Chapter#2

KINEMATIC

MEChanics

Study of Motion

Kinematics

Study of motion without its cause. (force)

Dynamics

Study of motion with its cause (Force)

Rest and Motion:-

No Motion

If a body doesn't change its position with respect to its surrounding, then it is called rest

If a body changes its position with respect to its surrounding, then it is called Motion

Example:- A book lying on table, not being moved or disturbed.

Example:- A person sitting Quietly in a corner.

Example:- A person dancing, running, walking from one place to another.

SLO Based Questions

Q Show that rest and motion are relative

Rest and motion are Relative:- Rest and motion are relative because whether something looks like its moving or not depends on (observer) where you are watching from.

Example:- If you are sitting in a car that's moving you might see the tree outside moving but if you were standing by the side of road the tree would be still but the car would be the one moving.

Q Differentiate b/w rest and motion

Rest	**Motion**
Definition	
A state where an object unchanged, with no motion or change in position	A state where an object ~~remains~~ changes its position or moves from one point to another.
Velocity	
Velocity is zero, as the object is not moving	Velocity is non-zero as the object is changing its position.
State of Object	
Object remains stationary and unchanged	object changes it position and moves.
Example	
A book lying on a table, not moving	A car driving down the road; changing its position

Types of Motions:-

Translatory Motion
(Motion of an object without rotation)

Rotatory Motion
(Motion of an objed about it own axis
E.g Motion of fan)

vibratory Motion
(to and fro motion of an object Example Motion of simple Pendulum)

rectelinear Motion
(Motion of an object in a straight line without rotation)
Example:-

Circular Motion
(Motion of an object in a curved line without rotation)
Example:- Motion of a car in a turn

Random Motion
(Motion of an object in Zig Zag path without rotation)
Example:- Brounion Motion of gas particles in a container

SLO Base Question

Q: Is there any condition where the body posses circulatory and rotatory motion simultaneously?

Wheel motion:- A wheel rotates on its axis and also moving in circular motion on the road.

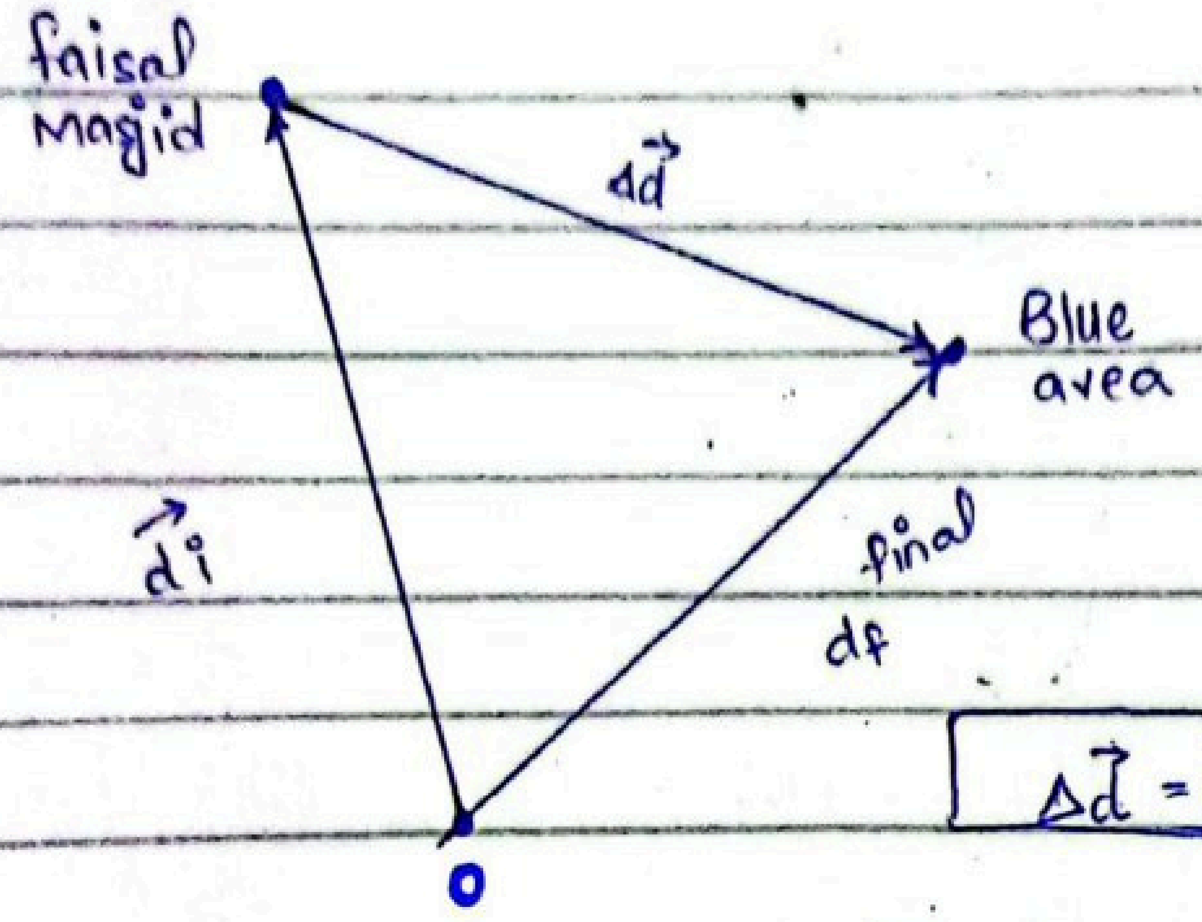
Planet motion:- A planet orbits the sun in circular motion while also rotating on its axis

Q2 What type of motion does a rider posses on ferris wheel?

The rider posses circular motion as it's not rotating on its axis. The body just sitting and moving circular. whil the ferris wheel rotates on its axis.

CamScanner

"Distance and Displacement"



$$\boxed{\vec{\Delta d} = \vec{d_f} - \vec{d_i}}$$

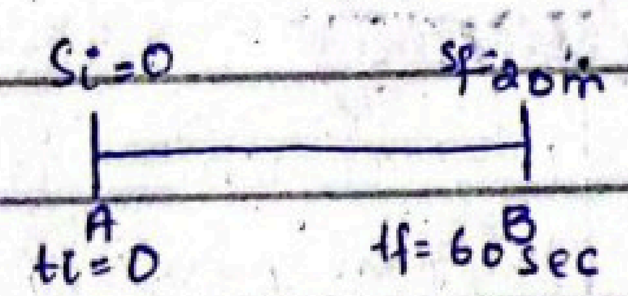
"Speed:-" The rate of change in distance is called speed

$\Rightarrow$ Speed = $\dfrac{\text{change in distance}}{\text{change in time}}$

$\Rightarrow V = \dfrac{\Delta d}{\Delta t}$

$\Rightarrow V = \dfrac{S_f - S_i}{t_f - t_i}$

Example:-



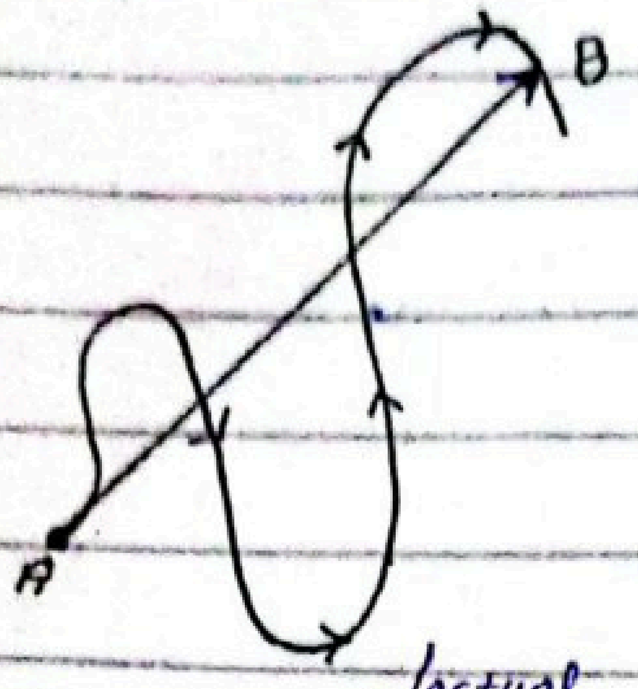
$\Rightarrow V = \dfrac{200m - 0m}{60s - 0s}$

$\Rightarrow V = \dfrac{200}{60} = 3.3\ m/s$

SI Unit of Speed
m/s

CamScanner

Distance and Displacement :-



Distance:- The Total actual path covered b/w two points is called Distance.

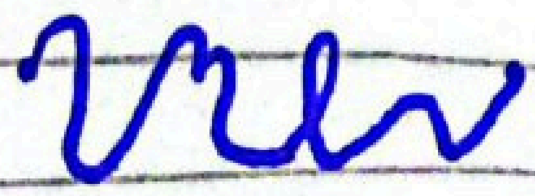
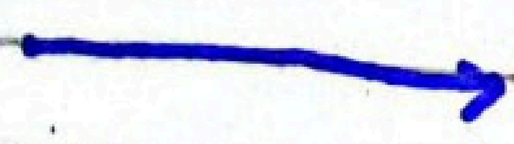
Displacement :- The Shortest path covered b/w two points is called displacement.

→ It's a vector quantity It is denoted by $\vec{d}$

→ It's a Scalar quantity. It is denoted by S

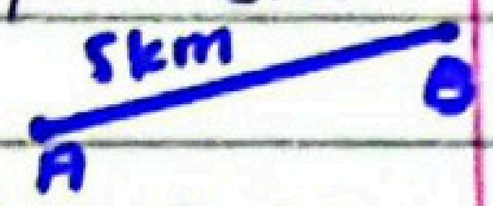
-: SLO Based Question :-

Q1 Differentiate b/w distance and displacement

Distance	Displacement
Difinition	
The total length of the path covered by an object	Shortest path covered b/w two point.
Quantity	
Distance is a ~~vector~~ scalar quantity.	Displacement is a Vector quantity
Representation	
denoted by $\Delta s\ \Delta r\ \Delta x\ \Delta l$	denoted by $\vec{d}$.
-: Negative or positive :-	
It is always positive	It ~~is~~ can be neg or Positive
Zero	
It can never be zero	It can be zero.
Diagram	
	

Qii Under what condition distance and displacement are equal

When a body moves on a straight line in one particular direction then the distance & displacement are equal. This because the actual distance and the shortest path b/w two points is the same. Ex:- an object is moving from initial position A to final position b in this case distance & displacement are equal



Qiii Can we get the negative value of distance and displacement

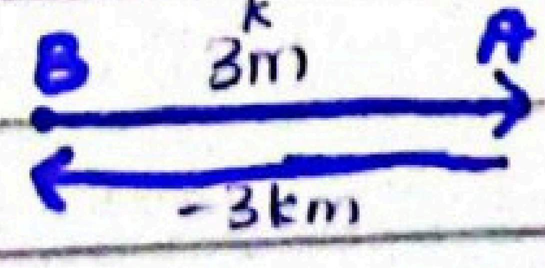
Negative value of distance :-

The distance travelled can never have negative value. This is because Distance is a Scalar quantity. The distance never decrease and cannot be negative.

Negative value of displacement :-

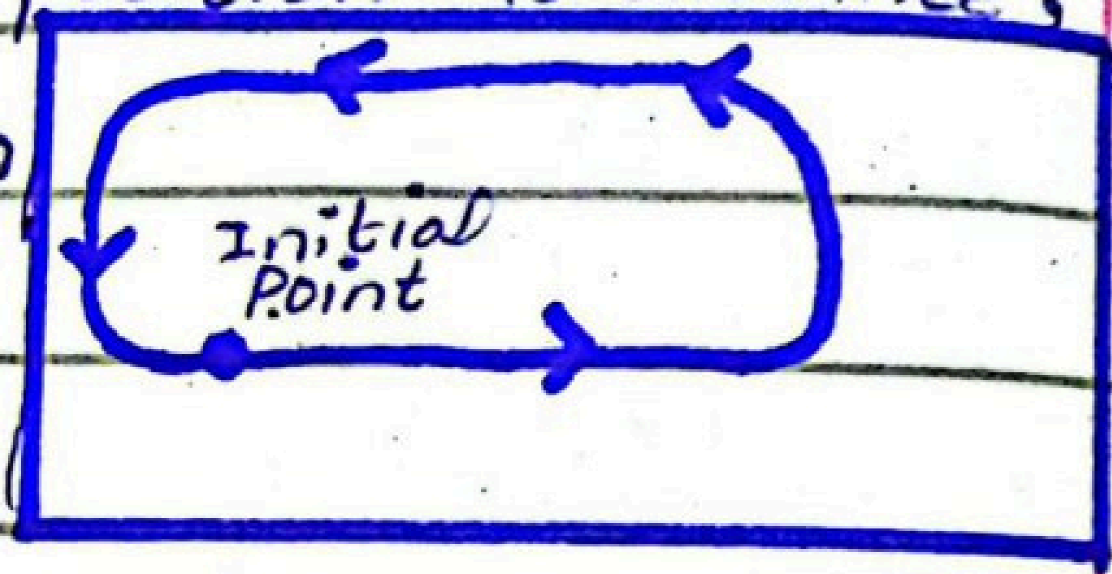
The displacement can be negative. It can be negative when the final position is towards the back of initial position. It happens when object moves in negative direction.

