} \quad \text{................(ii)}$$

As V_i = 0 m/s , t_i = 0 m/s , V_f = 8 m/s and t_f = 4 sec then equation (ii) becomes

$$\vec{a} = \frac{8-0}{4-0} = \frac{8}{4} = 2 \text{ m/s}^2.$$

Result:- So we can conclude that the speed-time graph gives us the magnitude of acceleration.

Show that Area under speed-time graphs represents or gives distance traveled

Consider the motion of the object which speeds up from 0 m/s to 8 m/s in 4s as shown in then speed-time graph.

From the speed-time graph:-

Area of rectangle = A = Length x width = l x w = Δt x ΔV

OR A = Δt x ΔV .... (i)

As $\Delta t = t_f - t_i$ = 4 – 0 = 4 sec and $\Delta V = V_f - V_i$ = 8 – 0 = 8 m/s Then equation (i) becomes

$A = \Delta t \times \Delta V = 4 \times 8 = 32\ m^2$

Result:- So we can conclude that Area under speed-time graphs represents or gives distance traveled .

Equation of motion:-

Definition: - Terms associated with motion can be related and calculated from equations are known as equation of motion.

Condition: - These equations can be utilized only for constant acceleration.

FIRST EQUATION OF MOTION

Definition:- The equation which shows the relation among the final velocity (V_f) , initial velocity(V_i) , acceleration (a) and time (t) is known as first equation of motion.

Condition:- This equation is only valid for constant acceleration.

Mathematical Form:- $V_f = V_i + at$

Proof:- From speed-time graph for the motion of a body as shown in figure (G).

From figure:-

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

$a = \frac{\overline{BC}}{t}$ OR $\overline{BC} = at$

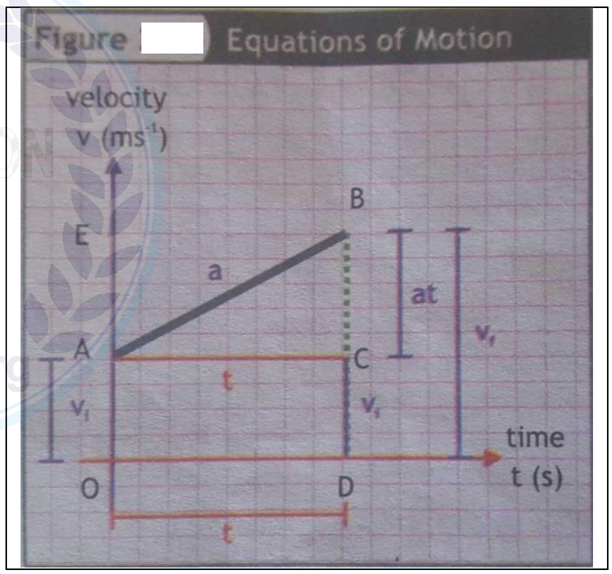
$\overline{OA} = \overline{DC} = V_i$

$\overline{OD} = \overline{AC} = t$

$\overline{BD} = \overline{DC} + \overline{CB}$ .... (i)

By putting values in equation (i) we get

$V_f = V_i + at$ .... (ii)



SECOND EQUATION OF MOTION

Definition:- The equation which shows the relation among the displacement (S) , initial velocity(V_i) , acceleration (a) and time (t) is known as second equation of motion.

Condition:- This equation is only valid for constant acceleration.

Mathematical Form:- $S = V_i + \frac{1}{2} a t^2$

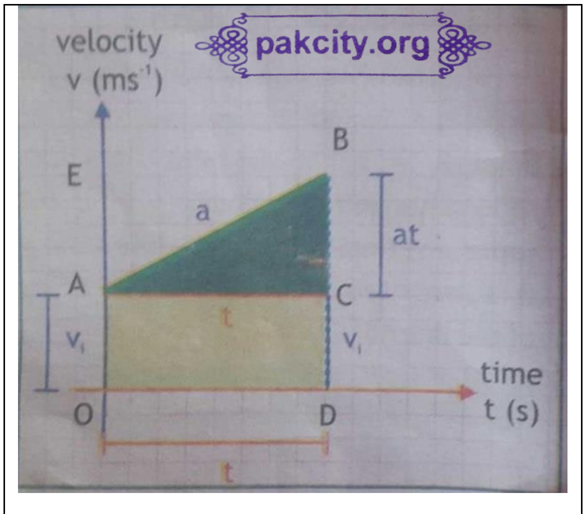
Proof :- From speed-time graph for the motion of a body as shown in figure.

