Chapter-3

Motion in a Straight Line

Rest and Motion

Rest : If a body doesn't changes its position with respect to time and surroundings then the body is said to be in rest.

Motion : If a body changes its position with respect to time and surroundings then the body is said to be in motion.

Note

Rest and motion are relative terms. They depends on observer.

Distance and Displacement

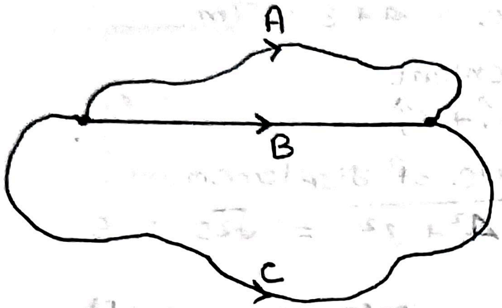
Distance :-

- Actual path travelled by the body.
- We should know the path.
- It can't be decreasing.
- It can't be negative.
- It can be zero or positive.
- It is a scalar term.
- It depends on the path.

Displacement:-

- Change in position vector. $[\vec{d} = \Delta\vec{r} = \vec{r}_f - \vec{r}_i]$
- It is the shortest distance between initial & final position.
- It is the minimum gap between initial & final position.
- It is a vector term as it follows laws of vector.
- It can be +ve, −ve or zero.
- It can be increasing or decreasing.
- Independent on path.

Note



Here,

- Displacement of A, B, C are same.
- Distance of A, B, C are different.

Questions on Distance & Displacement

1 (Initial) (2, 3, 4) → (Final) (7, 5, 9)

Find displacement.

$\Rightarrow \vec{d} = \vec{r}_f - \vec{r}_i \Rightarrow \boxed{5\hat{i} + 2\hat{j} + 5\hat{k}}$ Ans

2 (Final) (−5, 0, 0) ← (Initial) (0, 0, 0)

Find displacement.

$\Rightarrow \vec{d} = \vec{r}_f - \vec{r}_i \Rightarrow \boxed{-5\hat{i}}$ Ans

3 (Initial) ($x = 0$) → ($x = 10$), then back to ($x = 6$) (Final)

Find distance & displacement.

$\Rightarrow$ Distance $= 10 + 4 = 14$

Displacement $= 6$ (magnitude)

$= 6\hat{i}$ (vector)

4 (Initial) ($x = 0$) → ($x = 10$), then back to (Final) ($x = -5$)

Find distance & displacement.

$\Rightarrow$ Distance $= 10 + 10 + 5 = 25$

Displacement $= -5\hat{i}$

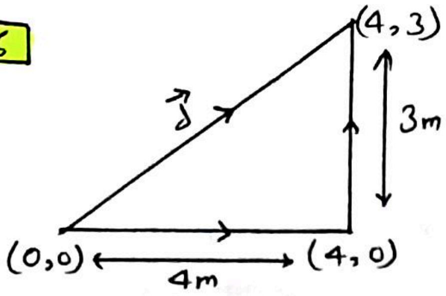
5 (Initial) ($x = 0$) → (Final) ($x = 10$)

Find distance & displacement.

$\Rightarrow$ Distance $= 10$

Displacement $= 10\hat{i}$ (Here, Distance $=$ |Displacement|)

6



Find distance & displacement

=> Distance = 4 + 3 = 7m

=> Displacement

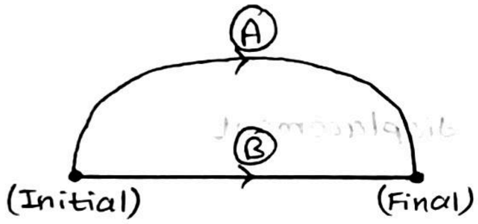
$\vec{d} = 4\hat{i} + 3\hat{j}$

=> Magnitude of displacement:

$\sqrt{4^2 + 3^2} = \sqrt{25} = 5$

(Here, Distance > |Displacement|)

7



Ⓐ → Semicircle

Ⓑ → Straightline

=>

	Ⓐ	Ⓑ
Distance	πr	$2r$
Displacement	$2r$	$2r$

अगर particle ने अपनी direction change नहीं की तो Displacement और distance equal होंगे।

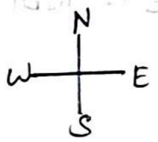
Always,

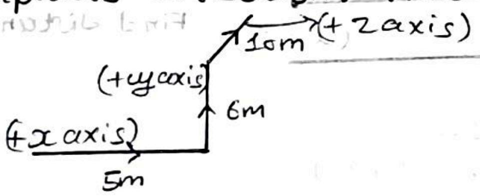
Distance ≥ |Displacement|

$\therefore \dfrac{\text{Distance}}{|\text{Displacement}|} \geq 1$

8 A particle moves 5m along east, then 6m along north and 10m in upward direction. Find distance & displacement.

=>





=> Distance = 5 + 6 + 10 = $\boxed{21}$

=> Displacement = $\vec{d_1} + \vec{d_2} + \vec{d_3}$

= $\boxed{5\hat{i} + 6\hat{j} + 10\hat{k}}$

=> Magnitude = $\sqrt{5^2 + 6^2 + 10^2} = \boxed{\sqrt{161}}$

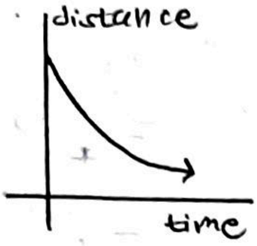
9 A particle moves 10m east, 5m north, 6m south, 8m west, 15m east and 20m north. Find distance & displacement.

=> Distance = 10 + 5 + 6 + 8 + 15 + 20 = $\boxed{64\ m}$

=> $\vec{d_1} = 10\hat{i}$, $\vec{d_2} = 5\hat{j}$, $\vec{d_3} = -6\hat{j}$, $\vec{d_4} = -8\hat{i}$, $\vec{d_5} = 15\hat{i}$, $\vec{d_6} = 20\hat{j}$

=> $\vec{d}_{net} = (10 - 8 + 15)\hat{i} + (5 - 6 + 20)\hat{j} = \boxed{17\hat{i} + 19\hat{j}}$

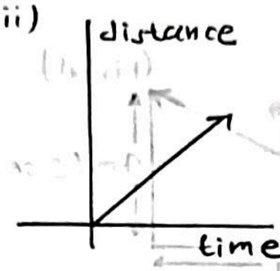
10 which of the graph is possible ?

(i)


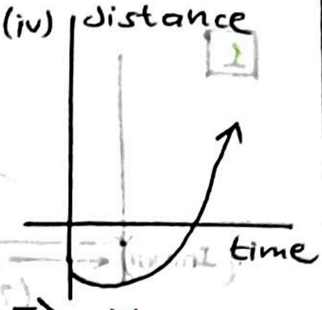
=> ✗

(ii)

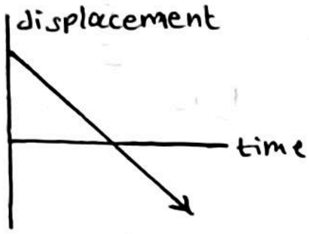

=> ✓

(iii)


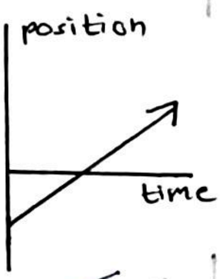
=> ✓

(iv)


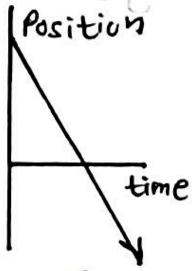
=> ✗

(v)


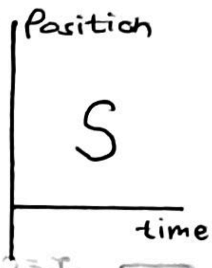
=> ✓

(vi)


=> ✓

(vii)


=> ✓

(viii)


=> ✗

Speed and Velocity

Velocity :-

$\boxed{\text{Average Velocity}} = \dfrac{\text{total displacement}}{\text{total time}}$

$= \dfrac{\text{Change in position}}{\text{time}}$

$= \dfrac{\vec{r_f} - \vec{r_i}}{\text{time}}$

Note
If displacement = 0
Then avg. velocity = 0

$\boxed{\text{Instantaneous Velocity}}$ = Velocity at a particular instance.

Speed :-

$\boxed{\text{Average Speed}} = \dfrac{\text{total distance}}{\text{total time}}$ [It can't be −ve]

$\boxed{\text{Instantaneous Speed}}$ = Speed at a particular instance.

Note

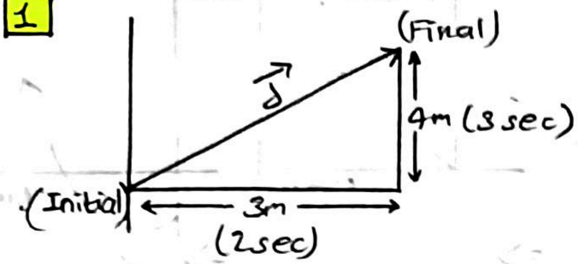
→ Distance ≥ |Displacement|
→ Average speed ≥ |Average velocity|
→ |Instantaneous velocity| = Instantaneous speed [Always]
→ If particle doesn't changes its direction then Avg. speed = |Avg. Velocity|

Avg. Velocity = $\dfrac{\text{Displacement}}{\text{Time}}$

Avg. Speed = $\dfrac{\text{Distance}}{\text{Time}}$

Questions on Speed & Velocity

1



Find ⇒ Average velocity.

⇒ Displacement = $3\hat{i} + 4\hat{j}$

⇒ Average velocity $= \dfrac{3\hat{i}+4\hat{j}}{2+3}$

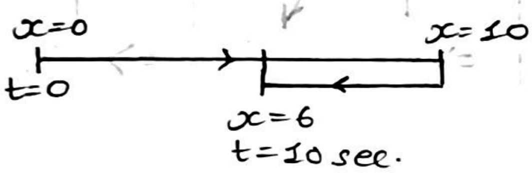
$= \dfrac{3\hat{i}+4\hat{j}}{5}$

$= \dfrac{\sqrt{3^2+4^2}}{5}$

$= \dfrac{5}{5}$

Ans ⇒ $\boxed{1 \text{ m/s}}$

2



Find averge speed and average velocity.

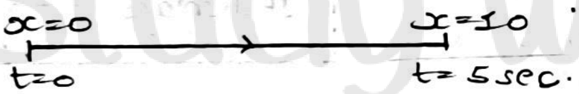
⇒ Distance = 10+4 = 14 unit

Averge speed $= \dfrac{14}{10} = \boxed{\dfrac{7}{5} \text{ unit/s}}$

⇒ Displacement = 6 units (magnitude)

Average velocity $= \dfrac{6}{10} = \boxed{\dfrac{3}{5} \text{ unit/s}}$

3



Find average speed and average velocity.

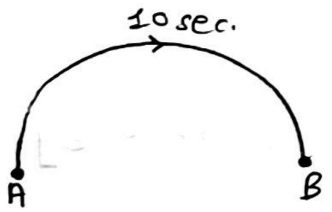
⇒ Distance = 10 unit

Displacement = 10 unit (magnitude)

⇒ Avg. Speed $= \dfrac{10}{5} = \boxed{2 \text{ unit/s}}$

⇒ Avg. Velocity $= \dfrac{10}{5} = \boxed{2 \text{ unit/s}}$

4



Find average speed and average velocity.

⇒ Distance = πR

Displacement = $2R$

Time = 10 sec

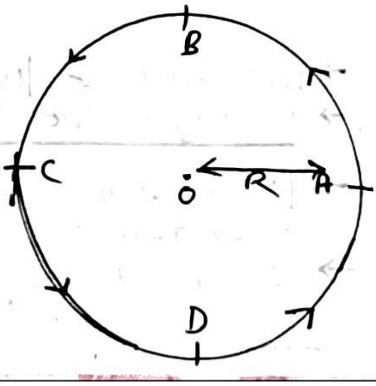
⇒ Avg. Speed = $\boxed{\pi R/10 \text{ unit/s}}$

⇒ Avg. Velocity = $2R/10$

$= \boxed{R/5 \text{ unit/s}}$

5 A particle is performing uniform circular motion with constant speed v having time period T, anticlockwise, Find averge speed & average velocity for

(i) A → B
(ii) A → B → C
(iii) A → B → C → D
(iv) A → B → C → D → A



Path	Average Speed	Average Velocity
$A \to B$	$\frac{2\pi R/4}{T/4} = \frac{2\pi R}{T}$	$\frac{R\sqrt{2}}{T/4}$
$A \to B \to C$	$\frac{\pi R}{T/2} = \frac{2\pi R}{T}$	$2R/T/2$
$A \to B \to C \to D$	$\frac{3\pi R/2}{3T/4} = \frac{2\pi R}{T}$	$\frac{R\sqrt{2}}{T/4}$
$A \to B \to C \to D \to A$	$\frac{2\pi R}{T}$	0

6 A car is moving along +x-axis. In first 4 hr. it travel with speed 50 kmph, in next 2 hr. it move with 70 kmph and in last part of journey it travel for 5 hr. with 80 kmph. Find its average speed.