Examples:- an objects moves 3km toward Point A and it moves -3km toward point B



Qiv If a person is walking on 400km running track and it comes back to its initial position than what is distance and what is displacement?

Distance:- As the actual path from initial position to final position is distance, hence distance is 400km



Displacement:- As the initial position and final position is same, hence the displace in this case is 0km.

Q3 Can displacement be greater than distance?

No it cannot, The ~~distance~~ displacement of an object can never be greater than distance.

Reason:- This is because the displacement is the shortest distance b/w to points. The displacement of an object can either be equal to or less than the distance travelled by object but it can never be ~~gere~~ **greater.**

Speed:-

S	10	20	30	40	50	60
t	5	10	15	20	25	30
v	2	2	2	2	2	2

(Constant/uniform Speed)

Average $= \frac{60}{30} = 2m/s$

↳ **Interval:-** Time duration

↳ **Instantaneous Speed:-** Speed at any instant.

SLO Based Question:-

Q Under what circumstances average Speed is equal to instant Speed?

when a body moves with uniform Speed then average and instantaneous speed is equal

Variable Speed:-

S	10	12	17	24	30	40
t	5	10	15	20	25	30
v	2	1.2	1.4	1.13	1.2	1.33

Example:-

Average speed = 1.33m/s

Variable ~~Average~~ Speed: If the distance changes with the passage of time than this is called variable speed

SLO Based Questions

Q1 How can we calculated the Speed of an object?/ whate are the necessary peramiters require to calculate speed of an object?

:We need at least two measurements:-

1. The distance we have travelled
2. The time that has elapsed while we covered this distance.

"Measure of distance ΔS coverd with passage of time is called (Δt) is called speed denoted by (V)

Mathematical formula:-

Speed $= \dfrac{\text{distance}}{\text{Time}}$ or $V = \dfrac{\Delta S}{\Delta t}$ or

$$V = \frac{S_i - S_f}{t_i - t_f}$$

Instantaneous Speed:-

$$V_{Inst} = \lim_{(\Delta t \to 0)} \left(\frac{\Delta S}{\Delta t} \right)$$

Limit $(\Delta t \to 0)$
(when Time is very short or time approches to zero)

Conversion of Unit:-

$$\text{km/hr} \xrightarrow{\times 1000/3600} \text{m/s}$$

$$\text{m/s} \xrightarrow{\times 3600/1000} \text{km/hr}$$

36 km/hr = —— m/s

1km = 1000 m

1hr = 3600 sec

$= 36 \times 1000 \text{m} / 3600 \text{sec}$

$= \dfrac{36 \times 1000}{3600}$ m/s

$= 36$ km/hr $= 10$ m/s

40 m/s ⟶ km/h

$= 40 \times \dfrac{3600}{1000}$

$= 144$ km/h

Tabel

S(m)	10	20	30	40	50	60	
T(s)	5	10	15	20	25	30	
V(m/s)	2	2	2	2	2	2	

Uniform Speed / constant speed :- If a body covers equal distances in equal intervals of time than, that is called uniform

Average Speed :- Total distance over tatal Time

$\Rightarrow V_{avg} = \frac{S}{t}$ $\quad v = 2m/s \quad V = \frac{60}{30} = 2$

{ SLO Based Questions }

Q Define Speed with the help of mathematical formula,

Math -: Speed:- The rate of change in distance is called Speed.

Mathamatical formula :-

$$V = \frac{\Delta d}{\Delta t} \qquad V = \frac{\text{Change in distance}}{\text{change in time}}$$

Example :- If a car travels 100 meter in 10 seconds, its Speed is

$$v = \frac{100m}{10s} = 10m/s$$

Q How speed can be speed calculated with the help of distance

Distance is the foundation for calculating Speed. It provide the necessay information for dermining how fast an object is moving, making it an essential component of the speed calculation.

Example:- If a Car traveled 100 meters in 10 seconds. we can calculate it as:

$$V = \frac{\Delta d}{\Delta t} \quad V = \frac{100m}{10s} = 10m/s$$

Q Define Uniform Speed?

If a body covers equal distance in equal intervals of time than, that is called uniform Speed.

Q Define average Speed with its mathematical formula?

Average Speed:- Total distance over total time

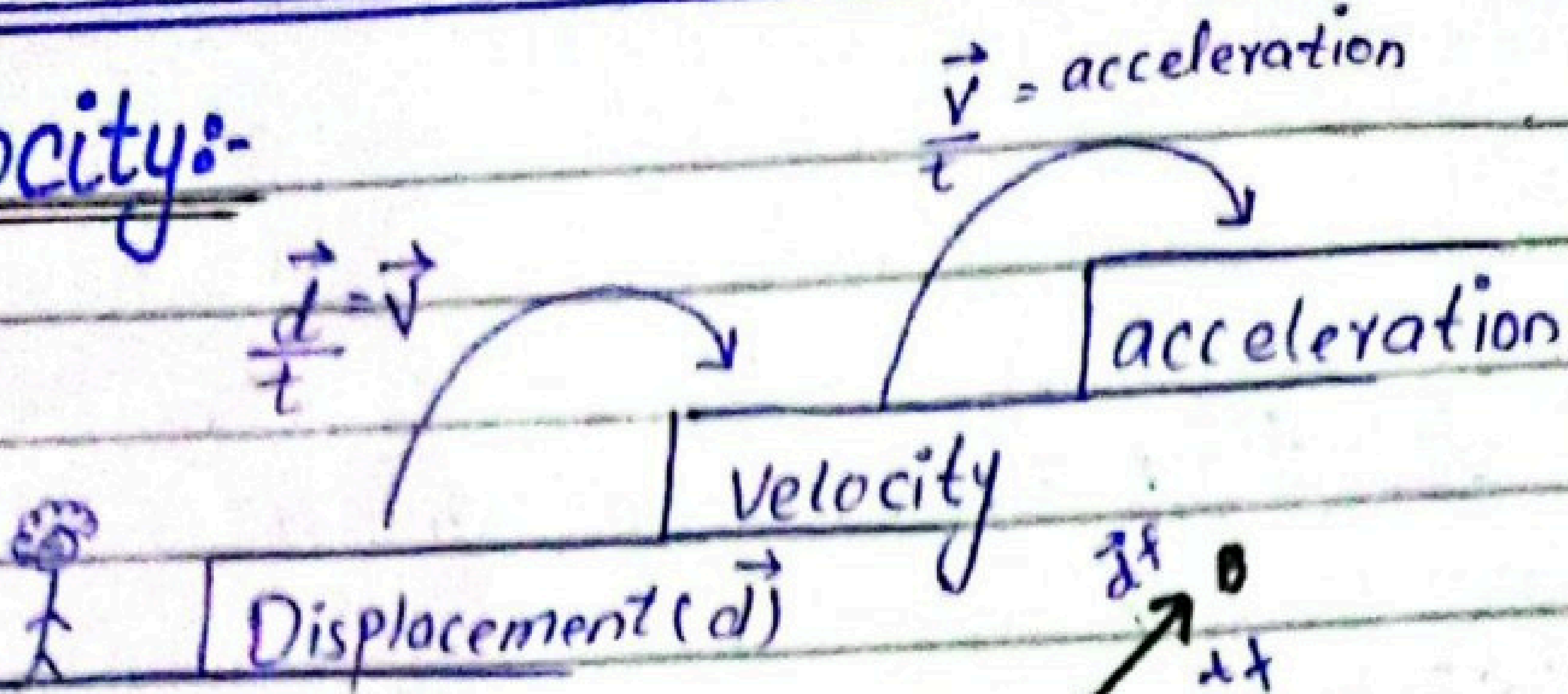
Mathematical formula:-

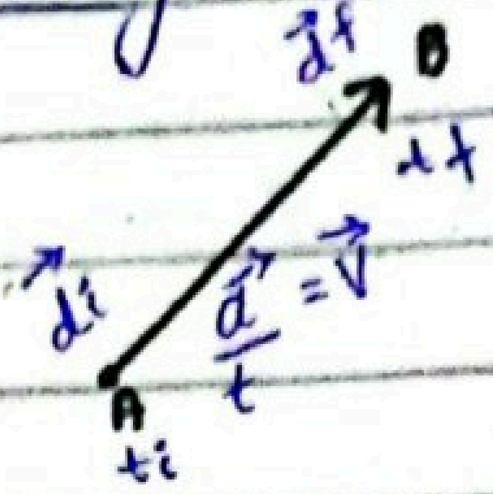
↳ $V_{avg} = \frac{S}{t}$ ∵ for example:- Distance = 60m

Time = 30sec

↳ $V = \frac{60m}{30sec} = V = 2m/s$

Velocity:-





Definitions:-

The rate of change in displacement is called velocity

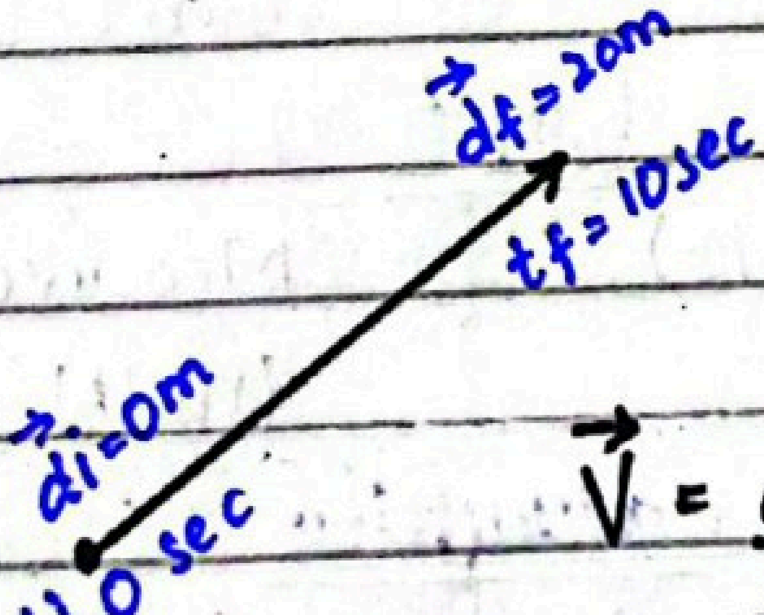
* $\vec{V} = \frac{\Delta \vec{d}}{\Delta t}$
* $\vec{V} = \frac{\vec{d_f} - \vec{d_i}}{t_f - t_i}$

"Important Points"

velocity has magnitude + direction so velocity is a vector quantity

* quantities which have direction / scalar quantities they can be negative.

Example:-



$$\vec{V} = \frac{\vec{d_f} - \vec{d_i}}{t_f - t_i}$$

$$\vec{V} = \frac{20m - 0m}{10sec - 0sec}$$

$$\vec{V} = \frac{20m}{10sec}$$

$$\vec{V} = 2m/s$$

Q Define velocity with help of mathematical formula?

Velocity:- The rate of change in displacement is called velocity

Mathematical formula:- $V = \frac{\Delta d}{\Delta t}$ or $\vec{V} = \frac{d_f - d_i}{t_f - t_i}$

Q Can velocity be taken as negative

Yes, velocity can be taken as negative because it is a vector quantity which has magnitude and direction both. It indicates when an object moves opposite direction to the one considered positive

Q Differentiate b/w speed and velocity.

Speed	Velocity
Definition	
Speed is the rate of change of distance with time	Velocity is the rate of change of displacement with time.
Unit	
Measured in (m/s) (km/h) etc.	Measured in (m/s) (km/h). etc.
Quantity	
Speed is a Scalar quantity	Velocity is a Vector quantity
Example	
A car travelling at 60 km/h has a Speed of 60 km/h	A car travelling north at 60 km/h has a velocity of 60km/h north.

? How is velocity and speed same or equal?
When a body moves straight so the distance and displacement are equal so Speed and velocity are considered equal or same.

Velocity :-

displacement ($\vec{d}$)	10	20	30	40	50
time (t)	5	10	15	20	25
Velocity ($\vec{V}$)	2	2	2	2	2

$$\text{Velocity}(\vec{V}) = \frac{\vec{d}}{t} = \frac{10m}{5s} = 2ms^{-1}$$

Uniform velocity:- When a body covers equal ~~distance~~ displacement in equal intervals of time then, it is called Uniform velocity.

Average velocity:- The average velocity is the total displacement ($\vec{d}$) covered in total time (t) $= \vec{V} = \frac{\vec{d}}{t}$

$$\vec{V} = \frac{\cancel{50}^{2} m}{\cancel{25} s} = 2ms^{-1}$$

Instantaneous velocity:- If velocity is measured at any instant or By keeping the time interval small then, the velocity is called instantaneous velocity.

$$\vec{V}_{ins} = \lim_{\Delta t \to 0} \frac{\Delta \vec{d}}{\Delta t}$$

$$V_{ins} = \lim_{\Delta t \to 0} \frac{\Delta \vec{d}}{\Delta t}$$

$\lim_{\Delta t \to 0}$ = time is very short

-: SLO Based Question:-

Q. Under what condition the value of instantaneous ~~Uniform~~ and average velocities of a body becomes equal

When a body moves with uniform velocity the average and instantaneous velocity will be the same.