$\overline{BC}$ = at

$\overline{OA} = \overline{DC} = V_i$
$\overline{OD} = \overline{AC}$ = t
$\overline{BD} = V_f$
Displacement = Area of rectangle + Area of triangle

S = OACD + Δ ACB .... (i)

$S = (\overline{OA} \times \overline{OD}) + \frac{1}{2}(\overline{AC} \times \overline{CB})$ .... (ii)



By putting values in equation (ii) we get

$$S = (V_i \times t) + \frac{1}{2} \times (t \times at)$$

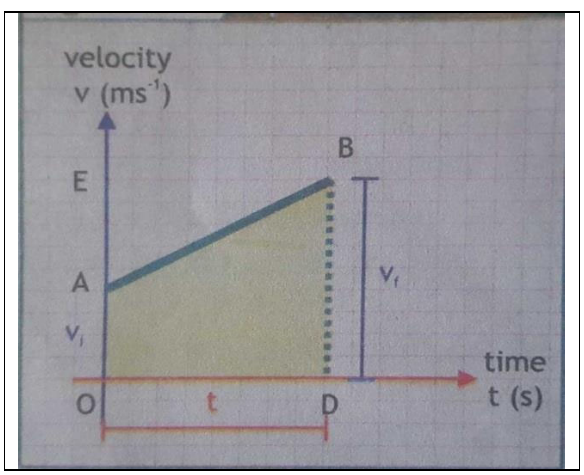
$$S = V_i t + \frac{1}{2} at^2$$

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

THIRD EQUATION OF MOTION

Definition:- The equation which shows the relation among the final velocity (V_f) , initial velocity(V_i) , acceleration (a) and displacement (S) is known as third equation of motion.
Condition:- This equation is only valid for constant acceleration.
Mathematical Form:- $\mathbf{2as = V_f^2 - V_i^2}$

Proof:- From speed-time graph for the motion of a body as shown in figure (T)
$\overline{OA} = V_i$
$\overline{OD}$ = t
$\overline{BD} = V_f$



Displacement = Area of trapezium OABD

$S = \frac{1}{2}$ (Sum of parallel sides) x Height

$S = \frac{1}{2}(\overline{OA} + \overline{DB}) \times \overline{OD}$ .... (i)

By putting values in equation (i) we get

$S = \frac{1}{2}(V_i + V_f) \times t$ .... (ii)

From first equation of motion:- $V_f = V_i + at$ OR $t = \frac{V_f - V_i}{a}$ .... (iii)

By putting equation (iii) in equation (ii) we get

$S = \frac{1}{2}(V_i + V_f) \times \left(\frac{V_f - V_i}{a}\right) = \frac{1}{2a}(V_i + V_f) \times (V_f - V_i)$

$S = \frac{1}{2a}(V_f^2 - V_i^2)$

(a +b) (a –b) = $a^2 - b^2$

OR $2as = V_f^2 - V_i^2$ .... (iv)

$(V_i + V_f) \times (V_f - V_i) = V_f^2 - V_i^2$

MOTION OF FREELY FALLING BODIES:-

History:- Galileo was the first scientist to notice that all the freely falling objects have the same acceleration independent of their masses.

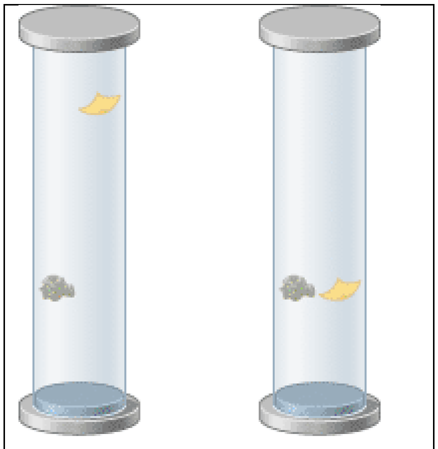
Definition:- The motion in which air resistance is neglected and the acceleration is nearly constant is known as free-fall motion.

Other Name:- It is also called Motion due to gravity.

Explanation:- The acceleration free falling body is called the acceleration due to gravity. It is denoted by "g" and its value is near the earth the surface is 9.8 m/s^2 or 32.2 ft/s^2.

(a) In the presence of air resistance the acceleration of the rock is greater that of the paper as shown in fig (a).

(b) In the absence of air resistance both the rock and the paper have the same acceleration as shown in fig (b).



Air-filled tube (a) Evacuated tube (b)

Gravitational Acceleration:-

Definition:-The acceleration of freely falling bodies is called gravitational acceleration. The acceleration of a body due to gravity is known as gravitational acceleration.