$\Rightarrow S = D/T$

$\Rightarrow D = S \times T$

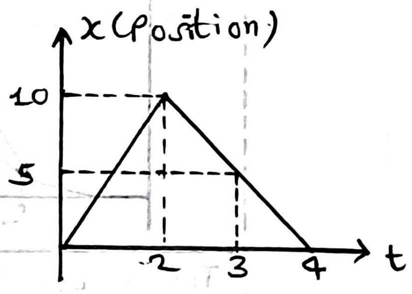
$\Rightarrow$ Avg. Speed $= \frac{\text{Total distance}}{\text{Total time}} = \frac{50\times4 + 70\times2 + 80\times5}{4+2+5}$

$= \frac{540}{11} = \boxed{49.09 \text{ km/h}}$ Ans

Questions based on graph

Note: If a particle is moving on x-axis only. Then average velocity $= \frac{\vec{x}_f - \vec{x}_i}{\text{time}} = \frac{\Delta \vec{x}}{\Delta t}$

1 A particle is moving on the x-axis such that its x-coordinate with respect to time changes as:



Find average velocity for

(i) $t=0 \to t=2$

$\Rightarrow \frac{10-0}{2-0} = \frac{10}{2} = \boxed{5}$

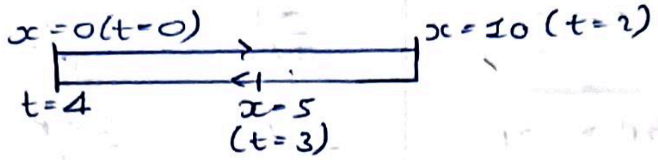
(ii) $t=0 \to t=3$

$\Rightarrow \frac{\vec{x}_f - \vec{x}_i}{\text{time}} = \frac{5-0}{3} = \boxed{\frac{5}{3}}$

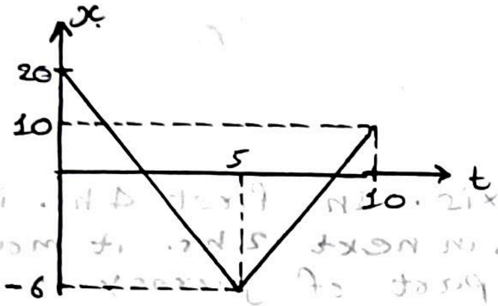
(iii) Find average speed for $t=0 \rightarrow t=3$.

$\Rightarrow$ Distance covered in 3 sec = $10+5 = 15m$

$\Rightarrow$ Avg. speed = $\frac{15}{3} = \boxed{5\,m/s}$



2



Find average velocity for

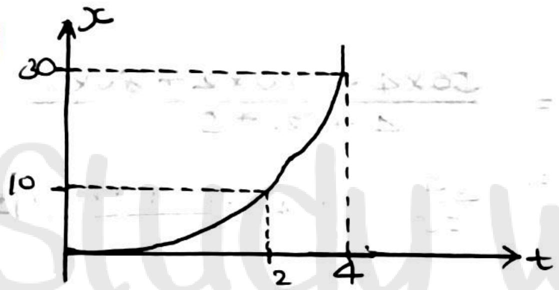
(i) $t=0 \rightarrow t=5$

$\Rightarrow \frac{x_f - x_i}{\text{time}} = \frac{-6-20}{5} = \boxed{\frac{-26}{5}\,m/s}$

(ii) $t=0 \rightarrow t=10$

$\Rightarrow \frac{x_f - x_i}{\text{time}} = \frac{10-20}{10} = \frac{-10}{10} = \boxed{-1\,m/s}$

3



Find average velocity from $t=2 \rightarrow t=4$ sec

$\Rightarrow$ Avg. velocity $= \frac{x_f - x_i}{\text{time}}$

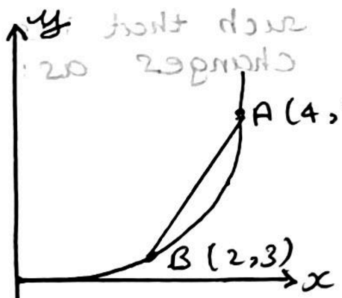
$= \frac{30-10}{4-2}$

$= \frac{20}{2}$

Ans $\Rightarrow \boxed{10\,m/s}$

Slope

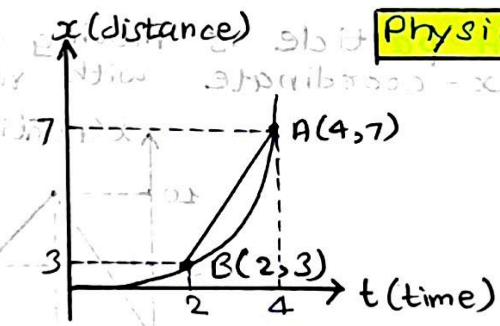
Mathematics



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

Slope of AB $= \frac{7-3}{4-2} = \frac{4}{2} = \boxed{2}$

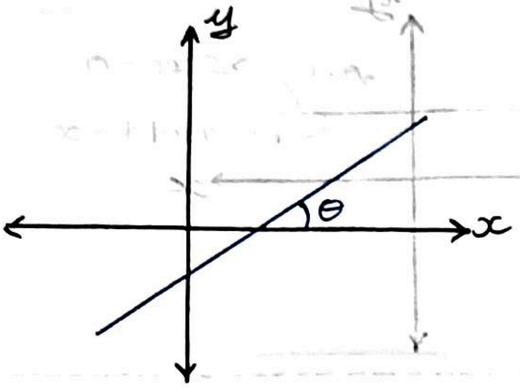
Physics



The slope of line joining 2 point of any (x-t) graph will give the average velocity between that two points.

According to the given diagram avg. velocity between A & B will be:

$= \frac{x_f - x_i}{t_2 - t_1} = \frac{7-3}{4-2} = \frac{4}{2} = \boxed{2}$



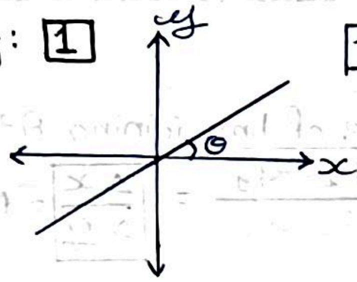
In a graph, straight line makes angle 'θ' with +ve x-axis and its 'tan θ' gives slope of that line.

$\therefore$ $\boxed{\tan\theta = \text{slope}}$

In the equation:
$\boxed{y = mx + c}$

$\underline{m} = \underline{\text{slope}} = \underline{\tan\theta}$

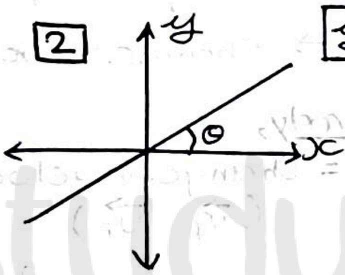
Eg: $\boxed{1}$



$\boxed{y = 5x}$

According to $y = mx + c$
Here, $m = \text{slope} = 5$
$\therefore$ $\tan\theta = 5$

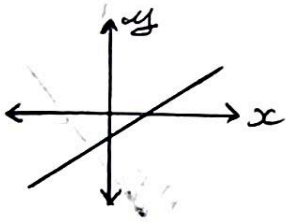
$\boxed{2}$



$\boxed{y = x\sqrt{3}}$

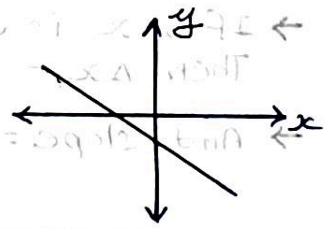
According to $y = mx + c$
Here, $m = \text{slope} = \sqrt{3}$
$\therefore$ $\tan\theta = \sqrt{3}$
$\therefore$ $\theta = 60°$

If line of a graph is towards right side then slope is +ve and, If line of a graph is towards left side the slope is −ve.



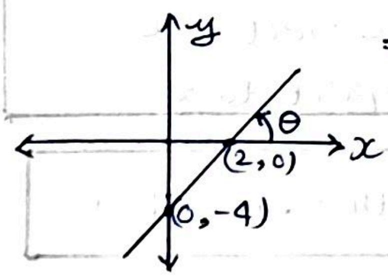
Here,
Slope = +ve

Here,
Slope = −ve



Eg: $\boxed{y = 2x - 4}$

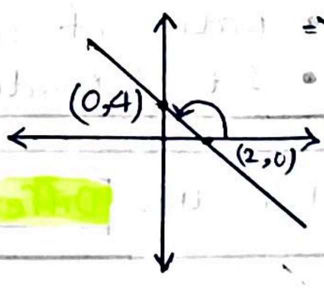
=> If $x = 0$
$y = -4$
If $y = 0$
$x = 2$



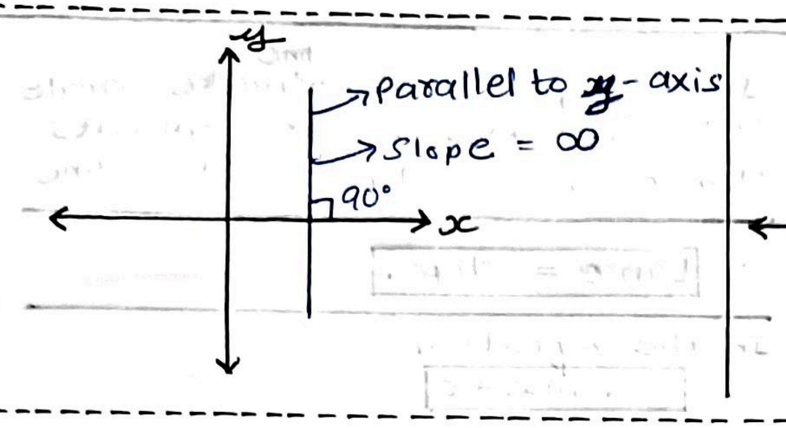
=> $\tan\theta = 2 = \text{slope}$
Here,
Slope is +ve

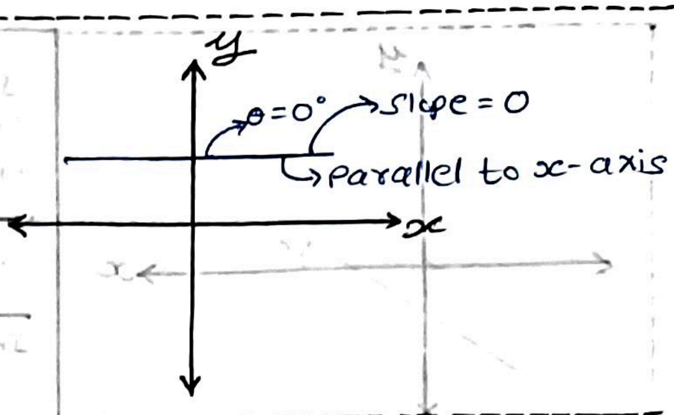
$\boxed{y = -2x + 4}$

=> If $x = 0$
$y = 4$
If $y = 0$
$x = 2$

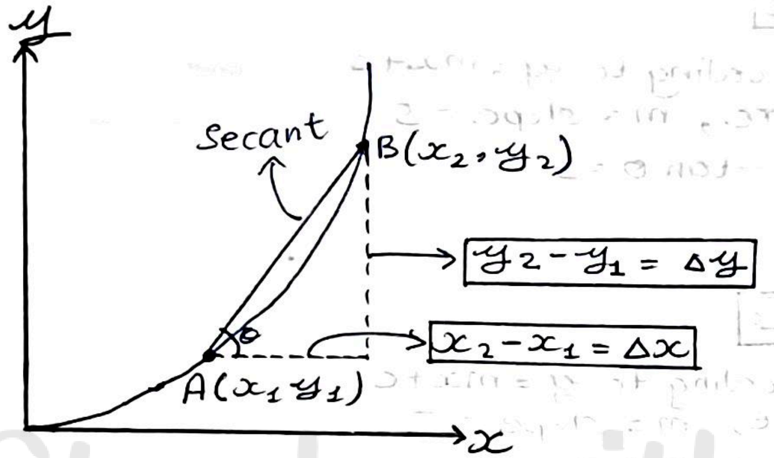


=> $\tan\theta = -2 = \text{slope}$
Here,
Slope is −ve





Differentiation



$\boxed{y_2 - y_1 = \Delta y}$

$\boxed{x_2 - x_1 = \Delta x}$

Slope of line joining A to B

$$= \frac{y_2 - y_1}{x_2 - x_1} = \boxed{\frac{\Delta x}{\Delta y}} = \tan\theta$$

$\Delta y \to$ Change in y

$\Delta x \to$ Change in x

Similarly,

$\Delta \vec{v}$ = change in velocity $(\vec{v}_f - \vec{v}_i)$

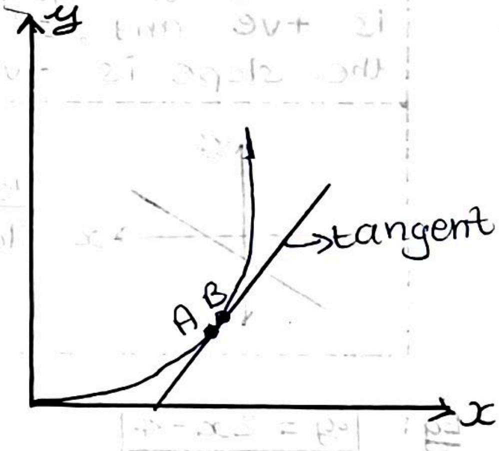
But, if change is very small :

→ If Δy is very small (near about 0)
Then $\Delta y = dy$

→ If Δx is very small (near about 0)
Then $\Delta x = dx$

→ And slope = $\frac{\Delta y}{\Delta x} = \boxed{\frac{dy}{dx}}$

→ In this case, we get a tangent in place of secant.