Displacement($\vec{d}$)	8	17	23	35	41
Time (t)	5	10	15	20	25
velocity ($\vec{V}$)	1.6	1.7	1.53	1.75	1.64

depends on

Case ① on the basis of magnitude

Case ② Changing direction

Varible velocity:- If a body is covering unequal displacement in equal interval of time then, It is called a varible velocity.

Q2:- Is there any possibility to have variable velocity in the case of constant displacement

Yes, It is possible If the body is travelling at a Uniform Speed ~~remains the same~~ on a Circular track. its speed remains Same but the velocity is non-uniform as the direction of the body is changing every time

Acceleration:- The measure of change in velocity $\Delta\vec{v}$ with the passage of time is known as acceleration

Mathematical formula:-

$$\text{acceleration} = \frac{\text{Change in Velocity}}{\text{time take}}$$

$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$$

SI unit of $\vec{a}$
$\vec{a} = \frac{ms^{-1}}{s}$
$ms^{-1}s^{-1}$
$\boxed{ms^{-2}}$ SI unit

Acceleration

Positive acceleration

city
$\vec{V}_f$

Eg $\vec{V}_i = 2m/s$ ----- $\vec{V}_f = 10m/s$

If velocity ofs increasing then we

increasing	decreasing

have positive $\vec{a}$

Negative acceleration

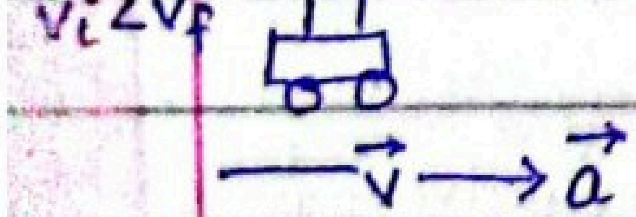
E.g:- $\vec{V}_i = 20ms^{-1}$ ---

$\vec{V}_f = 3ms^{-1}$

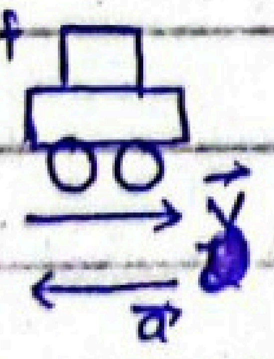
$\vec{V}_i > \vec{V}_f$

If the velocity of body is decreasing with passage of time then it is Negative $\vec{a}$

$\vec{v}_i < \vec{v}_f$



$\vec{v}_i > \vec{v}_f$



Q How can we know if the acceleration is positive or negative

If the $\vec{v}$ of body is increasing with pessage of time then it is ~~negative~~ positive $\vec{a}$. If the Velocity of body is decreasing then it is negative $\vec{a}$.

Uniform and variable Acceleration:-

Q Define Uniform acceleration with help of example.

$\vec{V}$ (ms^{-1})	10	20	30	40	50
t (S)	5	10	15	20	25
$\vec{a}$ (ms^{-2})	2	2	2	2	2

↳ **Uniform Accelration:-** when an object is changing its velocity at constant rate then it is called uniform acceleration

Q Define variable acceleration with help of example.

$\vec{V}$ (ms^{-1})	10	13	19	23	29	
t (S)	5	10	15	20	25	
$\vec{a}$ (ms^{-2})	2	1·3	1·27	1·15	1·16	

↳ **Variable acceleration** When an object is changing its velocity at non-uniform (changing) then it is called Non-Uniform acceleration.

Q Define instantanepus acceleration.

↳ **Instantaneous acceleration:-**

$$a_{ins} = \lim_{\Delta t \to 0} \frac{\Delta \vec{V}}{\Delta t}$$

The rate of change in velocity at any instant of time is called instantaneous acceleration.

Acceleration :-

"Case I"

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

Zero acceleration:-

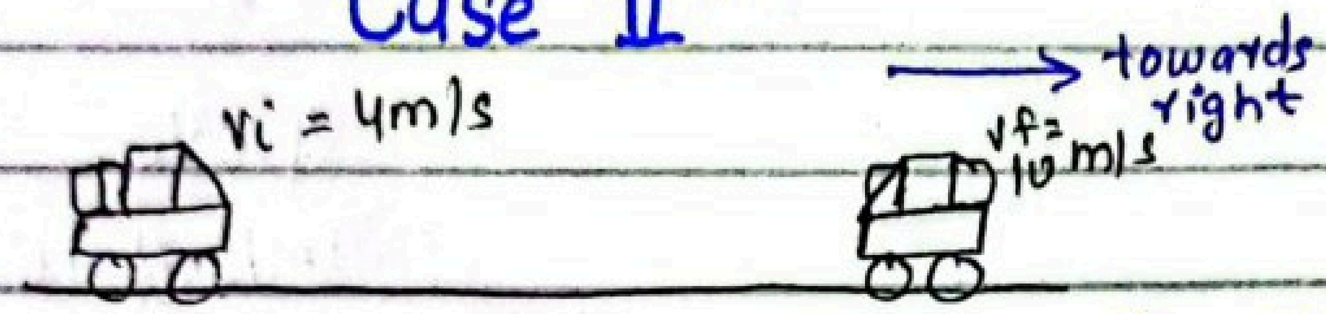
when There is no change in initial and final velocities then, There will be zero $\vec{a}$

$\frac{4m/s - 4m/s}{t} = \frac{0}{t}$

$\boxed{\Rightarrow \vec{a} = 0}$

Nothing / no $\vec{a}$

"Case II"

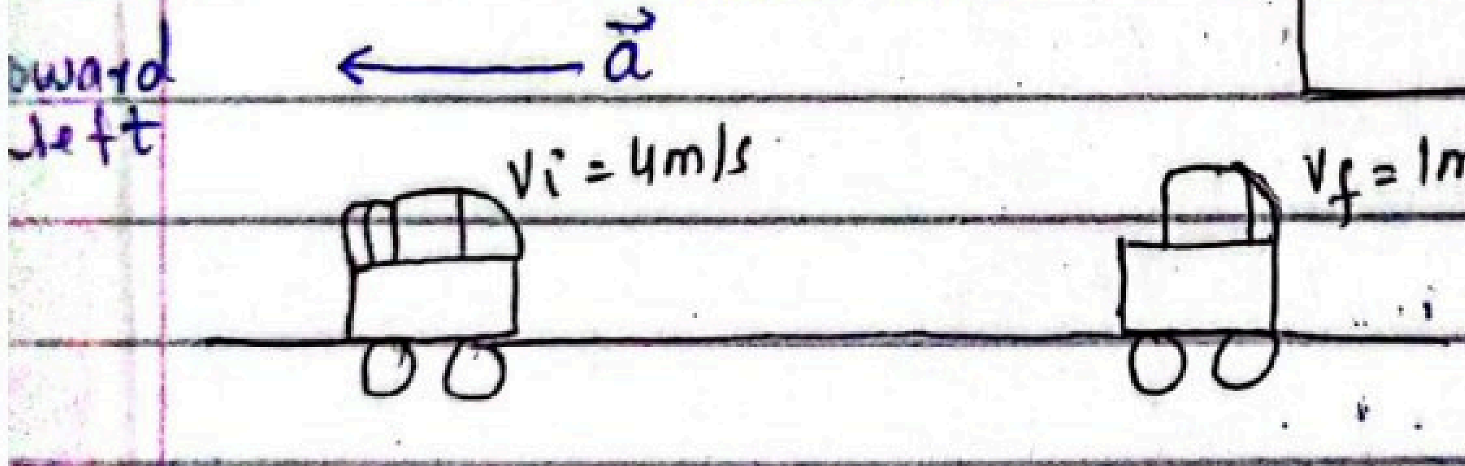


$\vec{a} = \frac{\vec{V}_f - \vec{V}_i}{t}$

$\vec{a} = \frac{10 - 4}{t}$

$\boxed{\vec{a} = \frac{+6}{t}}$

"Case III"

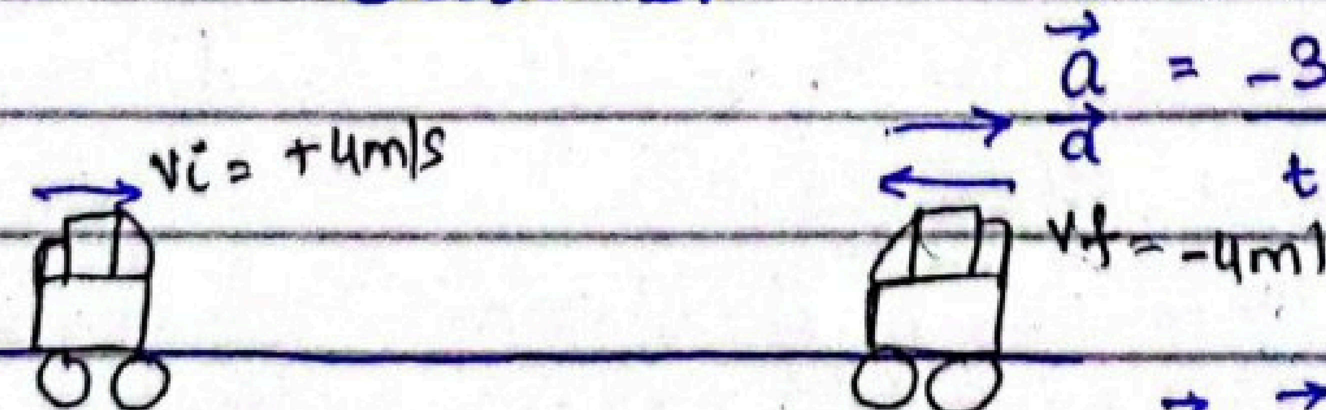


$\vec{a} = \vec{V}_f - \vec{V}_i$

$\vec{a} = \frac{1 - 4}{t}$

$\vec{a} = \frac{-3 \ m/s}{t}$

"Case IV"



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

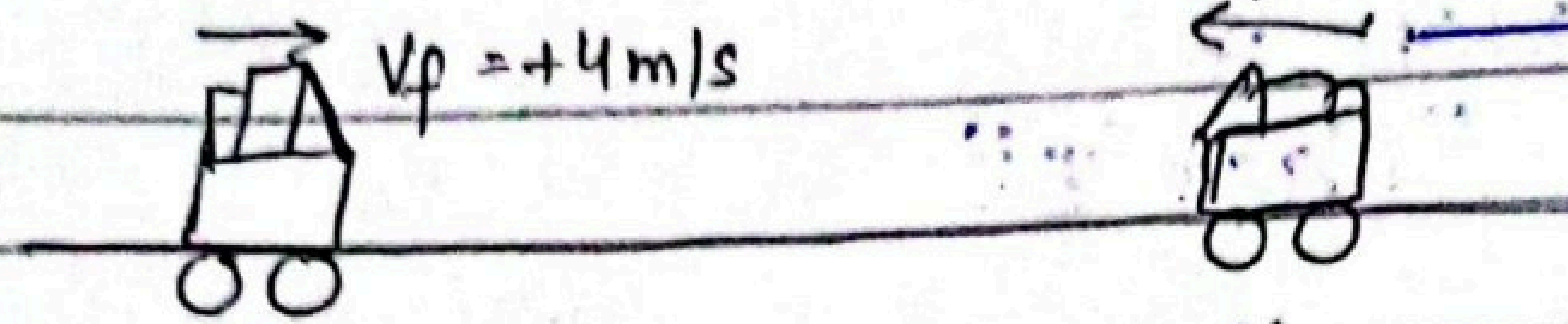
$\vec{a} = \frac{-4m/s - (+4m/s)}{t}$

$\vec{a} = \frac{-8}{t}$

Tip:- You have to take the direction of $\vec{a}$ with the reference of final velocity (V_f)

"Case V"

$v_f = +4\,m/s$ $\qquad$ $v_f = -10\,m/s$ $\qquad \vec{a}$



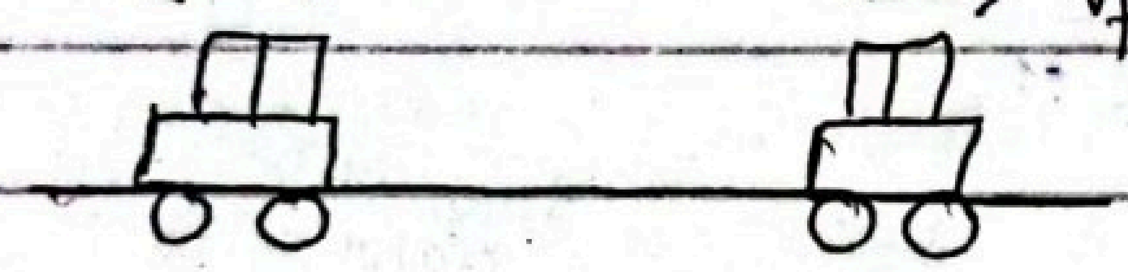
$$\vec{a} = \frac{\vec{v_f} - \vec{v_i}}{t}$$

$$\therefore\ \vec{a} = \frac{-10\,m/s - (+4\,m/s)}{t}$$

$$\vec{a} = \frac{-14\,m/s}{t}$$

"Case VI"

$v_i = -1\,m/s$ $\qquad \vec{a}$ $\qquad$ $v_f = 4\,m/s$



$$\vec{a} = v_f - v_i$$

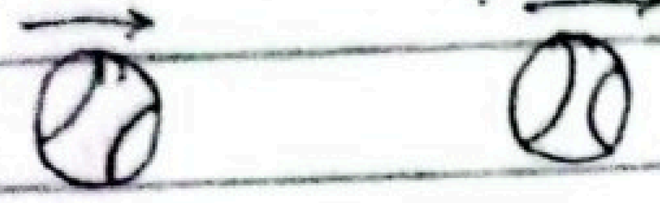
$$\vec{a} = 4\,m/s - (-1\,m/s)$$

$$\vec{a} = \frac{4 + 1}{t}$$

$$\vec{a} = \frac{+5}{t}$$

Case I

$\vec{v_i} = 2m/s$ $\vec{v_f} = 2m/s$

A) 

$\vec{a} = \dfrac{\vec{v_f} - \vec{v_i}}{t}$

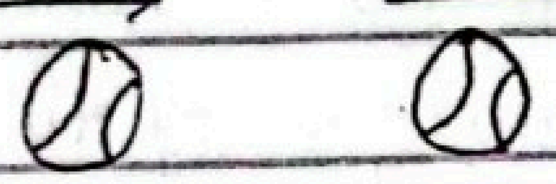
$\vec{a} = \dfrac{2-2m/s}{t}$

$\vec{a} = 0m/s$

In this case(I) velocity of ball is not changing with the passage of time. So, the acceleration of ball is 0. If the $\vec{a}$ of a body is 0 then ofcource there will be no direction of $\vec{a}$.