Symbol:-It is denoted by g.

Value:- On the surface of the Earth, its value is approximately 9.8 m/s^2 or 32.2 ft /s^2.

Note:-

(i) For bodies falling down freely g is positive.

ii. For bodies moving up gis negative.

Factor:- The value of "g" depends upon the Height from the Earth's surface i-e $g \propto \frac{1}{(R_e+h)}$

Where (i) R_e Shows the radius of earth.(ii) h shows the height.

Note:- the value of "g" is constant near the near the earth surface above up to a distance of 100 km. After that a change in value of "g" starts and continuously decreases and so on.

Independence:-The value of does not depends upon the mass of the body.

Equations of Motion for Bodies Moving Under Gravity:-

(i) $V_f = V_i + gt$

(ii) $S = V_i + \frac{1}{2} g t^2$

(iii) $2gS = V_f^2 - V_i^2$

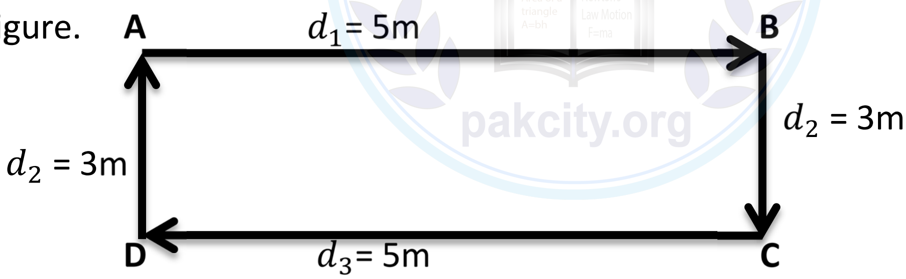
CONCEPTUAL QUESTIONS

(1) Is it possible that displacement is zero but not the distance. Under what condition displacement will be equal to distance.

Ans:- (a) **Statement**:- Yes is it possible that displacement is zero but not the distance.

Reason:- It is due to same starting and ending points.

Explanation:- As we known that when a body starts motion on a closed path and finally reaches its initial position then in this case the displacement is zero but not the distance as shown in figure.



(i) From figure the value of displacement is zero because of same starting and ending point.

(ii) The distance is not zero and is equal to the D = $d_1 + d_2 + d_3 + d_4$ = 16 m.

(b) Statement:- The magnitude of displacement and distance will equal when a body perform straight line motion.

Explanation:- A boy moves from **"A"** to point **"B"** on a straight path as shown in figure.

Result:- As conclusion we find that in case of straight line motion the both distance and displacement have same magnitudes i-e $\vec{S}$ = S = 10 m

(2) Does a speedometer measure a car's speed or velocity?

Ans:- **Statement**:- A speedometer measure a car's speed not velocity.

Reason:- It is because the speedometer measures only the magnitude of motion not its direction.

Explanation:- As we know that the velocity is a vector quantity. It has magnitude and direction. Speed is a scalar quantity. It has only magnitude but no direction. The speedometer of a car measures magnitude of motion only and does not give any information about the direction.

Conclusion:- As conclusion we find that the speedometer measure a car's speed not velocity.

(3) Is it possible for an object to be accelerating at rest at the same time? Explain with example.

Ans:- Statement:- Yes it is possible for an object to be accelerating at rest at the same time.

Reason:- It is because of free fall motion

Explanation:- When a body is thrown vertically upward in the air with initial velocity " V_i". During its entire trajectory it is accelerating downward. At highest point its final velocity "V_f" becomes zero. But still the body possess acceleration due to gravity.

Conclusion:- As conclusion we find that it is possible for an object to be accelerating at rest at the same time.

4.Can a object have zero acceleration and non-zero velocity at the same time ? Give example.

Ans:-Statement:-Yes an object can have zero acceleration and non-zero velocity at the same time.

Reason:- It is because during Uniform velocity acceleration is zero.

Explanation:- As we known that

$$a = \frac{\Delta V}{\Delta t} \text{ .... (i)}$$

From (i) it cleared that the value of acceleration depends upon the change in velocity (ΔV). If the ΔV is zero then the acceleration will be zero.

Conclusion:- As conclusion we find that when a body is moving with uniform velocity along a straight path then it has zero acceleration and non-zero velocity.

5. A person standing on the roof of a building throws a rubber ball down with a velocity of 0.8 m/s What is the acceleration (magnitude and direction) of the ball?