$\boxed{\frac{dy}{dx}}$

- Slope of tangent at that point.
- Ratio of very very small change in y to very very small change in x.
- Ratio of change in y with respect to x.
- 1st derivative of y with respect to x.

It is the **Differentiation** of y with respect to x.

Need of Differentiation

Average Velocity = $\boxed{\dfrac{\Delta x}{\Delta t} = \dfrac{x_f - x_i}{t_2 - t_1}}$

But,

For Istantaneous Velocity:

$\boxed{V = \dfrac{dx}{dt}}$

Differentiation of x (position) with respect to time.

Differentiation Formulas :-

1. $\dfrac{d}{dx}(x^n) = nx^{n-1}$

2. $\dfrac{d}{dx}(\text{constant}) = 0$

3. $\dfrac{d}{dx}(\sin x) = \cos x$

4. $\dfrac{d}{dx}(\cos x) = -\sin x$

5. $\dfrac{d}{dx}(\tan x) = \sec^2 x$

6. $\dfrac{d}{dx}(\sec x) = \sec x \tan x$

7. $\dfrac{d}{dx}(\cot x) = -\operatorname{cosec}^2 x$

8. $\dfrac{d}{dx}(\operatorname{cosec} x) = -\operatorname{cosec} x \cdot \cot x$

9. $\dfrac{d}{dx}(e^x) = e^x$

10. $\dfrac{d}{dx}(\ln x) = \dfrac{1}{x}$

Addition and Subtraction Rule :-

$$f(x) = g(x) \pm h(x)$$
$$\frac{d}{dx} f(x) = \frac{d}{dx} g(x) \pm \frac{d}{dx} h(x)$$

$\frac{dy}{dx}$ also can be writen as y'

So, $y = u \pm v$
$y' = u' \pm v'$

Questions -

1. $\boxed{y = x^5}$
$\Rightarrow \frac{dy}{dx} = 5x^4$

2. $\boxed{y = x^7}$
$\Rightarrow \frac{dy}{dx} = 7x^6$

3. $\boxed{y = x^{-5}}$
$\Rightarrow \frac{dy}{dx} = -5x^{-6}$

4. $\boxed{y = 2x^5}$
$\Rightarrow \frac{dy}{dx} = 5 \times 2x^4 = 10x^4$

5. $\boxed{y = t^3}$
$\Rightarrow \frac{dy}{dx} = 3t^2$

6. $\boxed{y = t^7}$
$\Rightarrow \frac{dy}{dx} = 7t^6$

7. $\boxed{x = t^4 + t^3 + t^5}$
$\Rightarrow \frac{dy}{dx} = 4t^3 + 3t^2 + 5t^4$

8. $\boxed{y = 1/x^2}$
$\Rightarrow y = x^{-2}$
$\frac{dy}{dx} = -2x^{-2-1} = -2x^{-3}$
$= \frac{-2}{x^3}$

9. $\boxed{y = x^2 + x^5}$
$\Rightarrow \frac{dy}{dx} = 2x + 5x^4$

10. $\boxed{y = x^3 - x^4}$
$\Rightarrow \frac{dy}{dx} = 3x^2 - 4x^3$

11. $\boxed{y = x^7 + x^8}$
$\Rightarrow \frac{dy}{dx} = 7x^6 + 8x^7$

12. $\boxed{x^9 + 1/x^5 = y}$
$\Rightarrow y = x^9 + x^{-5}$
$\frac{dy}{dx} = 9x^8 + (-5)x^{-5-1}$
$= 9x^8 - 5x^{-6}$
$= 9x^8 - \frac{5}{x^6}$

13. $\boxed{y = x^3 + x^8}$
$\Rightarrow \frac{dy}{dx} = 3x^2 + 8x^7$

14. $\boxed{y = t^3 + t^8}$
$\Rightarrow \frac{dy}{dx} = 3t^2 + 8t^7$

15. $\boxed{y = 5x^3}$
$\Rightarrow \frac{dy}{dx} = 3 \times 5x^2$
$= 15x^2$

16. $\boxed{y = 4x^2}$
$\Rightarrow \frac{dy}{dx} = 2 \times 4x$
$= 8x$

17. $\boxed{y = 3x^7}$
$\Rightarrow \frac{dy}{dx} = 7 \times 3x^{7-1}$
$= 21x^6$

18. $\boxed{2x^2 + 4x^3 + 6x^7}$
$\Rightarrow \frac{dy}{dx} = 2 \times 2x + 3 \times 4x^2 + 6 \times 7x^6$
$= 4x + 12x^2 + 42x^6$

19. $\boxed{y = x}$

$\Rightarrow \frac{dy}{dx} = 1 \times x^{1-1}$

$= x^0 = 1$

20. $\boxed{y = 4x}$

$\Rightarrow \frac{dy}{dx} = 4x^{1-1}$

$= 4 \times 1$

$= 4$

21. $\boxed{y = 10}$

$\Rightarrow \frac{dy}{dx} = 0$

---

22. $\boxed{y = 5}$

$\Rightarrow \frac{dy}{dx} = 0$

23. $\boxed{y = x^3 + 2x^5 + 7}$

$\Rightarrow \frac{dy}{dx} = 3x^2 + 10x^4 + 0$

24. $\boxed{y = x^5 - x^4 + 2}$

$\Rightarrow \frac{dy}{dx} = 5x^4 - 4x^3 + 0$

---

25. $\boxed{y = x^3 + \sin x}$

$\Rightarrow y' = 3x^2 + \cos x$

If any term is constant then its change is 0. That's why differentiation of constant is also 0.

Eg: $y = \overset{\rightarrow \text{constant}}{C}$

$y' = 0$

---

26. $\boxed{y = x^7 + \tan x + 10}$

$\Rightarrow y' = 7x^6 + \sec^2 x + 0$

---

27. $\boxed{y = 3x^3 + \sin x + \tan x}$

$\Rightarrow y' = 9x^2 + \cos x + \sec^2 x$

---

28. $\boxed{y = 2x^2 + \cos x + 5}$

$\Rightarrow y' = 4x - \sin x + 0$

29. $\boxed{y = \sin x}$

$\Rightarrow y' = \cos x$

---

30. $\boxed{y = \sin 30°}$

$\Rightarrow \sin 30° = \frac{1}{2}$

$= \frac{1}{2}$ is a constant

$\therefore y' = 0$

31. $\boxed{y = 3x^2 + \cos x + e^x - \sin x + 10}$

$\Rightarrow y' = 6x - \sin x + e^x - \cos x + 0$

32. $\boxed{y = \tan 45°}$

$\Rightarrow \tan 45° = 1$ (constant)

$\therefore y' = 0$

Product Rule :-

$y = u.v$

$y' = uv' + vu'$

Questions -

1. $\boxed{y = x^3 . \sin x}$

$\Rightarrow y' = x^3\left(\frac{d}{dx}\sin x\right) + \sin x\left(\frac{d}{dx}x^3\right) \Rightarrow \boxed{x^3\cos x + \sin x(3x^2)}$

2. $\boxed{y = x^5 \tan x}$

$\Rightarrow y' = x^5\left(\frac{d}{dx}\tan x\right) + \tan x\left(\frac{d}{dx}x^5\right)$

$\Rightarrow \boxed{x^5(\sec^2 x) + \tan x(5x^4)}$

---

3. $\boxed{y = x^3 e^x}$

$\Rightarrow y' = x^3\left(\frac{d}{dx}e^x\right) + e^x(x^3)$

$\Rightarrow \boxed{x^3 e^x + ex(3x^2)}$

---

4. $\boxed{y = x^4 \ln x}$

$\Rightarrow y' = x^4\left(\frac{d}{dx}\ln x\right) + \ln x(x^4)$

$\Rightarrow \boxed{x^4\left(\frac{1}{x}\right) + \ln x(4x^3)}$

---

5. $\boxed{y = e^x . \sin x}$

$\Rightarrow y' = e^x\left(\frac{d}{dx}\sin x\right) + \sin x(e^x)$

$\Rightarrow \boxed{e^x(\cos x) + \sin x(e^x)}$

---

6. $\boxed{y = e^x . \cos x}$

$\Rightarrow y' = e^x\left(\frac{d}{dx}\cos x\right) + \cos x\left(\frac{d}{dx}e^x\right)$

$\Rightarrow \boxed{e^x(-\sin x) + \cos x(e^x)}$

Division Rule -

$y = u/v$

$y' = \frac{vu' - uv'}{v^2}$

Question : $\boxed{y = x^5/\sin x}$

$\Rightarrow y' = \frac{\sin x(d/dx \cdot x^5) - x^5(d/dx \cdot \sin x)}{(\sin x)^2}$

Ans $\Rightarrow \frac{\sin x(5x^4) - x^5(\cos x)}{\sin^2 x}$

Method - 2: In form of product

$\Rightarrow y = x^5/\sin x$

$\Rightarrow y = x^5 \cdot \operatorname{cosec} x \quad \left[\frac{1}{\sin x} = \operatorname{cosec} x\right]$

Ans $\Rightarrow$ $\boxed{y' = x^5(-\operatorname{cosec} x \cdot \cot x) + \operatorname{cosec} x\,(5x^4)}$

$\Rightarrow \frac{\sin x}{\sin x}\left(\frac{5x^4}{\sin x}\right) - \frac{x^5}{\sin x} \times \frac{\cos x}{\sin x}$

$\Rightarrow \boxed{\frac{\sin(5x^4) - x^5(\cos x)}{\sin^2 x}}$

Chain Rule -

$$y = f(g(x))$$

$$y' = f'(g(x)) \cdot g'(x)$$

Questions-

1. $y = \sin(x^2 + x^7)$

$\Rightarrow y' = \cos(x^2 + x^7) \cdot (2x + 7x^6)$

2. $y = \cos(x^3)$

$\Rightarrow y' = -\sin(x^3) \cdot (3x^2)$

3. $y = \ln x^5$

$\Rightarrow y' = \frac{1}{x^5}(5x^4)$

4. $y = \ln x^4$

$\Rightarrow y' = \frac{1}{x^4}(4x^3)$

5. $y = \ln(\sin x)$

$\Rightarrow y' = \frac{1}{\sin x}(\cos x)$

6. $y = \tan^2 x$

$\Rightarrow y = (\tan x)^2$

$y' = 2\tan x(\sec^2 x)$

7. $y = \cos^5 x$

$\Rightarrow y = (\cos x)^5$

$y' = 5(\cos x)(-\sin x)$

8. $y = \sin^3 x$

$\Rightarrow y = (\sin x)^3$

$y' = 3(\sin x)^2 \cdot \cos x$

9. $y = \sin^4 x$

$\Rightarrow y = (\sin x)^4$

$y' = 4(\sin x)^3 \cdot \cos x$

10. $y = \ln(x^2 + x^3)$

$\Rightarrow y' = \frac{1}{x^2 + x^3}(2x + 3x^2)$

11. $y = \sin(x^2 + x^3)$

$\Rightarrow y' = \cos(x^2+x^3)(2x + 3x^2)$

12. $y = \tan(x^3)$

$\Rightarrow y' = \cancel{3(\tan x)^2}\ \sec^2(x^3)(3x^2)$

13. $y = \ln(\sin x^3)$

$\Rightarrow y' = \frac{1}{\sin x^3}(\cos x^3)(2x^2)$

Pahle andar wale ko 'x' suppose karke baharwale ka differentiation karo.