Case II

$\vec{v_i} = 2m/s$ $\vec{v_f} = 4m/s$

b) 

$\vec{a} = \dfrac{\vec{v_f} - \vec{v_i}}{t}$

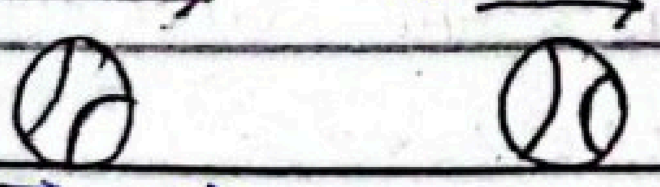
$\vec{a} = \dfrac{4-2m/s}{t}$

$\vec{a} = 2m/s$

In this case (II) velocity of ball is increasing with the passage of time so there acceleration is produced. $\vec{a}$ in this case is positive so, the direction of $\vec{a}$ is in the direction of velocity, towards right side.

Case III

$\vec{v_i} = 3m/s$ $\vec{v_f} = 1m/s$



$\vec{a} = \dfrac{\vec{v_f} - \vec{v_i}}{t}$

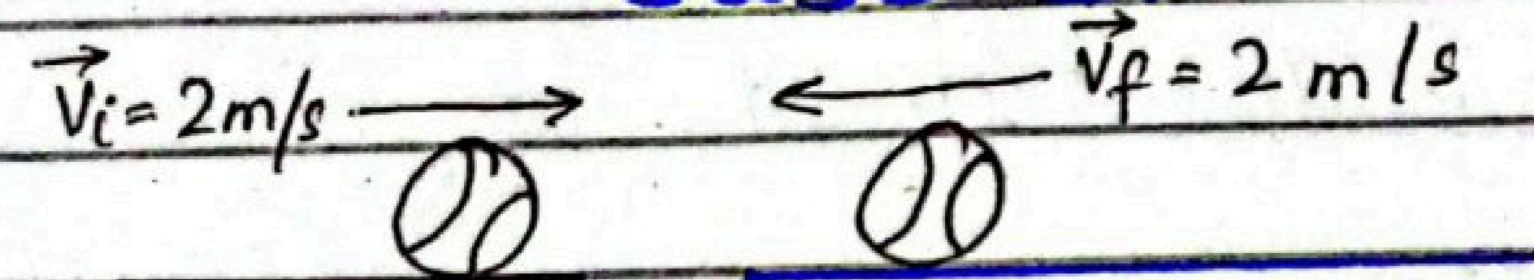
$\vec{a} = \dfrac{1-3}{t}$

$\vec{a} = -2m/s$

In this case (III) velocity of ball is decreasing, but there is still acceleration. because there is ~~still~~ change in the state of motion of ball. $\vec{a}$ in this case is negative, so the direction of $\vec{a}$ is opposite to the direction of velocity.

Tips:- You have to take the direction of $\vec{a}$ with reference to V_f. (final velocity)

Case IV



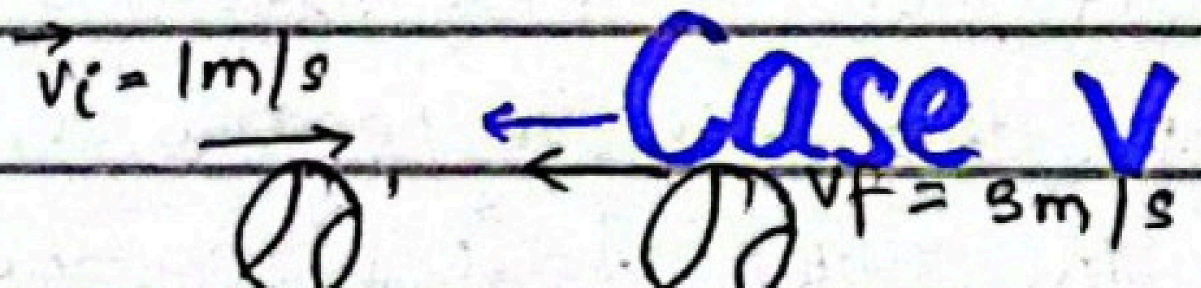
$$\vec{a} = \frac{\vec{V_f} - \vec{V_i}}{t}$$

$$\vec{a} = \frac{2-2}{t}$$

$$\vec{a} = 0$$

In this case (IV) velocity of ball is not changing with the passage of time so, the acceleration of ball is 0. If the $\vec{a}$ of a body is 0, then ofcourse there will no direction of $\vec{a}$

Case V



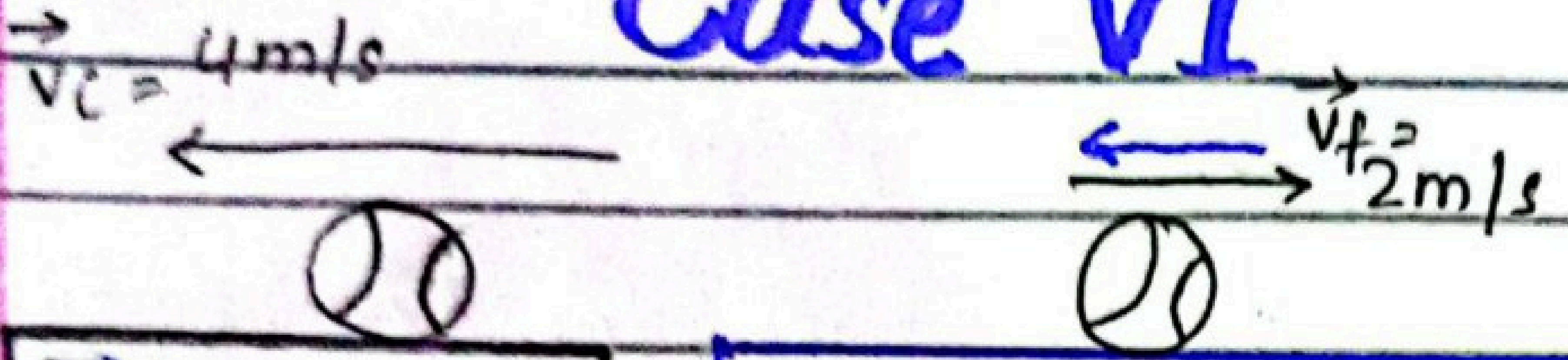
$$\vec{a} = \frac{\vec{V_f} - \vec{V_i}}{t}$$

$$\vec{a} = \frac{3-1}{t}$$

$$\vec{a} = 2m/s$$

In this case (V) ~~the~~ ~~First~~ ~~the~~ ~~direction of~~ the velocity of body is increasing so the direction of $\vec{a}$ is towards the direction of velocity.

Case VI



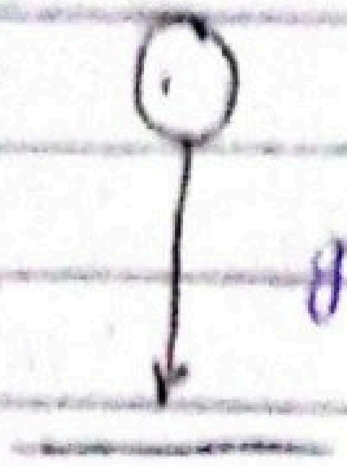
$$\vec{a} = \frac{v_f - v_t}{t}$$

$$\vec{a} = \frac{2-4}{t}$$

$$\vec{a} = -2 m/s$$

In this case (VI) velocity of a ball is decreasing but there is still $\vec{a}$, because there is change in the state of motion of ball. $\vec{a}$ in this case is negative and its direction is opposite to the direction of final velocity (V_f).

Motion due to gravity:-



Gravitional acceleration

gravity = $g = 9.8 ms^{-2}$

gravity = acceleration

$\vec{a}$ $\vec{v}$ ↓ $g = 9.8ms^{-2}$

$g = +9.8ms^{-2}$

↑ $\vec{v}$

$g\downarrow$ $g = -9.8ms^{-2}$

Both the free falling objects $\vec{a}$ will be the same If we neglect air resistance.

- Gravity does not depend on mass.

Q What is motion due to gravity?

Motion due to gravity is the downward movement of objects towards the ground, caused by the force of gravity with a constant acceleration of $9.8\ m/s^{-2}$ on Earth.

Q Explain? Gravity ~~due to mo~~ motion due to with help of Example,

-: Exampless-

-: **Dropping a pen:-** When you drop a pen it falls towards the ground due to gravity acceleration at $9.8 m/s^2$.

-: **falling leaves:-** leaves fall from trees due to gravity acceleration towards the ground

Q What is acceleration due to gravity?
Acceleration due to gravity denoted by 'g' is the rate of change of velocity of an object falling freely towards the ground. on earth the acceleration due to gravity is $9.8 m/s^{-2}$.

Q. Which object will fall first bird feather or a ball? and why?

In a vaccum:- Both the bird feather and the ball would fall at the same time, accelerating towards the ground at $9.8 m/s^{-2}$

In the Presence of air:- The bird feather would fall slower and reach the ground later than ball

-: Reasons:-

-: Air Resistance:- The feather has a larger surface area compared to its weight, creating more air resistance, which slows it down.

-: Density:- The feather is ~~more~~ less dense than the ball, making it more susceptible to air resistance.

Q what is the gravity near earth's surface?

-: Gravity near earth's surface:-
Gravity near the earth's surface is approximately: "$9.8 m/s^{-2}$"

or

"$32.2 ft/s^{2}$"

CamScanner

Q) When is the gravity taken positive & negative?

-: **Positive (+g)** :- when it is directed downwards toward the centre of the earth, and objects are falling towards the ground.

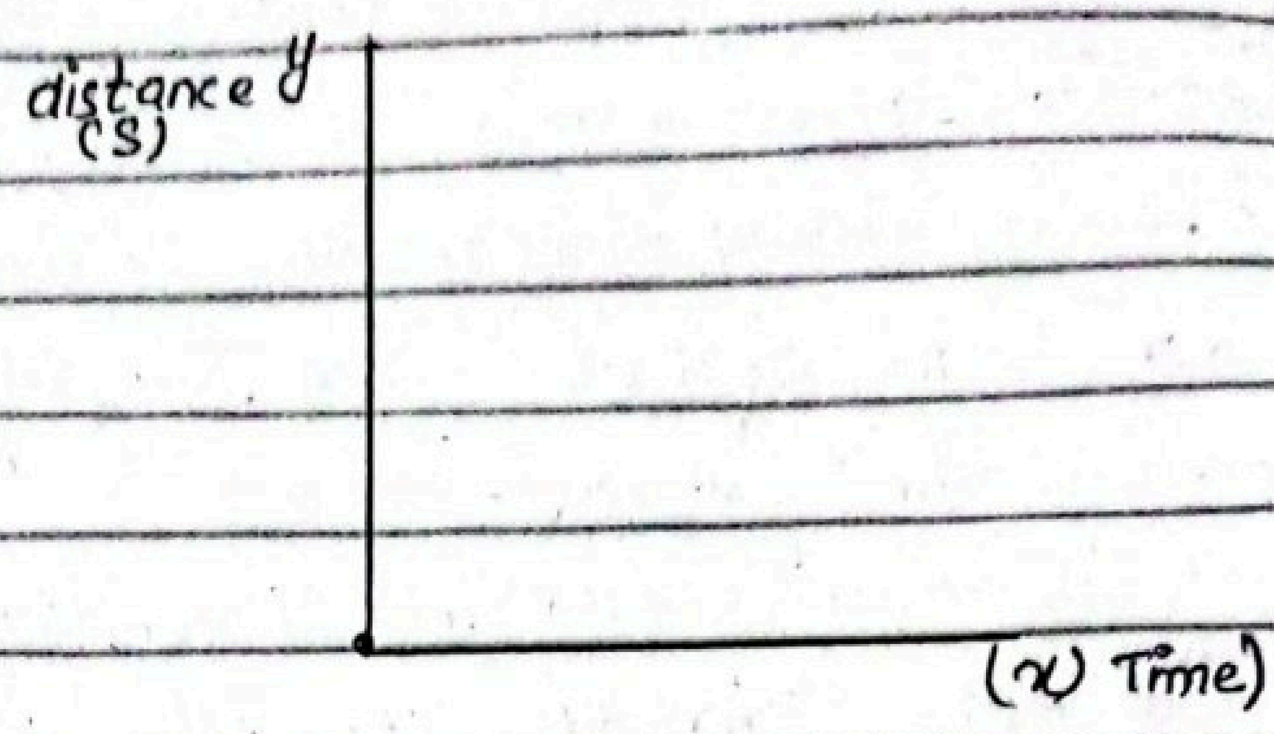
-: **Negative (-g)** :- when it is directed upwards, away from the centre of the earth and objects are moving away from the ground.