Ans:- Statement:- A person standing on the roof of a building throws a rubber ball down with a velocity of 0.8 m/s then its acceleration will 9.8 m/s^2.

Reason:- It is because the motion of ball is under gravity.
Explanation:- When a person standing on the roof of a building throws the rubber ball down. The ball falls down due to gravity. Its magnitude will be 9.8 m/s^2 in downward direction if the air resistance is ignored.
Conclusion:- As conclusion we find that when a person standing on the roof of a building throws a rubber ball down with a velocity of 0.8 m/s then its acceleration will 9.8 m/s^2.

6. Describe a situation in which the speed of an object is constant while the velocity is not?

Ans:-Statement:- During uniform circular motion the speed of an object is constant while the velocity is not.
Reason:- It is because at each point on the circular path the direction of velocity is continuously changing.
Explanation:- As we know that when an object is moving along a circular path with uniform speed , there is no change in magnitude of speed but the direction of velocity changes at each point due to which an acceleration is produces which is known as centripetal acceleration and always directed towards the center of the circular path.
Conclusion:- As conclusion we find that in case of circular motion the speed of an object is constant while the velocity is not.

7. Can an object have north velocity and a southward acceleration? Explain.

Ans:-Statement:-Yes it is possible that an object can have northward velocity and a southward acceleration.
Reason:- It is because in case of deceleration the velocity and acceleration are opposite in direction
Explanation:- When a body moving towards north with accelerating velocity then its acceleration will be towards south.
Example:- A ball rolling down on an inclined plane.
Conclusion:- As conclusion we find that object can have northward velocity and a southward acceleration.

8. As a freely falling objects speed up ,what happening to its acceleration. Does it increases, decrease or stay the same?

Ans:-Statement:- When a freely objects speed up then its acceleration stay remains the same.
Reason:- It is because the motion of objects under constant gravity i-e g = constant.
Explanation:- As we known that if the air resistance is negligible the acceleration of the free fall motion of the object speedup at constant rate, hence acceleration of constant magnitude 9.8 m/s^2 is produced.
Conclusion:- As conclusion we find that When a freely objects speed up then its acceleration stay remains the same.

9. A ball is thrown upward with initial speed of 5m/s. What will be its speed when it returns to starting point?

Ans:- Statement:- A ball is thrown upward with initial speed of 5m/s.Its speed when it returns to starting point will be 5 m/s.

Reason:- It is because the motion under constant gravity.

Explanation:- As we know that for free fall objects we ignore the air resistance. When a ball is thrown upward with initial speed of 5m/s . Its speed when it returns to starting point will be 5 m/s because its motion is under constant gravitation acceleration.

Conclusion:- As conclusion we find that the ball returns to its starting point it will gain the same speed i-e 5m/s.

NUMERAL QUESTIONS

Pb#01:- A squash ball makes contact with a squash racquet and change velocity from 15 m/s west to east in 0.10 s. Determine the vector acceleration of the quash ball.

Given Data:-

Initial Velocity= V_i=15m/s

Final velocity = V_f = 25 m/s

Time = t= 0.10 s

Required Data:-

Acceleration= a = ?

Solution:-

Formula:- $a = \frac{\Delta V}{\Delta t}$ .... (i)

As $\Delta V = V_f - V_i$ then eq(i) becomes

$a = \frac{V_f - (-V_i)}{\Delta t} = \frac{V_f + V_i}{\Delta t}$ .... (ii)

Calculation:- By putting values in eq (ii) we get

$a = \frac{25+15}{0.10} = \frac{40}{0.10} = 400\ m/s^2$

a = 400 m/s^2

Result:- So the acceleration of squash ball is 400 m/s^2 .

(2) A golf ball that is initially traveling at 25 m/s hits a sand trap and slows down with acceleration of – 20m/s^2 . Find its displacement after 2.0 s.

Ans: **Solution**:-

Given Data:-

Initial Velocity = V_i = 25 m/s

Acceleration = a = - 20 m/s^2

Time = t = 2.0 s

Required Data:-

Displacement = S = ?

Formula:- From 2^{nd} equation of motion

$$S = V_i t + \frac{1}{2}at^2 \text{ .... (i)}$$

Calculation:- By putting the values in equation (i) we get

$$S = 25 \times 2.0 + \frac{1}{2} \times (-20)(2.0)^2 = 50 + \frac{1}{2} \times -20 \times 4 = 50 \times \frac{1}{2} \times -80$$

$$S = 50 + (-40) = 50 - 40 = 10 \text{ m/s}$$

S = 10 m/s

Result:- The displacement covered by golf ball is 10 m/s .