14. $y = \sin(e^x)$

$\Rightarrow y' = \cos(e^x)(e^x)$

15. $y = e^{x^3}$

$\Rightarrow y' = e^{x^3}(3x^2)$

16. $y = \sin\left(5x + \frac{\pi}{3}\right)$

$\Rightarrow y' = \cos\left(5x + \frac{\pi}{3}\right)(5+0)$

Miscellaneous Questions

1. $y = \pi x^2$
$\Rightarrow y' = \pi 2x$

2. $y = \pi x^3$
$\Rightarrow y' = \pi 3x^2$

3. $A = \pi r^2$
$\Rightarrow A' = \pi 2r$

4. $V = \frac{4}{3}\pi r^3$
$\Rightarrow V' = \frac{4}{3}\pi 3r^2$

5. $y = t^2 - 4t + 10$
$\Rightarrow y' = 2t - 4 + 0$
$y'' = 2 - 0$

6. $x = t^2 - 4t + 10$
$\Rightarrow x' = 2t - 4 + 0$
$x'' = 2 - 0$

7. $y = t^3 - 4t^2 + 10$
$\Rightarrow y' = 3t^2 - 8t + 0$
$y'' = 6t - 8 + 0$

8. $x = t^3 - 4t^2 + 10$
$\Rightarrow x' = 3t^2 - 8t + 0$
$x'' = 6t - 8 + 0$

9. $y = \sin x$
$\Rightarrow y' = \cos x$
$y'' = -\sin x$

10. $P = \ln t$
Find P' at $t = 10s$
$\Rightarrow P' = \frac{1}{t} = \frac{1}{10}$

11. $y = x^2 + 3x$
Find y' at $x = 4$
$\Rightarrow y' = 2x + 3$
$= 2\times4 + 3$
Ans $\Rightarrow \boxed{11}$

12. $y = x^3$
Find y' at $x = 2$
$\Rightarrow y' = 3x^2$
$= 3\times2^2$
Ans $\Rightarrow \boxed{12}$

13. $y = t^3$
Find y' at $t = 10s$
$\Rightarrow y' = 3t^2$
$= 3\times10^2$
Ans $\Rightarrow \boxed{300}$

14. $x = t^2$

Find x' at $t = 10$

$\Rightarrow x' = 2t$

$= 2 \times 10$

Ans $\Rightarrow \boxed{20}$

15. $x = t^2 + 2t$

Find x' at $t = 3s$

$\Rightarrow x' = 2t + 2$

$= 2 \times 3 + 2$

Ans $\Rightarrow \boxed{8}$

16. $x = t^3 - 2t^2 + 5$

Find x' and x'' at $t = 2sec$

$\Rightarrow x' = 3t^2 - 4t + 0$

$= 3 \times 2^2 - 4 \times 2$

$= 12 - 8$

Ans $\Rightarrow \boxed{4}$

$\Rightarrow x'' = 6t - 4$

$= 6 \times 2 - 4$

$= 12 - 4$

Ans $\Rightarrow \boxed{8}$

17. $y = x^3/\sqrt{3}$

Find y' at $x = 1$.

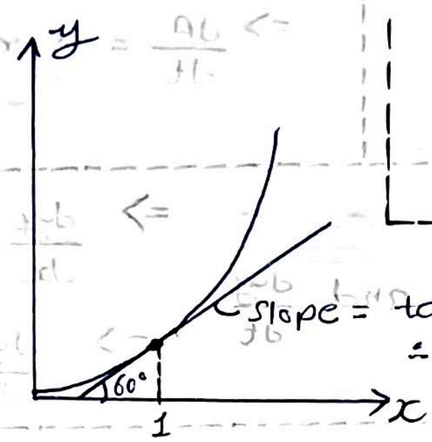
$\Rightarrow y = \frac{1}{\sqrt{3}} x^3$

$y' = \frac{1}{\sqrt{3}} \times 3x^2$

$= \sqrt{3} x^2$

$\Rightarrow$ At $x = 1$:

$\sqrt{3} \times 1^2 = \boxed{\sqrt{3}}$ Ans



Slope $= \tan\theta = \sqrt{3}$

$\therefore \boxed{\theta = 60^\circ}$

$\Rightarrow$ Slope $= \sqrt{3} = \tan\theta$

$\therefore \theta = 60^\circ$

Here, at different values of 'x', Slope will be different.

18. $x = t^3 - 4t^2 + 5$

Find $\frac{dx}{dt}$ at $t = 2sec$.

Find $\frac{d^2x}{dt^2}$ at $t = 2sec$.

$\Rightarrow x' = 3t^2 - 8t + 0$

$= 3 \times 2^2 - 8 \times 2$

$= 12 - 16 \Rightarrow \boxed{-4}$ Ans

$\Rightarrow x'' = 6t - 8$

$= 6 \times 2 - 8 \Rightarrow \boxed{4}$ Ans

Constant agar multiply me hai to uska differentiation wahi hoga.

Constant agar addition ya subtraction me hai to uska differentiation 0 hoga.

Eg: $y = \frac{1}{\sqrt{3}} + x^3$

$y' = 0 + 3x^2$

But

$y = \frac{1}{\sqrt{3}} x^3$

$y' = \frac{1}{\sqrt{3}} 3x^2$

19. $y = x^3$. Find differentiation of y with respect to time.

$\Rightarrow \frac{dy}{dt} = 3x^2 \left(\frac{dx}{dt}\right)$

20. $y = x^5$. Find dx/dt.

$\Rightarrow \frac{dx}{dt} = 5x^4 \left(\frac{dx}{dt}\right)$

21. $y = x^7$. Find dx/dt.

$\Rightarrow \frac{dx}{dt} = 7x^6 \left(\frac{dx}{dt}\right)$

22. $y = 5x^2$. Find dx/dt

$\Rightarrow \frac{dx}{dt} = 10x \left(\frac{dx}{dt}\right)$

23. $y = \pi x^2$

Find dy/dt and dy/dx

$\Rightarrow \dfrac{dy}{dt} = \pi 2x\left(\dfrac{dx}{dt}\right)$

$\Rightarrow \dfrac{dy}{dx} = \pi 2x$

24. $A = \pi r^2$

Find $\dfrac{dA}{dr}$ and $\dfrac{dA}{dt}$

$\Rightarrow \dfrac{dA}{dr} = \pi 2r$

$\Rightarrow \dfrac{dA}{dt} = \pi 2r\left(\dfrac{dr}{dt}\right)$

25. $y = \dfrac{4}{3}\pi x^3$

Find $\dfrac{dy}{dx}$ and $\dfrac{dy}{dt}$

$\Rightarrow \dfrac{dy}{dx} = \dfrac{4}{3}\pi 3x^2$

$\Rightarrow \dfrac{dy}{dt} = \dfrac{4}{3}\pi 3x^2\left(\dfrac{dx}{dt}\right)$

---

26. $y = \sin x$

Find $\dfrac{dy}{dx}$ and $\dfrac{dy}{dt}$

$\Rightarrow \dfrac{dy}{dx} = \cos x$

$\Rightarrow \dfrac{dy}{dt} = \cos x\left(\dfrac{dx}{dt}\right)$

---

27. Radius of a circle increases with respect to time with the rate of +5 m/sec. Find rate of change of area with respect to time when radius is 10m.

$\Rightarrow$ Given : $\dfrac{dr}{dt} = 5$, $r = 10m$

$\Rightarrow \boxed{A = \pi r^2}$

$\Rightarrow \dfrac{dA}{dt} = \pi 2r\left(\dfrac{dr}{dt}\right)$

$= \pi 2r(5) = \pi 2 \times 10(5)$

Ans $\Rightarrow \boxed{100\pi}$

Here,

$\dfrac{dy}{dx}$ = Rate of change of y with respect to x.

$\dfrac{dA}{dt}$ = Rate of change of Area with respect to time.

$\dfrac{dr}{dt}$ = Rate of change of radius with respect to time.

---

28. If radius of a sphere is increasing at the rate of 10 m/s. At what rate volume of sphere will change when radius is 3m.

$\Rightarrow$ Given : $\dfrac{dr}{dt} = 10$, $r = 3m$

$\Rightarrow V = 4/3\,\pi r^3$

$\Rightarrow \dfrac{dv}{dt} = \dfrac{4}{3}\pi 3r^2\left(\dfrac{dr}{dt}\right)$

$= \dfrac{4}{3}\pi\, 3(3)^2(10)$

$= \dfrac{4}{3} \times 270 \Rightarrow \boxed{360\pi}$ Ans

29. A particle is moving on x-axis such that it x-coordinate with respect to time changes as $x = t^2 - 4t + 10$.

(i) Find velocity at t = 3 sec.

=> $x = t^2 - 4t + 10$

$x' = 2t - 4 + 0$

=> v at 3 sec.

$= 2\times3 - 4 = 2$

Ans => $\boxed{2 m/s}$

(ii) Find velocity at t = 4 sec

=> $x = t^2 - 4t + 10$

$x' = 2t - 4 + 0$

=> v at 4 sec.

$= 2\times4 - 4 = 4$

Ans => $\boxed{4 m/s}$

(iii) Find initial velocity $\boxed{\text{at } t=0.}$

=> $x = t^2 - 4t + 10$

$x' = 2t - 4$

=> v at 0 sec.

$= 2\times0 - 4 = -4$

Ans => $\boxed{-4 \text{ see.}}$

---

30. $\boxed{x = t^2 - 6t + 10}$ Find velocity at t = 3, t = 6 and t = 0. Find average velocity t = 0 → t = 3.

=> $x = t^2 - 6t + 10$

$x' = 2t - 6$

=> Velocity at t = 3 sec.

$= 2\times3 - 6$

Ans => $\boxed{0 m/s}$

=> velocity at 0 sec.

$= 2\times0 - 6$

Ans => $\boxed{-6 m/s}$

=> velocity at 6 sec.

$= 2\times6 - 6$

Ans => $\boxed{6 m/s}$

=> Avg. velocity from t = 0 → t = 3.

avg. velocity $= \dfrac{x_f - x_i}{t_2 - t_1}$

t = 0, $x_i = 0 - 0 + 10$

$\boxed{x_i = 10}$

~~t = 3, $x_f = 3^2 - 63 + 10$~~

t = 3, $x_f = 3^2 - 6\times3 + 10$

$= 9 + 10 - 18$

$\boxed{x_f = 1}$

=> Avg. velocity $= \dfrac{1-10}{3-0}$

Ans => $\boxed{-3 m/s}$

31. Find average velocity from $t=0 \rightarrow t=6$ if $x = t^2 - 6t + 10$.

$\Rightarrow$ At $t=0$, $x = 10$

At $t=6$, $x = 6^2 - 6\times6 + 10$

$= 10$

$\Rightarrow$ $x_i = 10$

$x_f = 10$

$\Rightarrow$ Avg. velocity $= \dfrac{x_f - x_i}{t_2 - t_1} = \dfrac{10-10}{6-0} = \boxed{0\ m/s}$ Ans

---

32. If $\boxed{x = t^2 - 4t + 5}$

(i) Find velocity at $t=0$, $t=2$ and $t=4$.

$\Rightarrow$ $x = t^2 - 4t + 5$

$x' = 2t - 4 + 0$

$\Rightarrow$ $\underline{V \text{ at } t=0}$

$= 2\times0 - 4 \Rightarrow \boxed{-4\ m/s}$ Ans

$\Rightarrow$ $\underline{V \text{ at } t=2}$

$= 2\times2 - 4 = \boxed{0\ m/s}$ Ans

$\Rightarrow$ $\underline{V \text{ at } t=4}$

$= 2\times4 - 4 = \boxed{4\ m/s}$ Ans

(ii) Find avg. velocity from $t=0 \rightarrow t=4$ sec.

$\Rightarrow$ $t=0$, $x_i = \underline{5}$

$t=4$, $x_f = 4^2 - 4\times4 + 5 = \underline{5}$

$\Rightarrow$ avg. velocity $= \dfrac{5-5}{4-0} = \dfrac{0}{4} = \boxed{0\ m/s}$ Ans

Questions on Average Speed

1. If $x = t^2 - 4t + 5$. Find average speed from $t=0 \rightarrow t=4$.

$\Rightarrow$ At $t=0$, $x=5$

At $t=4$, $x=5$

$\Rightarrow$ $\boxed{\begin{array}{l} x_i = 5 \\ x_f = 5 \end{array}}$

$\Rightarrow$ $x = t^2 - 4t + 5$

$v = 2t - 4$

$\Rightarrow$ $\underline{\text{If } v=0}$

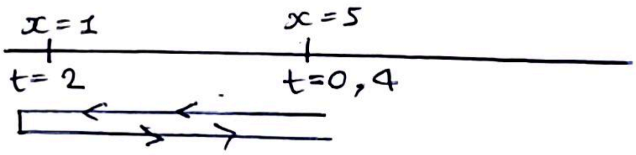
$2t - 4 = 0$

$t = 2$ sec.