-: This can occur in situation like:-

"objects thrown upwards or launched into space."

Graphical Analysis of Motion
(Basic Concept)

Distance - Time Graph:-

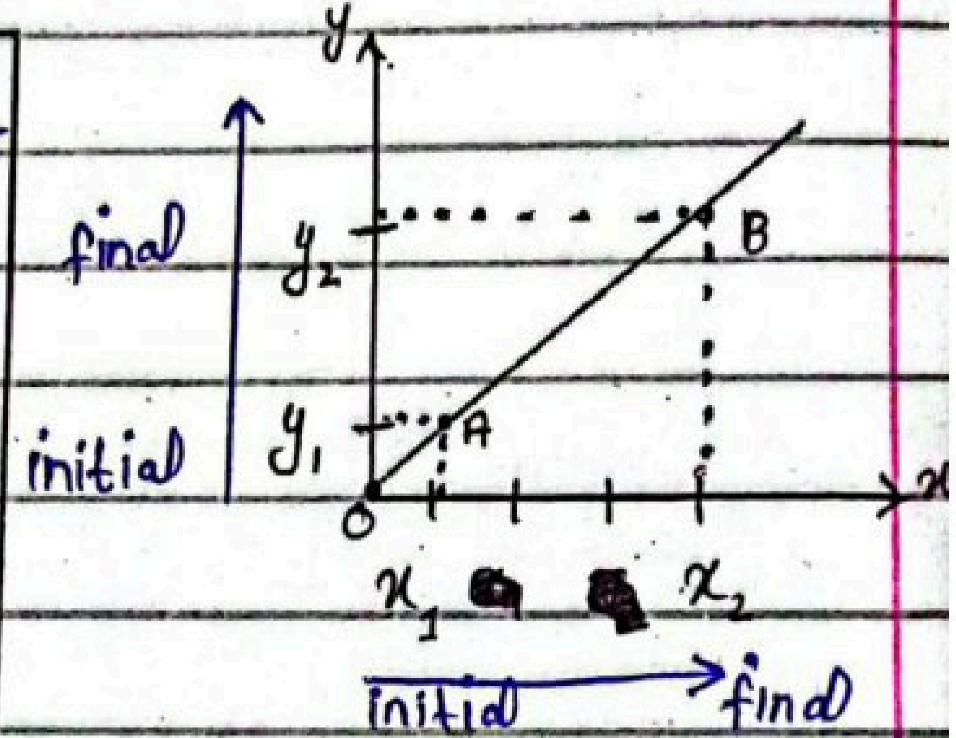


on y-axis we always take dependent quantities

on x-axis we alway take independent quantities

Slope/Gradiant =

Slope/Gradiant of Distance-time graph gives us the value of Speed. It means when divide the value of distance over time then we get Speed."

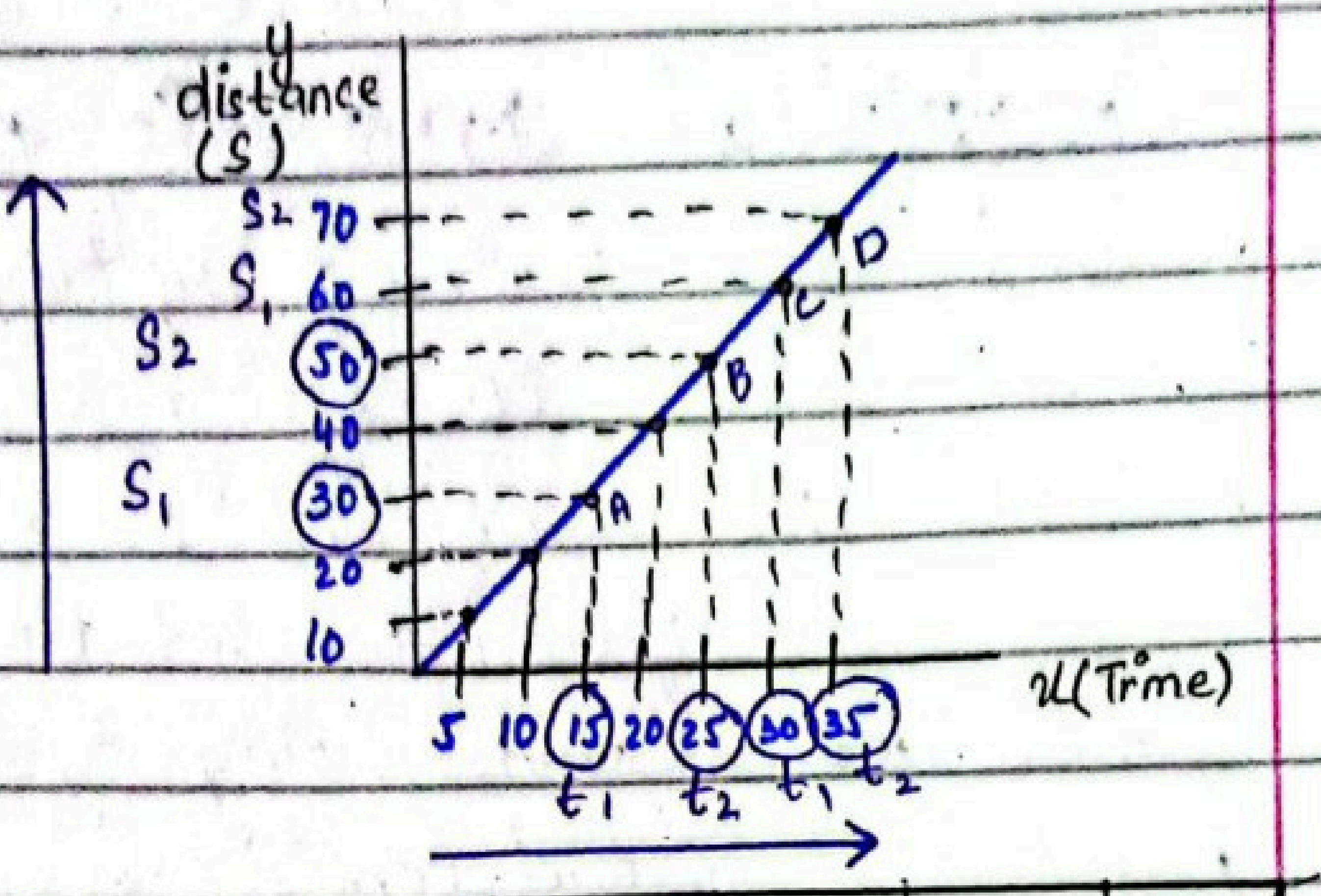


Slope/Gradiant of line AB = $\frac{\text{Change in y-axis}}{\text{change in x-axis}}$

Slope/gradiant of AB $= \frac{\text{final } y - \text{initial } y}{\text{final } x - \text{initial } x}$

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

Graphical Analysis of Motion



is	Distance(S) (m)	10	20	30	40	50	60	70
xis	Time(t) (m/s)	5	10	15	20	25	30	35
e	Speed(v) (m/s)	2	2	2	2	2	2	2

Gradiant of line AB = $\frac{\text{Change in y-axis}}{\text{Change in x-axis}} = \frac{S_f - S_i}{t_f - t_i}$

Gradiant of line AB $= \frac{S_2 - S_1}{t_2 - t_1}$

$= \frac{50-30}{25-15}$

$= \frac{\cancel{20}\,m}{\cancel{10}\,s}$

$= 2ms^{-1}$

Gradiant of line CD $= \frac{S_2 \text{ change in y-axis}}{\text{Change in x-axis}}$

$= \frac{S_2 - S_1}{t_2 - t_1}$

$= \frac{70 - 60}{35 - 30}$

$= \frac{^{2}\cancel{10}\,m}{\cancel{5}_{1}\,s}$

$= 2ms^{-1}$

SLO Questions

Q Explain graphical analysis of Motion?

Graphical analysis of Motion

Graphical analysis of motion is a method used to analyze and visualize motion of an object by ploting its positions, velocity and acceleration against time. This is done using graphs, which provide a clear and concise representation of the objects motion.

Why graphical analysis is important?

Graphical analysis is important for several reasons:

1. Visual representation
2. Trend identification
3. Data analysis
4. Simplification of complex Data
5. Enhance understanding.

What is the distance time graph?

Distance-time graph

A distance time graph is a graphical representation of the relationship b/w the distance traveled by an object and the time taken to travel that distance. It is fundamental concept in physics and mathematics, used to describe the motion of objects.

Q What is slope/gradiant ?

Slope/Gradient

A slope also know as gradient, is a measure of How steep a line or a curve is. It reprents the rate of change of dependent varicable (y-axis) with respect to the independent variable (x-axis).

Q Explain Slope/gradient with help of mathematical formula.

The Slope also know as gradient is a Measure of How steep a line or a curve is.

Mathematical formula

Slope/gradient is calculated using the following mathematical formula:

$$\text{gradient} = \frac{\Delta s}{\Delta t} = \frac{S_f - S_i}{t_f - t_i} = v$$

gradient = v

$$\text{gradient} = \frac{\text{Change in Y-axis}}{\text{change in } x\text{-axis}} = \frac{S_f - S_i}{t_f - t_i}$$

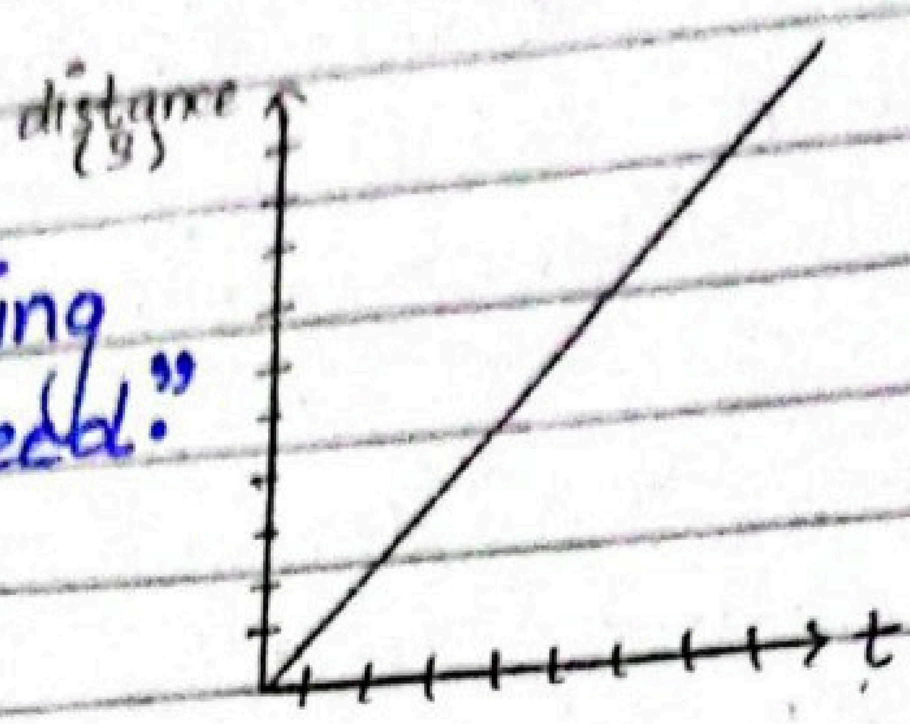
$$= \frac{S_2 - S_i}{t_2 - t_i}$$

Graphical Analysis of Motion

-: Distance - time Graph :-

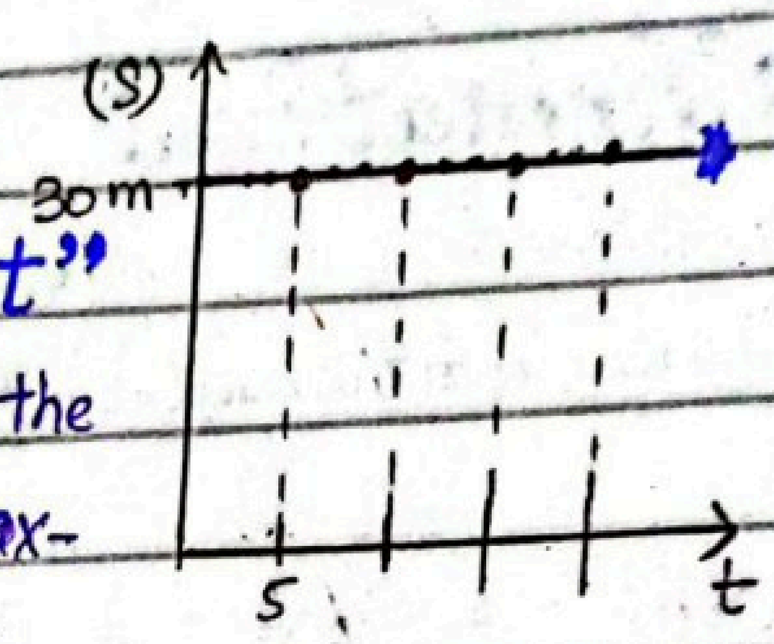
Case 1

(a) "Object is moving at uniform Speed."