(3) A bullet accelerates the length of the barrel of a gun 0.75 m long with a magnitude of 5.35 x 10^5 m/s^2 . With what speed does the bullet exit the barrel.

Ans:- Solution:-

Given Data:-

Initial Velocity = V_i = 0 m/s

Distance = S = 0.75 m

Acceleration = a = 5.35 x 10^5 m/s^2

Required Data:-

Final Velocity = V_f = ?

Formula:- From 3^{rd} equation of motion $2as = V_f^2 - V_i^2$ OR $V_f^2 = 2aS + V_i^2$ .... (i)

Calculation:- By putting values in equation we get

$$V_f^2 = 2 \times 0.75 \times 5.35 \times 10^5 + (0)^2$$

$$V_f^2 = 8.025 \times 10^5 + 0 = 8.025 \times 10^5 \text{ m/s} = 802500 \text{ m/s}$$

$$\sqrt{V_f^2} = \sqrt{802500}$$

$$V_f = 895.82 \text{ m/s}$$

Result:- The bullet exits from barrel with the speed of 895.82 m/s .

(4) A driver is traveling at 18m/s when she sees a red light ahead . Her car is capable of decelerating at a rate of 3.65 m/s^2. If she applies brakes when she is only 20.0m from the

intersection when she sees the light, will she be able to stop in time.

Ans:- <u>Solution</u>:-

<u>Given Data</u>:-

Initial Velocity = V_i = 18m/s

Acceleration = a = -3.65 m/s^2

Distance = S = 20.0m

Final velocity = V_f = 0 m/sec

<u>Required Data</u>:-

distance needed to stop = S_1= ?

<u>Formula</u>:- From 3rd equation of motion $2aS_1 = V_f^2 + V_i^2$ ……………. (i)

Calculation:- By putting values in equation (i) we get

$$2 \times -3.65 \times S_1 = (0)^2 - (18)^2$$

$$-7.3 \times S_1 = 0 - 324$$

$$-7.3 \times S_1 = -324 \quad \text{OR} \quad S_1 = \frac{-324}{-7.3} = 44.4 \text{ m}$$

$$S_1 = 44.4 \text{ m}$$

<u>Result</u>:- No, the driver will be unable to stop the car in 20m. She will go 24.3 m past the red light. ($S_2 = S_1 - S = 44.4 - 20 = 24.3$).

(5) An antelope moving with constant acceleration 2m/s^2 covers crosses a point where its velocity is 5m/s. After 6.00 s how much distance if it has covered and what is its velocity.

<u>Given Data</u> :-

Acceleration = a = 2 m/s^2

Initial Velocity = V_i = 5m/s

Time = t = 6.00 s

Required data:-

(a) Final Velocity = V_f = ?

(b) Distance = S = ?

(a) **For V_f: –**

<u>Formula</u>:- From 1st equation of motion $V_f = V_i + at$ …………… (1)

Calculation:- By putting values in equation (1) we get

$$V_f = 5 + 2 \times 6.00 = 5 + 12 = 17 \text{ m/s}$$

(b) **<u>For S</u>** :- From 3rd equation of motion $2as = V_f^2 - V_i^2$ …………. (2)

<u>Calculation</u>:- By putting values in equation (2) we get

$$2 \times 2 \times S = (17)^2 - (5)^2 \quad OR \quad 4 \times S = 289 - 25$$

$$4 \times S = 264 \quad OR \quad S = \frac{264}{4} = 66 \text{ m}$$

Result:-

(i) The final velocity of antelope is 17 m/s.

(ii) The distance covered by antelope is 66m.

(6) with what speed must a ball be thrown vertically from ground level to rise to a maximum height of 50 m?

Ans:- Solution:-

Given data:-

Height= h = 50m

Final velocity= V_f = 0 m/s

Gravitational Acceleration = g = -10 m/s $^{-2}$.

Required Data:-

Initial velocity = V_i = ?

Formula:- From 3rd equation of motion $2as = V_f^2 - V_i^2$ OR $2gh = V_f^2 - V_i^2$ .... (1)

Calculation:- By putting the values in equation (1) we get

$$2 \times -10 \times 50 = (0)^2 - V_i^2$$

$$-1000 = -V_i^2 \quad OR \quad 1000 = V_i^2$$

$$\sqrt{1000} = \sqrt{V_i^2} \quad OR \quad 31.62 = V_i$$

V_i =31.62 m/s

Result:- The speed of ball is 31.62 m/s.