$\Rightarrow$ At $t=2$, $x = 2^2 - 4\times2 + 5$

$= \boxed{1}$ (turning point)

$\Rightarrow$ Path:



$\Rightarrow$ Total distance $= 4 + 4 = 8$

$\Rightarrow$ Avg. speed $= \dfrac{8}{4} \Rightarrow \boxed{2\ m/s}$ Ans

2 If $x = t^2 - 2t + 10$. Find average speed from $t=0 \rightarrow t = 3$ sec.

$\Rightarrow$ At $t=0$, $x = 10$
At $t = 3$, $x = 3^2 - 2\times3+10$
$x = 13$

$\Rightarrow$ $\boxed{x_i = 10 \quad x_f = 13}$

$\Rightarrow$ $x = t^2 - 2t + 10$
$v = 2t - 2$

$\Rightarrow$ If $v = 0$
$2t - 2 = 0$
$t = 1$ sec.

$\Rightarrow$ At $t = 1$, $x = \boxed{9}$
(turning point)

$\Rightarrow$ Path: $x=9$, $x=10$, $x=13$; $t=1$, $t=0$, $t=3$

$\Rightarrow$ Total distance $= 1+4 = 5$

$\Rightarrow$ Avg. speed $\Rightarrow \boxed{\frac{5}{3} m/s}$ Ans

---

3 $x = 2t^2 - 4t + 5$. Find avg. speed from $t=0 \rightarrow t=2$.

$\Rightarrow$ At $t=0$, $\boxed{x_i = 5}$
At $t = 2$, $x = 2\times2^2 - 4\times2+5$
$\boxed{x_f = 5}$

$\Rightarrow$ $x = 2t^2 - 4t + 5$
$v = 4t - 4$

$\Rightarrow$ If $v = 0$
$4t - 4 = 0$
$t = 1$ sec.

$\Rightarrow$ At $t = 1$, $\boxed{x = 3}$ (turning pt.)

$\Rightarrow$ Path: $x=3$, $x=5$; $t=1$, $t=0,2$

$\Rightarrow$ Total distance $= 2+2$
$= 4$

Avg. speed $\Rightarrow \frac{4}{2}$ ~~$\Rightarrow$ 2m/s Ans~~

Ans $\Rightarrow \boxed{2 m/s}$

---

4 $x = t^2 - 2t + 4$. Find avg. speed at $t=0 \rightarrow t = 3$ sec.

$\Rightarrow$ At $t = 0$, $x = 4$
At $t = 3$, $x = 3^2 - 2\times3+4$
$x = 7$

$\Rightarrow$ $\boxed{x_i = 4 \quad x_f = 7}$

$\Rightarrow$ $x = t^2 - 2t + 4$
$v = 2t - 2$

$\Rightarrow$ If $v = 0$
$2t - 2 = 0$
$t = 1$ sec.

$\Rightarrow$ At $t = 1$,
$\boxed{x = 3}$ (turning point)

$\Rightarrow$ Path: $x=3$, $x=4$, $x=7$; $t=1$, $t=0$, $t=3$

$\Rightarrow$ Total distance $= 1+4 = 5$

$\Rightarrow$ Avg. speed $\Rightarrow \boxed{\frac{5}{3} m/s}$ Ans

5 $x = 2t^2 - 4t + 2$. Find avg. velocity from $t=0 \rightarrow t=3$ sec.

$\Rightarrow$ At $t=0$, $x=2$

At $t=3$, $x=8$

$\Rightarrow$ $\boxed{x_i = 2 \quad x_f = 8}$

$\Rightarrow$ $x = 2t^2 - 4t + 2$

$v = 4t - 4$

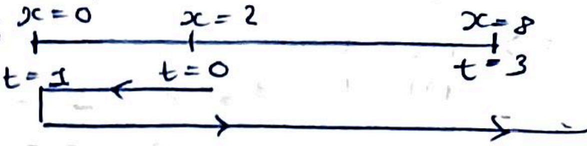
$\Rightarrow$ If $v=0$

$4t - 4 = 0$

$t = 1$ sec.

$\Rightarrow$ At $t=1$, $\boxed{x = 0}$ (turning point)

$\Rightarrow$ Path:



$\Rightarrow$ Total distance $= 2 + 8 = 10$

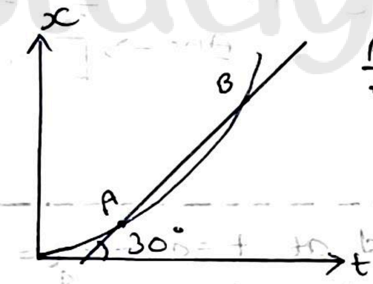
$\Rightarrow$ Avg. speed $\Rightarrow \boxed{\frac{10}{3}\ m/s}$ Ans

More About slope

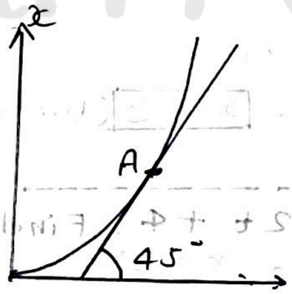
Average Velocity $= \frac{x_f - x_i}{t_2 - t_1}$ = (x-t) graph me 2 points ko join karne wali line ka slope.

Instantaneous Velocity $= \frac{dx}{dt}$ = (x-t) graph me slope of tangent at that point.

Eg:

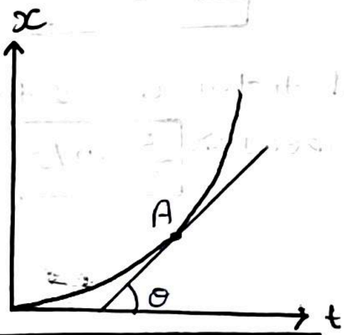


Avg. Velocity
= slope of line AB
= tan 30°
$\Rightarrow \boxed{1/\sqrt{3}}$



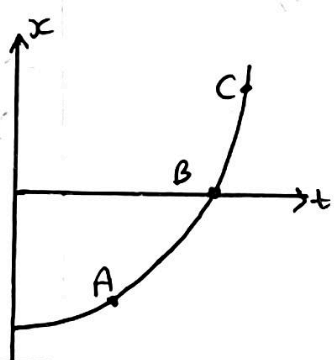
Velocity at A
= tan 45°
$\Rightarrow \boxed{1}$

1



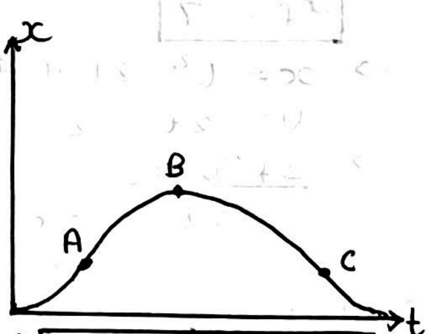
$\Rightarrow$ $\boxed{(\text{slope})_A = \tan\theta \quad (\text{slope})_A > 0}$

2



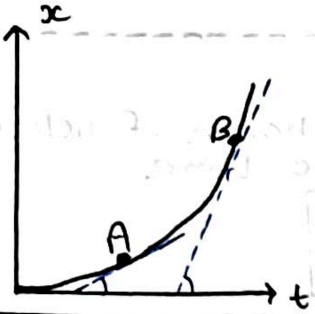
$\Rightarrow$ $\boxed{(\text{slope})_A > 0 \quad (\text{slope})_B > 0 \quad (\text{slope})_C > 0}$

3



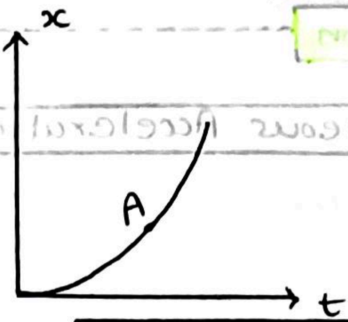
$\Rightarrow$ $\boxed{(\text{slope})_A = +ve \quad (\text{slope})_B = 0 \quad (\text{slope})_C = -ve}$

4



=> $(\text{slope})_A > 0$
$(\text{slope})_B > 0$
$(\text{slope})_B > (\text{slope})_A$
$t\uparrow$ = slope $\uparrow$

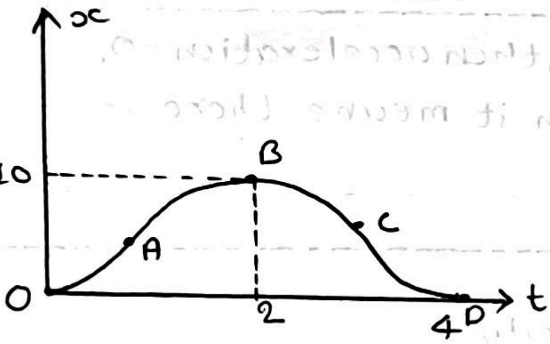
5



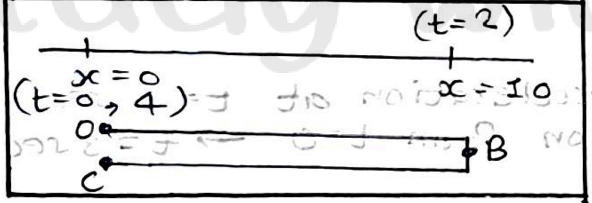
=> $\because$ Slope of the line at that point in (x-t) graph gives velocity.

=> Here, $(\text{slope})_A > 0$
$V_A > 0$ = +ve

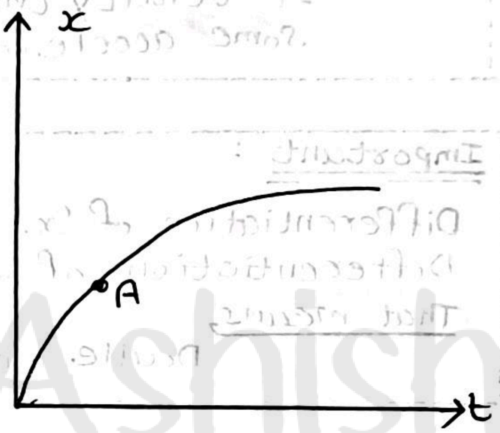
6



=> $V_A > 0$
$V_B = 0$ (turning point)
$V_C < 0$

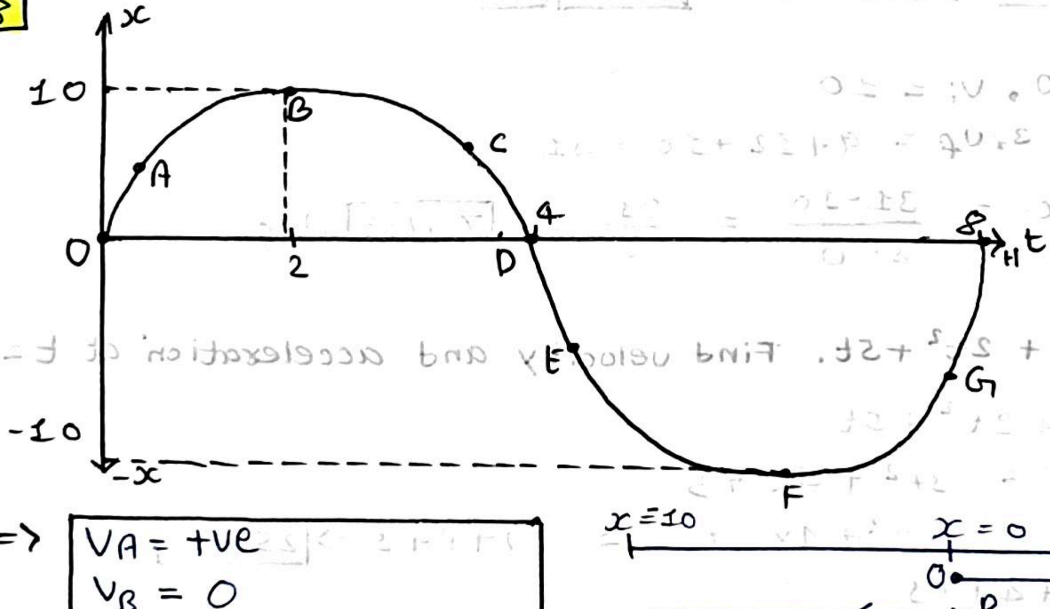


7

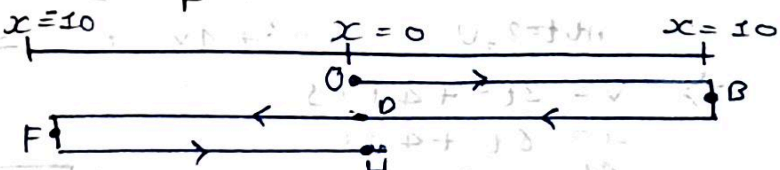


=> $V_A > 0$ = +ve

8



=> V_A = +ve
$V_B = 0$
V_C, V_D, V_E = -ve
$V_F = 0$, V_G = +ve



Acceleration

Instantaneous Acceleration = Rate of change of velocity with respect to time.

$$\vec{a} = \frac{d\vec{v}}{dt}$$

Average Acceleration = $\dfrac{\text{Change in Velocity}}{\text{Change in time}}$

$$= \frac{\Delta \vec{v}}{\Delta \vec{t}} = \frac{\vec{v}_f - \vec{v}_i}{t_2 - t_1}$$

Note: If velocity is constant, then acceleration $= 0$.
If velocity changes then it means there is some acceleration.