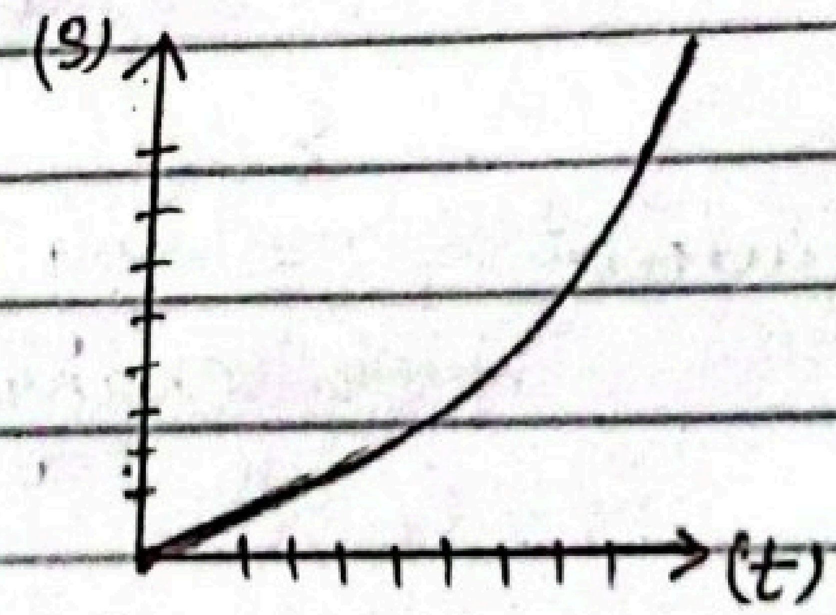
Case 2

(b) "Object is at rest"
when the line of the graph is parallel to ax-axis then the object will be at rest.



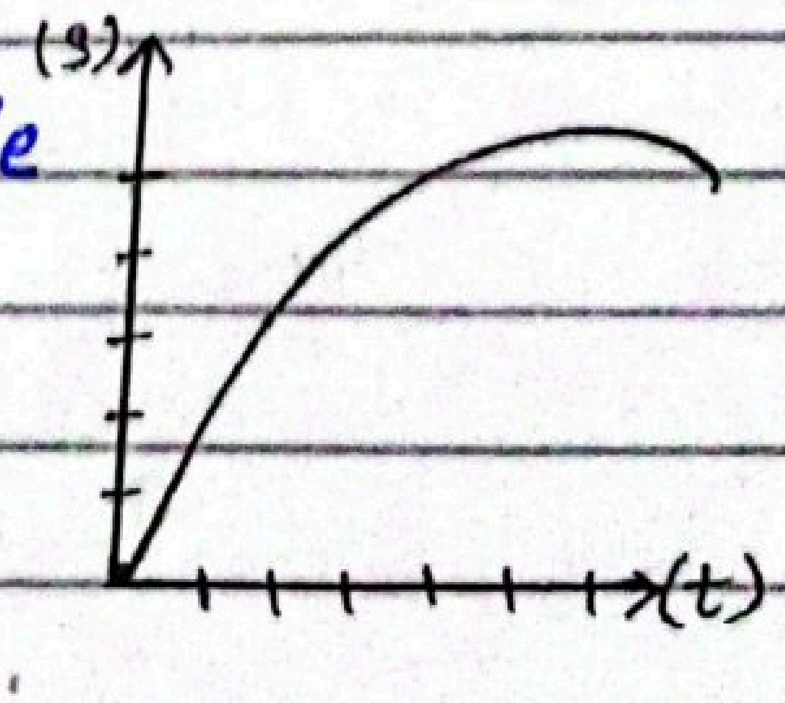
Case 3

(c) "variable increasing Speed"



Case 4

(d) "Non-Uniform/variable decreasing Speed"



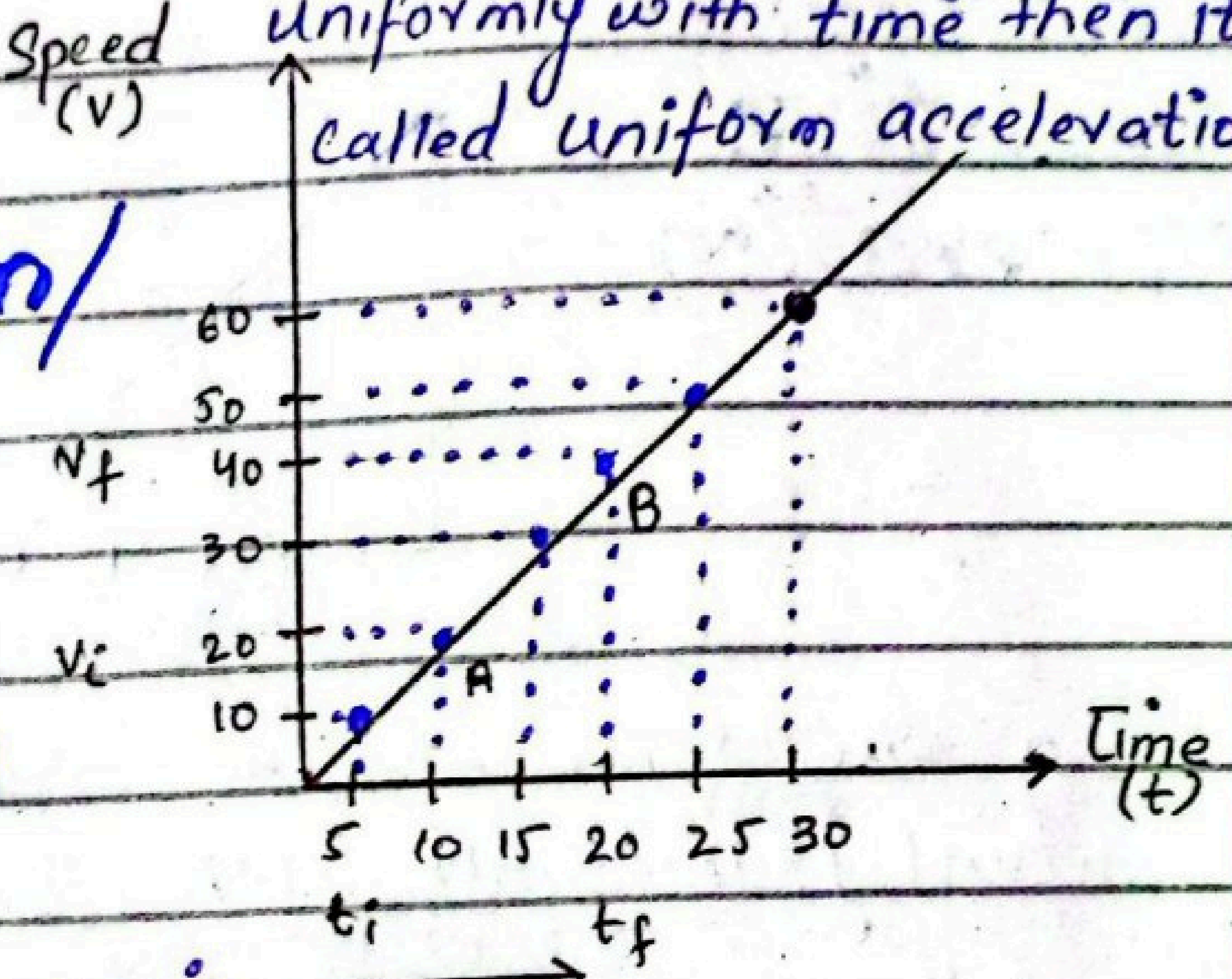
Speed-time Graph :-

Q Explain Uniform positive acceleration.

"when the speed of an object is increasing constantly/ uniformly with time then it is called uniform acceleration"

Uniform acceleration/

↑ Uniform Positive acceleration



"An object is moving in a straight line"

→ Distance & displacement are same.

→ Speed and velocity are also same.

-: key points of speed-time graph:-

(1) Slope of speed time graph gives us acceleration

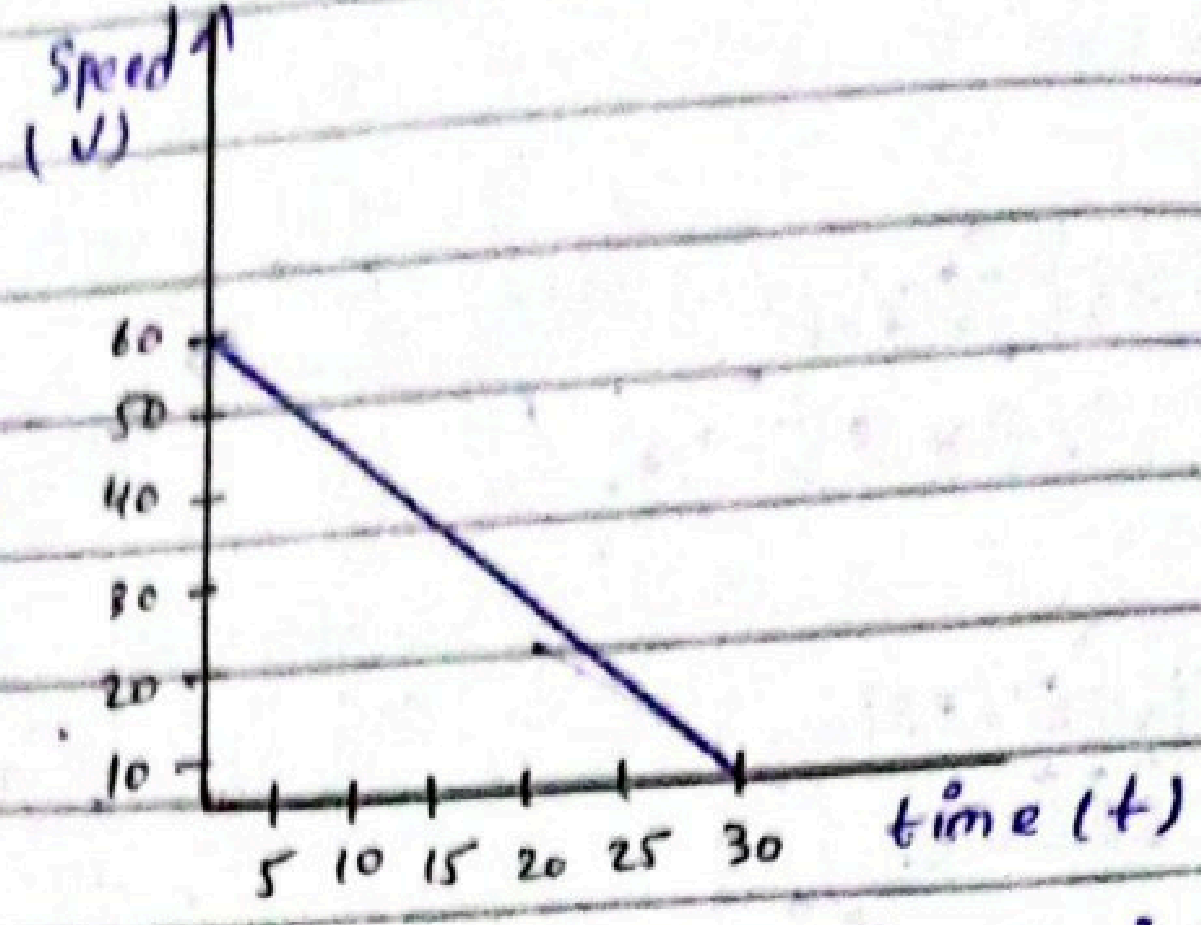
(2) Area under speed time graph gives us Distance

Speed	10	20	30	40	50	60
Time	5	10	15	20	25	30
acceleration	2	2	2	2	2	2

$$\vec{a} = \frac{v_f - v_i}{t_f - t_i} = \frac{40-20}{20-10} = \frac{\cancel{20}\,2}{\cancel{10}\,1} \qquad \vec{a} = 2 m s^{-1}$$

Q Explain Uniform negative acceleration.