Important:
Differentiation of 'x' gives velocity.
Differentiation of 'velocity' gives acceleration.
That means,
Double differentiation of 'x' gives acceleration.

Q.1 $V = t^2 + 4t + 10$. Find acceleration at $t = 1$ sec.
Find average acceleration from $t = 0 \rightarrow t = 3$ sec.

$\Rightarrow$ $a = \dfrac{dv}{dt} = 2t + 4 + 0$

At $t = 1 \Rightarrow 2 \times 1 + 4 = \boxed{6\ m/s^2}$ Ans

$\Rightarrow$ At $t = 0$, $v_i = 10$
At $t = 3$, $v_f = 9 + 12 + 10 = 31$

$\Rightarrow$ Avg. acc. $= \dfrac{31 - 10}{3 - 0} = \dfrac{21}{3} \Rightarrow \boxed{7\ m/s^2}$ Ans

Q.2 $x = t^3 + 2t^2 + 5t$. Find velocity and acceleration at $t = 2s$.

$\Rightarrow$ $x = t^3 + 2t^2 + 5t$
$v = x' = 3t^2 + 4t + 5$
At $t = 2$, $v = 3 \times 2^2 + 4 \times 2 + 5 = 12 + 8 + 5 \Rightarrow \boxed{25\ m/s}$ Ans

$\Rightarrow$ $v = 3t^2 + 4t + 5$
$a = 6t + 4 + 0$
At $t = 2$, $a = 6 \times 2 + 4 \Rightarrow \boxed{16\ m/s^2}$ Ans

Q.3 If $x = 3t^2 - 12t + 10$ the find:

(i) x, v, a at $t = 0$, $t = 2$, $t = 3$ sec.

=> $x = 3t^2 - 12t + 10$

$v = 6t - 12$

$a = 6$

=> Putting different values of t in respected equations –

	a	v	x
t = 0	6	-12	10
t = 2	6	0	-2
t = 3	6	6	1

Ans

(ii) Find 'x' & 'a' when particle comes at rest.

=> ~~At v = 0~~

$x = 3t^2 - 12t + 10$

$v = 6t - 12$

=> At $v = 0$

$6t - 12 = 0$

$t = 2$ sec

=> At $t = 2$ (particle comes at rest)

$x = 3 \times 2^2 - 12 \times 2 + 10$

$= 3 \times 4 - 24 + 10 \Rightarrow -2$

$a = 6 \cancel{\times 2 - 12 \Rightarrow 0}$

Ans => $\boxed{\text{when particle comes at rest } x = -2,\ a = 6}$

(iii) Find avg. velocity and avg acceleration and avg. speed from $t = 0 \rightarrow t = 3$.

=> (a) Avg. velocity $= \dfrac{x_f - x_i}{t_2 - t_1} = \dfrac{1 - 10}{3 - 0} \Rightarrow \boxed{-3 \text{ m/s}}$ Ans

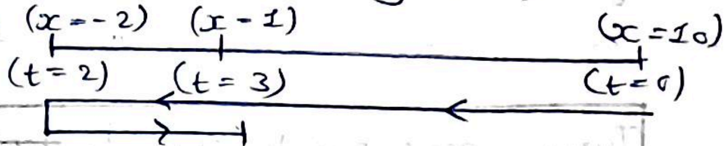
(b) Avg. acceleration $= \dfrac{v_f - v_i}{t_2 - t_1} = \dfrac{6 - (-12)}{3 - 0} = \dfrac{18}{3} \Rightarrow \boxed{6 \text{ m/s}^2}$ Ans

(c) Avg. speed => At $t = 0$, $x_i = 10$

At $t = 3$, $x_f = 1$

At $t = 2$, $x = -2$ (turning point)

=> Path =>



=> Total distance = 15

=> Avg speed $= \dfrac{15}{3} \Rightarrow \boxed{5 \text{ m/s}}$ Ans

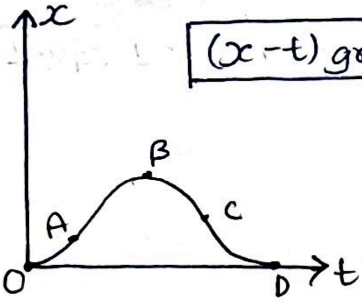
Graph

Slope of (x-t) graph gives velocity.

Slope of (v-t) graph gives acceleration.

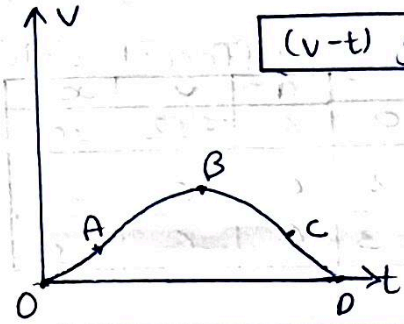
Eg:

(x-t) graph



Here, $v_A > 0$
$v_B = 0$
$v_C < 0$

(v-t) graph

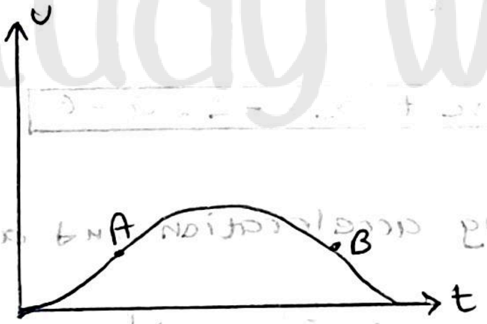


Here, $a_A > 0$
$a_B = 0$
$a_C < 0$

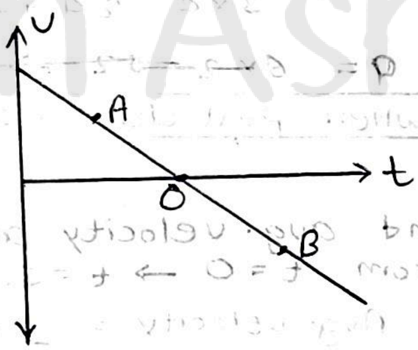
$\vec{v}, \vec{a}$ => have same sign => speed up

$\vec{v}, \vec{a}$ => have opposite sign => speed down

Eg:



Here,
$v_A > 0$, $a_A > 0$ => speedup
$v_B > 0$, $a_A < 0$ => speed down
(v is in 1st quadrant and in 1st quadrant x and y, both axes are +ve.)
(By slope direction)

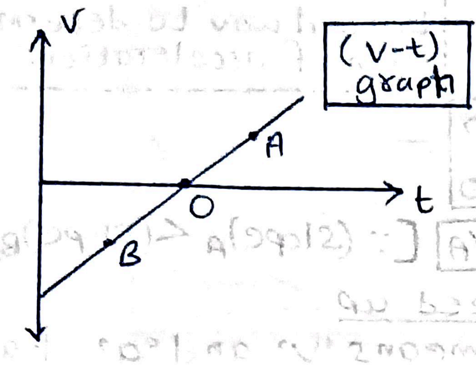


Here,
$v_A > 0$, $a_A < 0$ => Speed down
$v_B < 0$, $a_A < 0$ => speed up
(1st quadrant)
(4th quadrant)
(By slope dirn)

Turning point par v = 0 (✓). (v=0) par turning point (x).

At turning point => (v=0) and 'v' changes its sign.

Eg:



In this graph:

Point 'A' is in 1st quadrant.

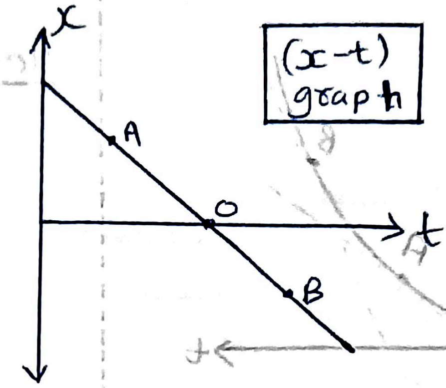
$\therefore V_A = +ve$

Point 'B' is in 4th quadrant.

$\therefore V_B = -ve$

At point 'O', $V = 0$ (zero)

$\therefore$ 'O' is turning point.



In this graph:

At every point (slope < 0)

$\therefore$ A and B both have ($v = -ve$)

$\therefore$ 'O' is not a turning point.

Straight line of (x-t) ~~give~~ graph gives constant velocity.

Straight line of (v-t) graph gives constant acceleration.

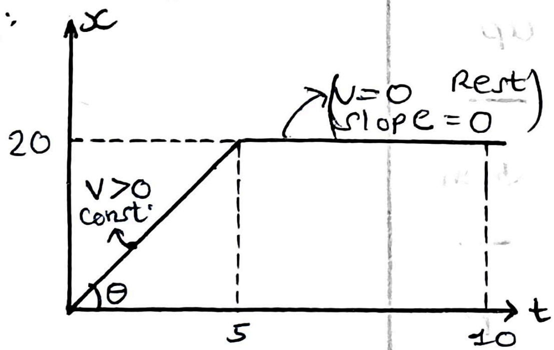
That means, straight line ka slope constant hota hai.

Eg: $x = 3t + 10$ (straight line x-t graph)

$\Rightarrow V = 3 + 0$ (constant velocity)

$a = 0$ (constant acceleration)

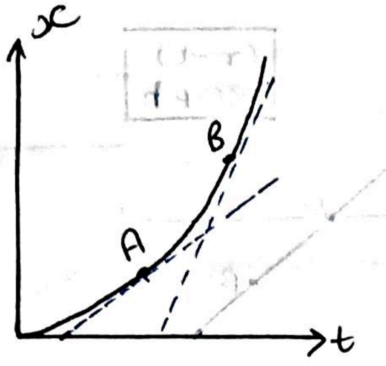
Eg:



($t = 0 \rightarrow t = 5 \Rightarrow \vec{v} = $ constant)

($\tan\theta = 20/5$, slope $= 4$)

($v = 4$)



Here,

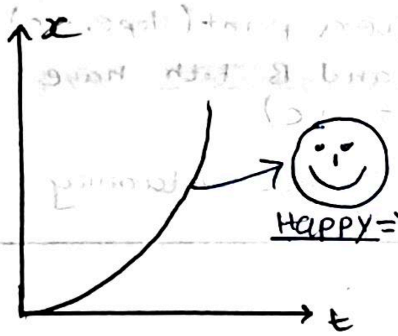
$\boxed{\begin{matrix} V_A > 0 \\ V_B > 0 \end{matrix}}$

$\boxed{V_B > V_A}$ $[\because (\text{slope})_A < (\text{slope})_B]$

$\therefore$ Speed up

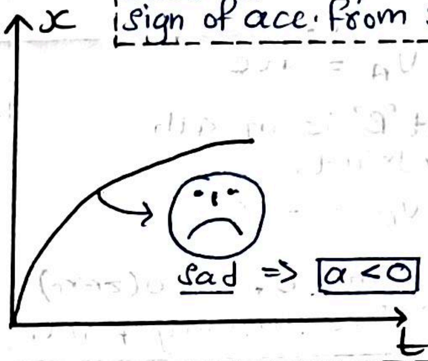
That means 'v' and 'a' have same sign. $(v > 0, a > 0)$.

Logical way to determine sign of acceleration.