Uniform Negative acceleration

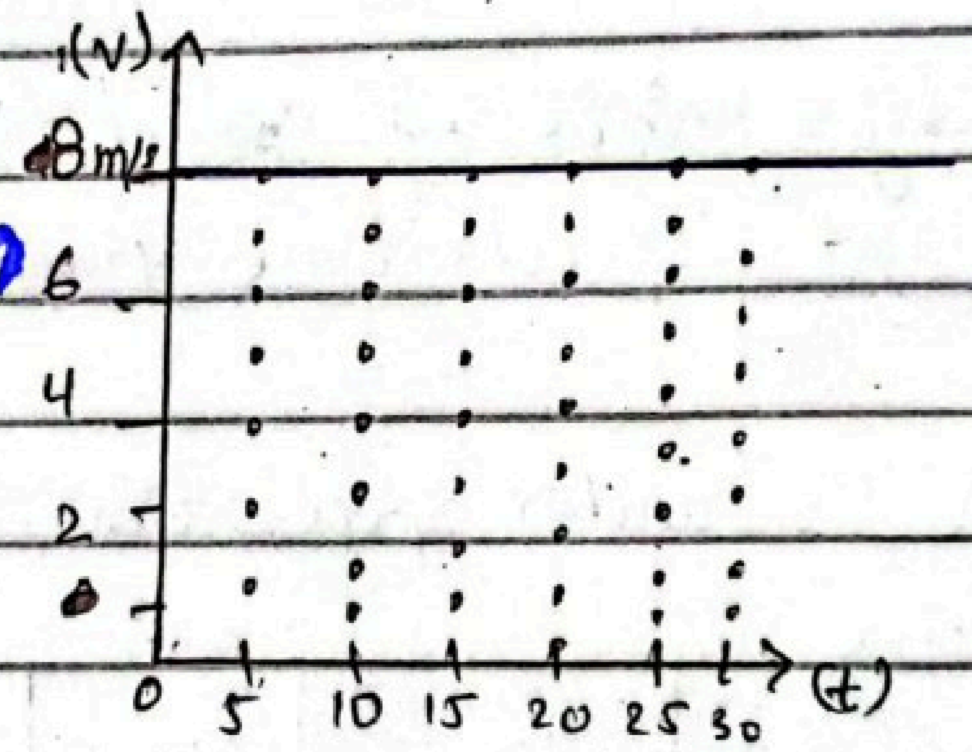


when the Speed of an object decreasing constantly/uniformly with the passage of time then this is called Uniform negative acceleration

Q Define Zero acceleration.

Zero acceleration

* | Zero $\vec{a}$ is not a constant |



"when there is no change in Speed/ velocity then the acceleration is Zero"

:SLO Based MCQ's:-

1) When the slope of (V-t) graph is parallel to x-axis then $\vec{a}$ is Zero
2) Slope of positive acceleration is (positive)
3) Slope of negative retardation is negative
4) when the Speed of an object increases with passage of time then the slope will be Positive

-: SLD Based Question:-

Define Speed-time graph.

Speed Time graph :- is the graphical representation the relationship between the speed of an object and time. It is a plot of speed y-axis) against time x-axis.

Explain the keypoints of Speed time graph?

Slope of Speed-time graph gives us $\vec{a}$

Area under speed-time graph gives us distance.

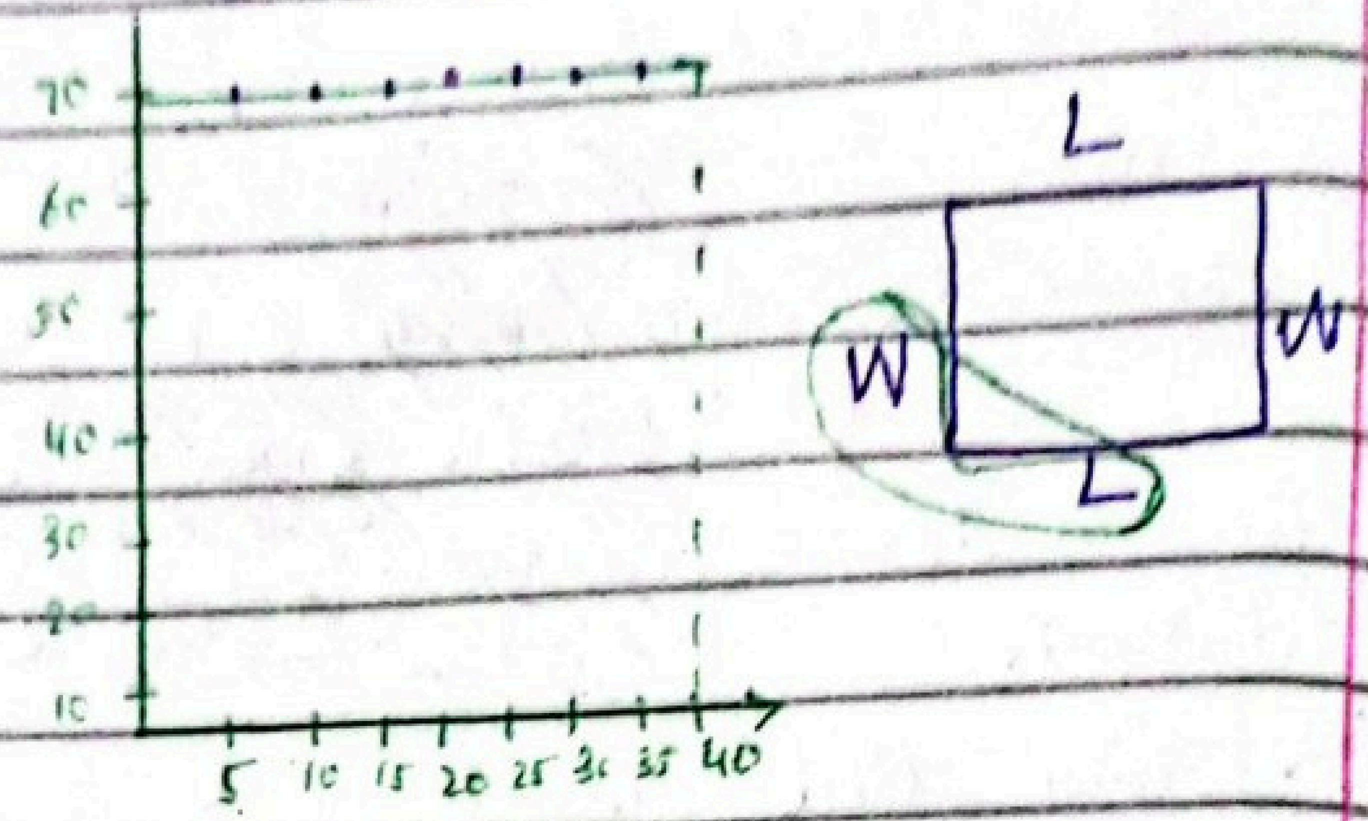
Explain the importance of speed time graph.

1. Visualized motion
2. Analyzes acceleration
3. Calculate distance

-: Case 1 :-

* Zero acceleration/Uniform Speed

In Speed-time graph the area under the curve gives the distance.

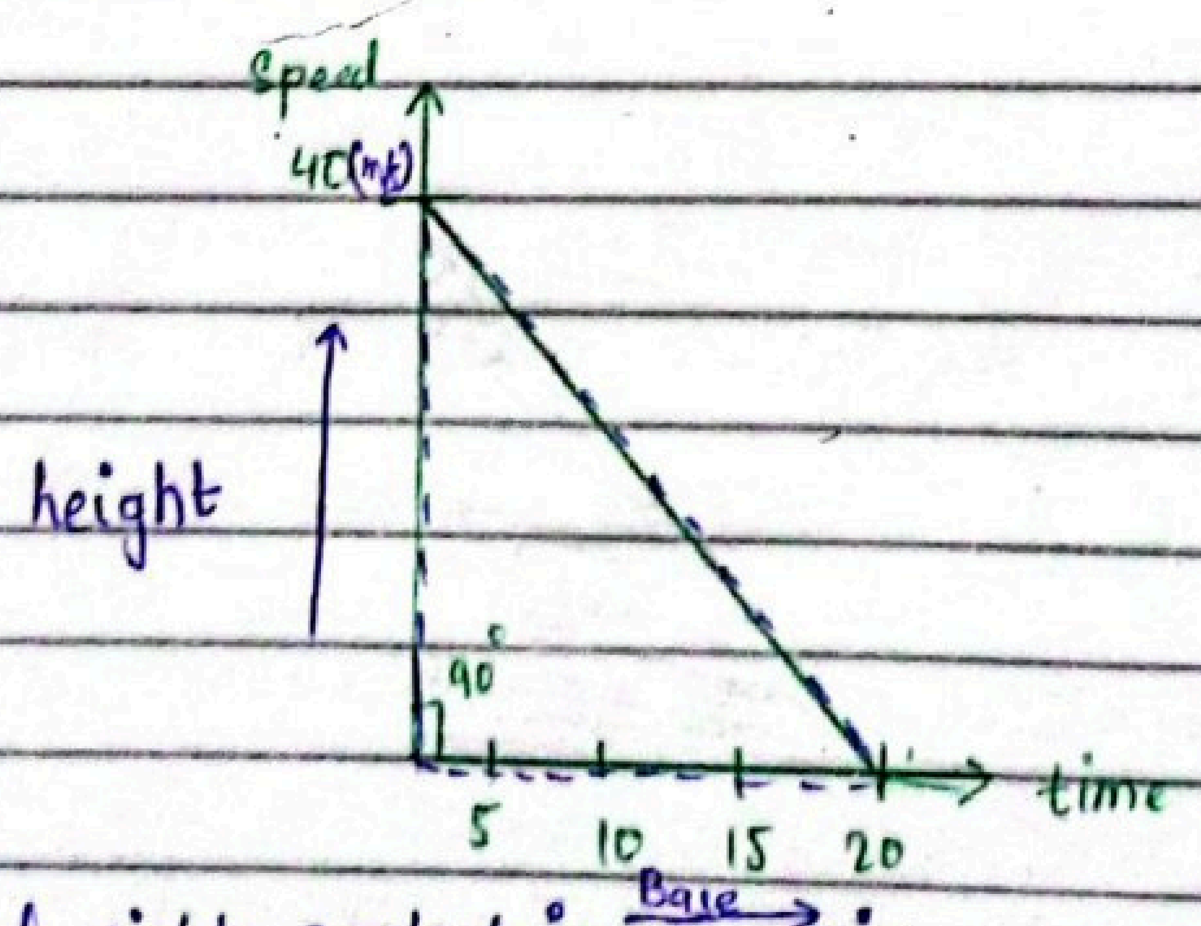


Area of rectangle = Distance covered = Length x width
= 40 x 70
= 2800 m/~~s~~ x ~~s~~

Distance = 2800m

Case 2

* Negative acceleration/Retardation/ Decleration



Area of right angle triangle = Distance covered
$= \frac{1}{2} \times Base \times height$

Distance covered $= \frac{1}{\cancel{2}_1} \times \cancel{20}^{10}s \times 40m/s$

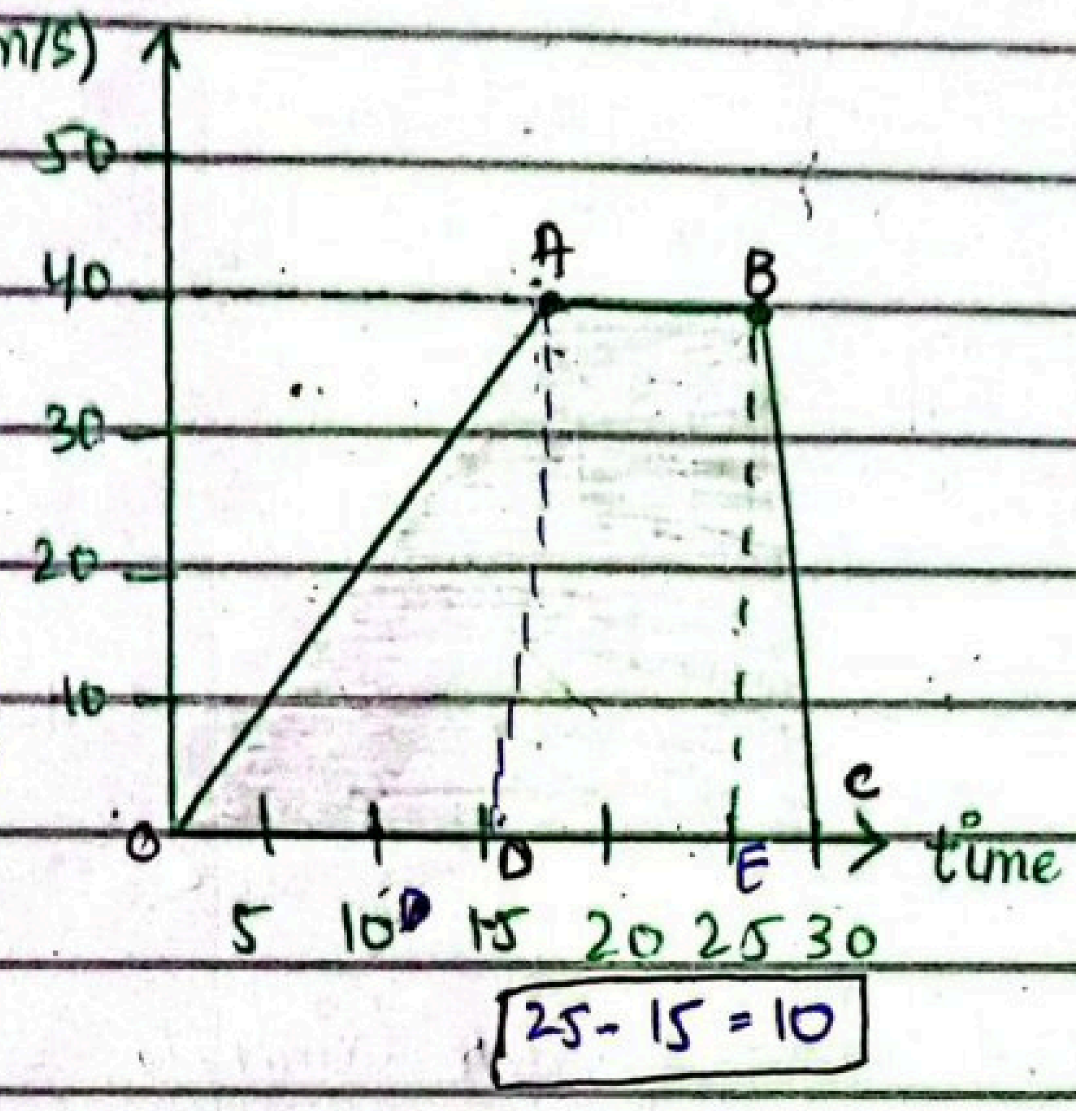
$= 10 \times 40 \cancel{s} \times m/\cancel{s}$

Distance covered $= 400m$

Case 4

: Area of trapezium :-

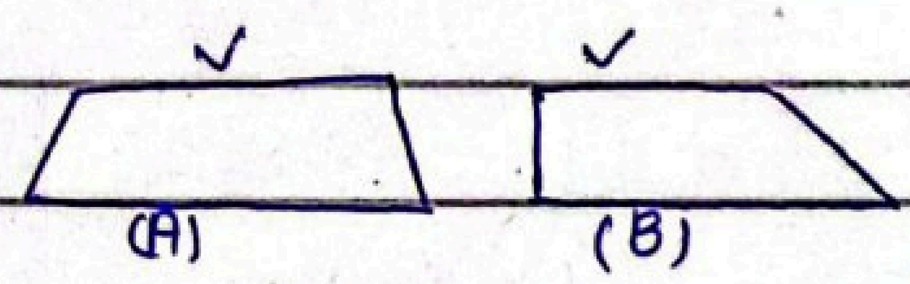
"A quadrilateral with one pair of parallel sides is called trapezium"



OA = Uniform positive acceleration

AB = Zero acceleration

BC = Negative uniform acceleration/Retardation.



Area of trapezium = Distance covered $= \frac{1}{2} \times$ (Sum of Parallel sides) $\times$ height

Distance covered $= \frac{1}{2} \times AB + OC \times AD$

$= \frac{1}{2} \times (10s + 30s) \times 40m/s$

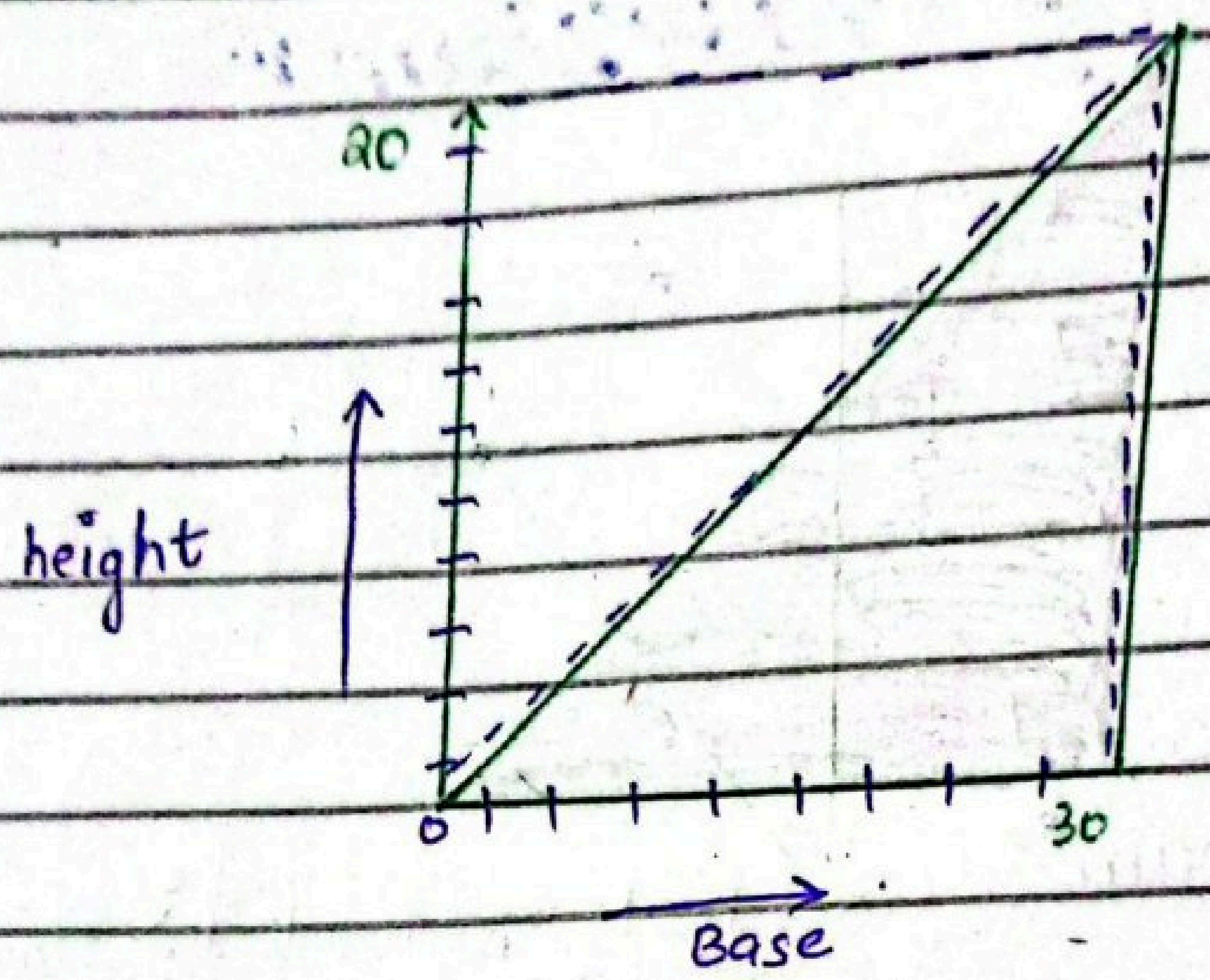
$= \frac{1}{\cancel{2}} \times \cancel{40}^{20} s \times 40$

$= 20 \times 40 \cancel{s} \times m/\cancel{s}$

Distance covered $= 800m$

Case 3

Uniform Positive acceleration



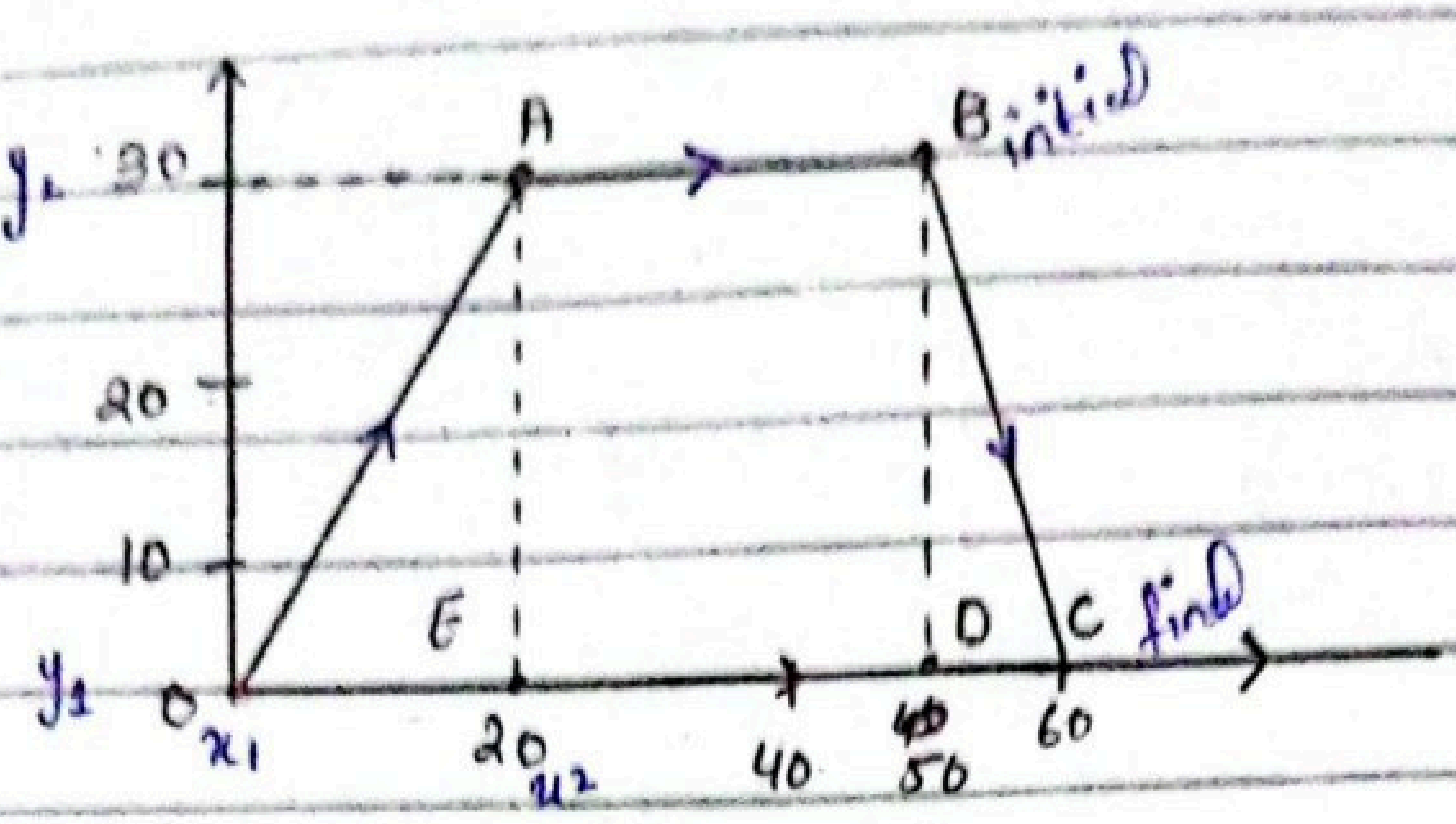
Area of right angle triangle $= \frac{1}{2} \times \text{Base} \times \text{height}$

Distance covered $= \frac{1}{\cancel{2}_1} \times \cancel{30}^{15}\,s \times 20\,m/s$

$= 15\cancel{s} \times 20\,m/\cancel{s}$

Distance covered $= 300m$

"Numerical" 2.6



(a) Magnitude of acceleration
(i) In first 20 seconds
(ii) from 20 to 50 second
(iii) In last ten seconds
(b) ~~Distance~~ total Distance covered
(c) Average Speed

a) :- Magnitude of acceleration :-

(i) In first 20 seconds:-

Slope of line OA $= |\vec{a}| = \dfrac{\Delta y}{\Delta x} = \dfrac{y_2 - y_1}{x_2 - x_1}$

$$\Rightarrow |\vec{a}| = \frac{30 - 0\,m/s}{20 - 0s}$$

$$\Rightarrow |\vec{a}| = \frac{30\,m/s}{20} \Rightarrow |\vec{a}| = \boxed{1.5ms^{-2}}$$

ii from 20 sec to 50 sec:-

Slope of line AB $= |\vec{a}| = \dfrac{\Delta y}{\Delta x} = \dfrac{y_2 - y_1}{x_2 - x_1}$

$$|\vec{a}| = \frac{30m/s - 30m/s}{50s - 20s} \Rightarrow |\vec{a}| = \frac{0}{30s} \Rightarrow |\vec{a}| = \boxed{0m/s^2}$$

iii In last 10 seconds

Slope of line BC $= |\vec{a}| = \dfrac{\Delta y}{} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{0ms^{-1} - 30m}{60s - 50s}$

$|\vec{a}| = \frac{-30ms^{-1}}{10s} \Rightarrow |\vec{a}| = \boxed{-3ms^{-2}}$

(b) Total Distance Covered

Total distance covered $= \begin{pmatrix}\text{Area of OAE} \\ \text{Triangle}\end{pmatrix} + \begin{pmatrix}\text{Area of} \\ \text{rectangle} \\ \text{ABDE}\end{pmatrix} + \begin{pmatrix}\text{Area of} \\ \text{triang CBD}\end{pmatrix}$

$\Rightarrow S = \frac{1}{2} \times (OE \times AE) + (AE \times ED) + \frac{1}{2}(BD \times DC)$

$\Rightarrow S = \frac{1}{2} \times 20s \times 30ms^{-1} + 30ms^{-1} \times 30s + \frac{1}{2} \times 30ms^{-1} \times 10\,s$

$S = 300m + 900 + 150m = \boxed{1350\ m}$

(c) average Speed

$\text{Average Speed} = \frac{\text{total distance}}{\text{total time}}$

$V_{ave} = \frac{135\cancel{0}m}{6\cancel{0}s}$

$\boxed{= 22.5m/s}$

:- By Using formula of trapezium :-

Total distance covered = Area of trapezium

=

$\Rightarrow S = \frac{1}{2} \times \text{sum of Parallel sides} \times \text{height}$

$S = \frac{1}{2} \times (AB + OC) \times AE$

$S = \frac{1}{2} \times (30 + 60) \times 30ms^{-1}$

$S = \frac{1}{\cancel{2}_1} \times \cancel{90}^{45} \times 30$

$S = 1350m$