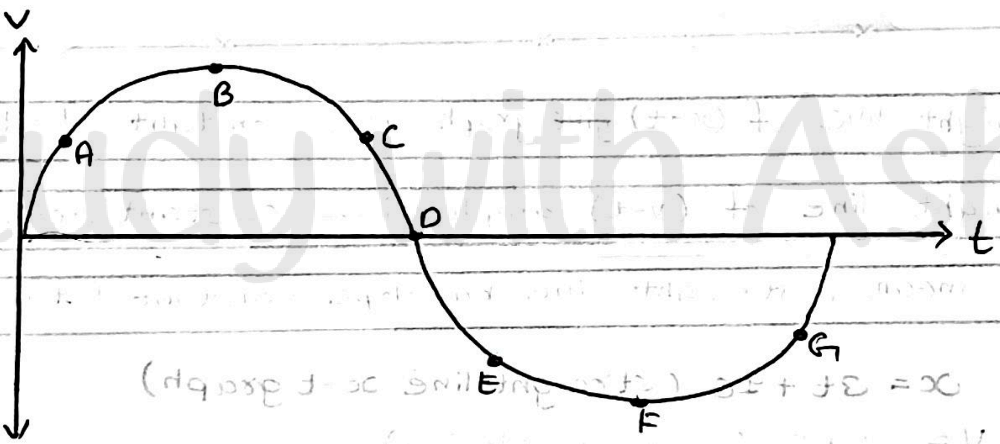
Happy => $\boxed{a > 0}$

Shortcut way to determine sign of acc. from x-t graph



Sad => $\boxed{a < 0}$

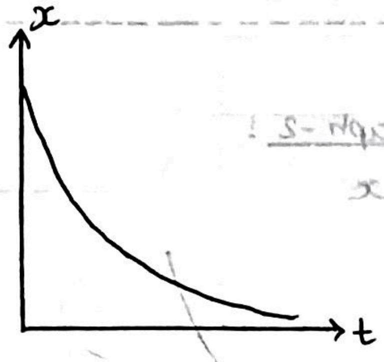
Q. 1



=>

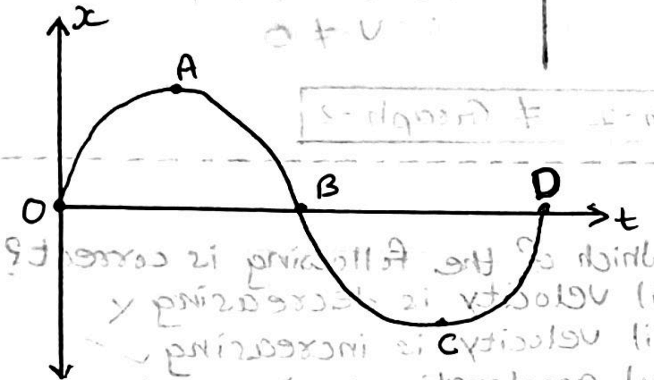
Point	V	a	speed
A	+ve	+ve	up
B	+ve	0	—
C	+ve	−ve	down
D	0	−ve	—
E	−ve	−ve	up
F	−ve	0	—
G	−ve	+ve	down

Q.2



=> $V < 0$ (By slope)
$a > 0$ (By shortcut = ☺)
$\therefore$ speed down (opposite sign)

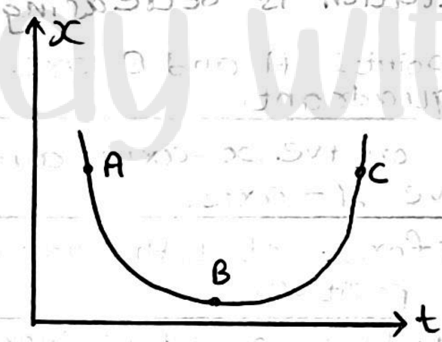
Q.3



=>

Point	V	a	speed
$O \to A$	+ve	-ve	down
$A \to B$	-ve	-ve	up
$B \to C$	-ve	+ve	down
$C \to D$	+ve	+ve	up

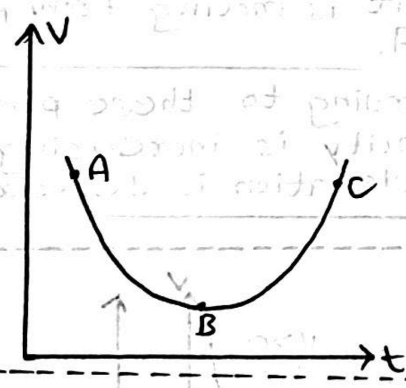
Q.4



=>

Point	V	a	speed
A	-ve	+ve	down
B	0	+ve	—
C	+ve	+ve	up

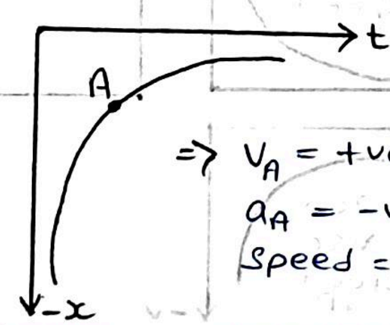
Q.5



=>

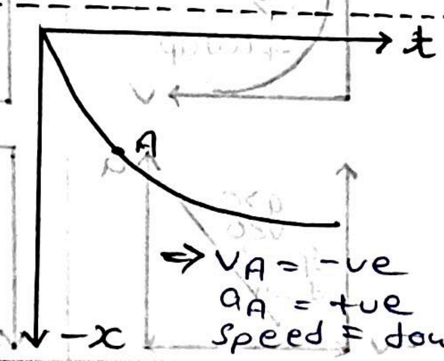
Point	V	a	Speed
A	+ve	-ve	down
B	+ve	0	—
C	+ve	+ve	up

Q.6



=> $V_A = +ve$
$a_A = -ve$
Speed = down

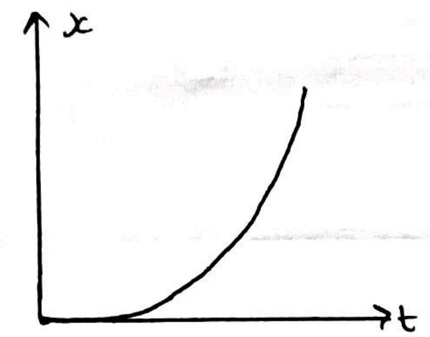
Q.7



=> $V_A = -ve$
$a_A = +ve$
Speed = down

Important

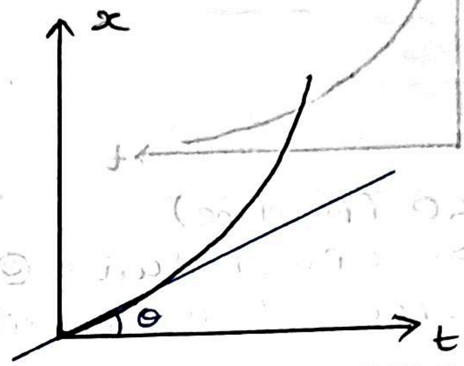
Graph-1 :



At $t=0$, slope $=0$

$\therefore v = 0$

Graph-2 :

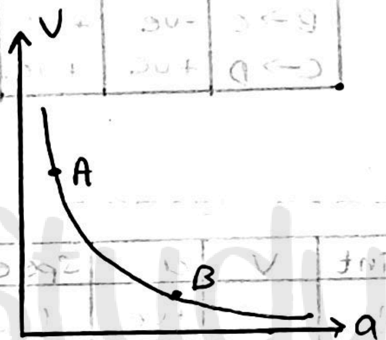


At $t=0$, slope $\neq 0$

$\therefore v \neq 0$

$\boxed{\text{Graph-1} \neq \text{Graph-2}}$

Q.8



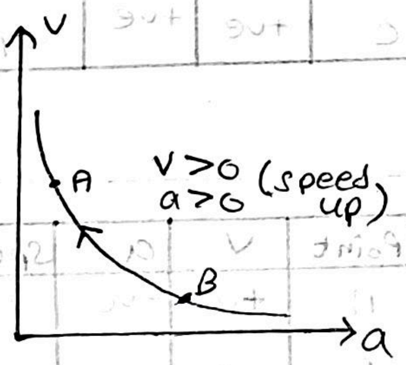
Which of the following is correct?

(i) velocity is decreasing ✗

(ii) velocity is increasing ✓

(iii) acceleration is increasing ✗

(iv) acceleration is decreasing ✓



⇒ Both points A and B are in 1st quadrant.

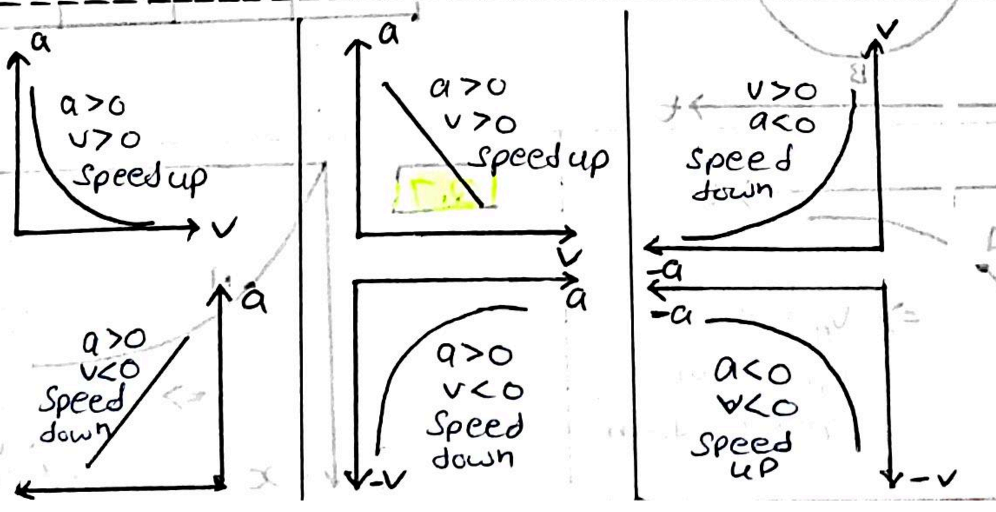
⇒ 'a' is on +ve x-axis, and 'v' is on +ve y-axis.

⇒ There-fore, at both point 'a' and 'v' are positive.

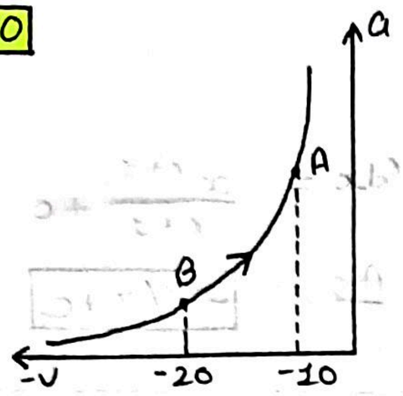
⇒ ∴ Particle's speed is increasing and it is moving from point B→A.

Ans ⇒ According to these points, velocity is increasing and acceleration is decreasing.

Q.9



Q.10



=> A and B are in 2nd quadrant.

=> v is on -ve x axis and 'a' is on +y axis.

=> At both point 'a' is positive and 'v' is negative.

=> Speed of particle is decreasing.

=> Particle is moving from B to A.

∴ Acceleration is increasing and velocity is decreasing.

Integration

→ It is the reverse process of differentiation.

$$f(x) \underset{\text{integration}}{\overset{\text{differentiation}}{\rightleftarrows}} g(x)$$

→ Integration
- → Definite Integration
- → Indefinite Integration

→ $\frac{dy}{dx}$ = differentiation of y with respect to x.

$\int y\,dx$ = integration of y with respect to x.

→ $\frac{d}{dx} f(x) = f'(x)$

$\int f'(x)\cdot dx = f(x) + \underbrace{c}_{\text{Constant}}$

Indefinite Integration

All important integration formula :-

(i) $\int x^n \cdot dx = \frac{x^{n+1}}{n+1} + c$

(ii) $\int \cos x \cdot dx = \sin x + c$

(iii) $\int -\sin x \cdot dx = \cos x + c$

(iv) $\int \sin x \cdot dx = -\cos x + c$

(v) $\int e^x \cdot dx = e^x + c$

(vi) $\int \frac{1}{x} dx = \ln x + c$

Questions:-

1. $\int x^4\,dx = \frac{x^{4+1}}{4+1} + c$

Ans $= \boxed{x^5/5 + c}$

2. $\int x^6\,dx = \frac{x^{6+1}}{6+1} + c$

Ans $= \boxed{x^7/7 + c}$

3. $\int x^7\,dx = x^8/8 + c$

↳ differentiate with respect to x:

$$\frac{8x^7}{8} + 0 = x^7$$

4. $\int x^{10}\,dx = x^{11}/11 + c$

5. $\int x^{50}\,dx = x^{51}/51 + c$

6. $\int x^{25}\,dx = x^{26}/26 + c$

7. $\int x^{-5}\,dx = \frac{x^{-4}}{-4} + c$

8. $\int x^2\,dx = x^3/3 + c$

9. $\int x^7\,dx = x^8/8 + c$

10. $\int (x^2 + x^3)\,dx$

$\Rightarrow \int x^2\,dx + \int x^3\,dx$

Ans $\Rightarrow \boxed{\frac{x^3}{3} + \frac{x^4}{4} + c}$

11. $\int 5x^4\,dx$

$\Rightarrow 5\int x^4\,dx$

$\Rightarrow 5\frac{x^5}{5} + c = \boxed{x^5 + c}$ Ans

12. $\int 6x^5\,dx$

$\Rightarrow 6\int x^5\,dx$

$\Rightarrow 6\frac{x^6}{6} + c = \boxed{x^6 + c}$ Ans

13. $\int (3x^2 + 7x^6)\,dx$

$\Rightarrow 3\int x^2\,dx + 7\int x^6\,dx$

$\Rightarrow 3\frac{x^3}{3} + 7\frac{x^7}{7} + c$

$\Rightarrow \boxed{x^3 + x^7 + c}$ Ans

14. $\int x^{-3}\,dx$

$\Rightarrow \frac{x^{-3+1}}{-3+1} + c = \frac{x^{-2}}{-2} + c$

Ans $= \boxed{\frac{-1}{2x^2} + c}$

15. $\int \frac{1}{x^3}\,dx$

$\Rightarrow \int x^{-3}\,dx = \frac{x^{-2}}{-2} + c$

Ans $= \boxed{\frac{-1}{2x^2} + c}$

16. $\int\left(\frac{1}{x^2} + \frac{1}{x^3}\right)dx$

$\Rightarrow \int (x^{-2} + x^{-3})\,dx$

$\Rightarrow \int x^{-2}\,dx + \int x^{-3}\,dx$

$\Rightarrow \frac{x^{-1}}{-1} + \frac{x^{-2}}{-2} + c$

Ans $\Rightarrow \boxed{\frac{-1}{x} - \frac{1}{2x^2} + c}$

17. $\int\left(\frac{1}{x^9} + \frac{1}{x^{10}}\right)dx$

$\Rightarrow \int (x^{-9} + x^{-10})\,dx$

$\Rightarrow \int x^{-9}\,dx + \int x^{-10}\,dx$

$\Rightarrow \frac{x^{-8}}{-8} + \frac{x^{-9}}{-9} + c$

Ans $\Rightarrow \boxed{\frac{-1}{x^8} - \frac{1}{x^9} + c}$

18. $\int (3x^2 - 4x^3)\,dx$

$\Rightarrow \int (3x^2 - 4x^3)\,dx$

$\Rightarrow 3\int x^2\,dx - 4\int x^3\,dx$

Ans $\Rightarrow \boxed{x^3 - x^4 + c}$

19. $\int dx$

$\Rightarrow \int dx = \int 1 .\,dx$

$= \int x^0\,dx$

$= \frac{x^{0+1}}{0+1} + c$

$= \frac{x^1}{1} + c$

Ans $\Rightarrow \boxed{x}$

20. $\int (3x^2 + 4x^3 + 5)\,dx$

$\Rightarrow 3\frac{x^3}{3} + 4\frac{x^4}{4} + 5x + c$

Ans $\Rightarrow \boxed{x^3 + x^4 + 5x + c}$

21. $\int (2t + 7t^6 + 10 + 0)\,dt$

$\Rightarrow \boxed{t^2 + t^7 + 10t + c}$

IMPORTANT

$\boxed{\int \cos x .\,dx = \sin x + c}$

$\boxed{\therefore \int \cos(ax+b)\,dx = \frac{1}{a}\sin(ax+b)}$

$\int \cos 2x .\,dx = \sin 2x + c$ (X)

$\longrightarrow$ differentiate $= 2(\cos 2x) + 0$

$\therefore \boxed{\int \cos 2x .\,dx = \frac{1}{2}\sin 2x + c}$ differentiate $= \frac{1}{\cancel{2}}(\cos 2x) \times \cancel{2} = \boxed{\cos 2x}$

Similarly,

- $\int \sin(ax+b)\,dx = -\frac{1}{a}\cos(ax+b) + c$
- $\int e^{ax+b}\,dx = \frac{1}{a}e^{ax+b} + c$
- $\int \frac{1}{ax}\,dx = \frac{1}{a}\int \frac{1}{x}\,dx = \frac{1}{a}\ln x + c$

Definite Integration :-

$$\int_{x_i = a \text{ (lower limit)}}^{x_f = b \text{ (upper limit)}} f(x)\,dx = g(x)\Big|_{x_i = a}^{x_f = b} = g(b) - g(a)$$

Questions :-

1. $\int_0^3 x^2\,dx = \frac{x^3}{3}\Big|_0^3 = \frac{3^3}{3} - \frac{0^3}{3} = \boxed{9}$ Ans

2. $\int_2^3 4x^3\,dx = \frac{\cancel{4}x^4}{\cancel{4}}\Big|_2^3 = 3^4 - 2^4 = \boxed{65}$ Ans

3. $\int_0^{\pi/2} \cos x\,dx = \sin x\Big|_0^{\pi/2} = (\sin \pi/2) - (\sin 0)$
$= 1 - 0 = \boxed{1}$ Ans

4. $\int_1^4 2x\,dx = \frac{\cancel{2}x^2}{\cancel{2}}\Big|_1^4 = 4^2 - 1^2 = \boxed{15}$ Ans

5. $\int_0^1 7x^6\,dx = x^7\Big|_0^1 = 1^7 - 0^7 = \boxed{1}$ Ans

6. $\int_2^3 e^x\,dx = e^x\Big|_2^3 = \boxed{e^3 - e^2}$ Ans

7. $\int_0^{10} 2x \cdot dx = x^2 \Big|_0^{10} = 10^2 - 0^2 = \boxed{100}$ Ans

---

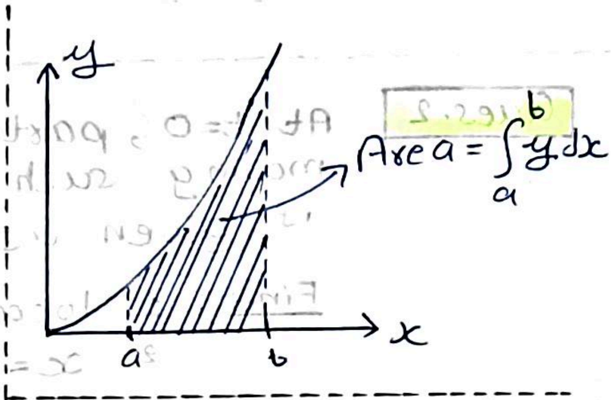
8. $\int_0^1 (3x^2 + 2x)\, dx = \frac{\cancel{3}x^3}{\cancel{3}} + \frac{\cancel{2}x^2}{\cancel{2}} = x^3 + x^2 \Big|_0^1 = (1^3 + 1^2) - (0^3 + 0^2)$

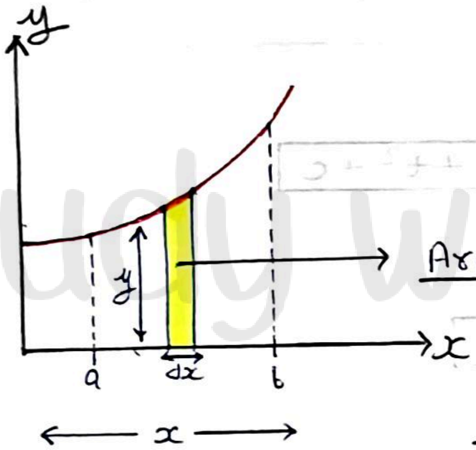
$= \boxed{2}$ Ans

Meaning of Integration :-

$\boxed{\int = \text{Summation}}$

$\boxed{\int_{x_i = a}^{x_f = b} y \cdot dx = \text{Area under curve from } x = a \text{ to } x = b.}$





Area of this strip $= y \cdot dx = dA$ (small area)

$\boxed{\int dA = \int y\, dx}$

$\therefore$ $\boxed{\text{Area from } x = a \text{ to } x = b = \int_a^b y\, dx}$

$x \underset{\text{Integration}}{\overset{\text{Differentiation}}{\rightleftarrows}} v \underset{\text{Integration}}{\overset{\text{Differentiation}}{\rightleftarrows}} a$

$\frac{dy}{dx}$ = Slope of tangent at that point.

$\int y\, dx$ = Area under curve

V-t graph ka area = Change in position (displacement)

a-t graph ka area = Change in velocity

x-t graph ka slope = V

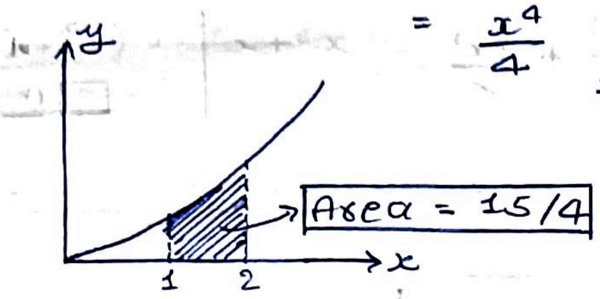
v-t graph ka slope = a

$V = dx/dt$
$a = dv/dt$
Displacement $= \int v\,dt$
Change in velocity $= \int a\,dt$

Ques. 1 $y = x^3$. Find area under curve from $x = 1$ to $x = 2$.

$\Rightarrow$ $$\text{Area} = \int_1^2 y \cdot dx = \int_1^2 x^3 \cdot dx$$

$$= \left.\frac{x^4}{4}\right|_1^2 = \frac{2^4}{4} - \frac{1^4}{4} = \boxed{\frac{15}{4}} \text{ Ans}$$



Ques. 2 At $t = 0$, particle is at $x = 10$. Particle is moving such that its 'V' vs time relation is given as: $\boxed{V = 3t^2 + 2t}$

Find : 1. location of particle at $t = 1$ sec
2. $x = f(t)$

$\Rightarrow$ $V = 3t^2 + 2t$

$$x = \int v.dt = \int (3t^2 + 2t)\,dt = \boxed{t^3 + t^2 + c}$$

$\Rightarrow$ $\underline{x, \text{ at } t = 0} \Rightarrow \underline{t = 10}$

$\therefore$ $10 = 0 + 0 + c \Rightarrow \boxed{c = 10}$

$\Rightarrow$ $x = t^3 + t^3 + 10$

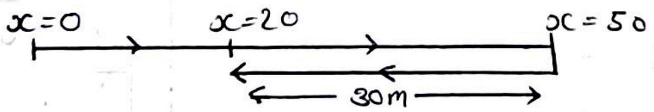
$\Rightarrow$ At $t = 1 \Rightarrow x = 1^3 + 1^2 + 10 = \boxed{12}$ Ans

---

More on Graph

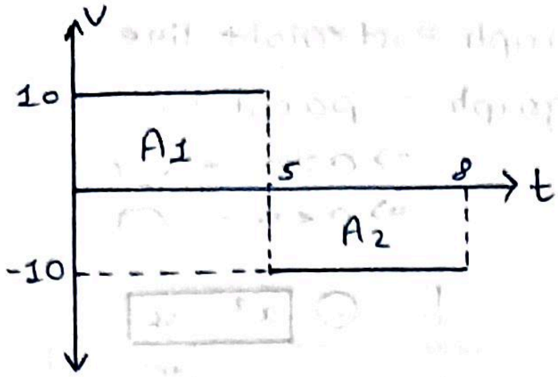
Ques. A particle is moving with velocity $+10$ m/s for 5 sec. along $+x$-axis then it reversed its direction and move with velocity -10 m/s for 3 second. Find distance and displacement.

$\Rightarrow$



$\Rightarrow$ Displacement $= 20 - 0 = \boxed{20\text{ m}}$ Ans

$\Rightarrow$ Distance $= 50 + 30 = \boxed{80\text{ m}}$ Ans



$\Rightarrow$ Displacement $= A_1 - A_2$

$= (10 \times 5) - (3 \times 10)$

$= 50 - 30$

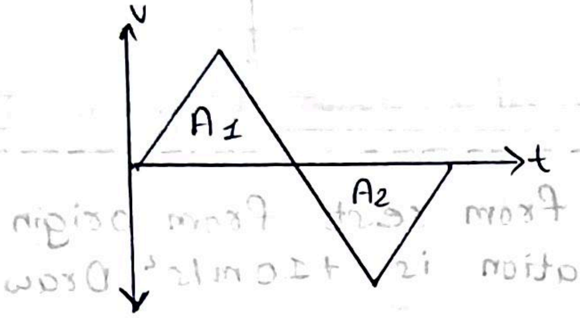
Ans $\Rightarrow$ $\boxed{20m}$

$\Rightarrow$ Distance $= A_1 + A_2$

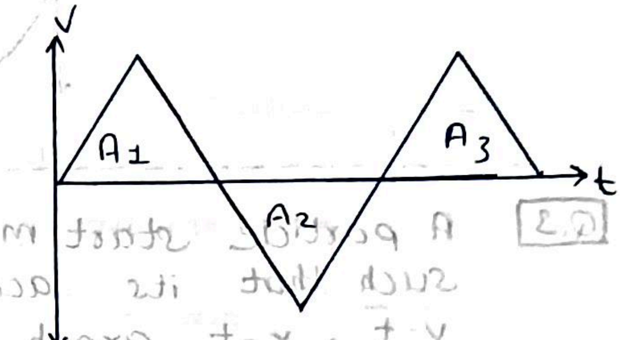
$= 50 + 30$

Ans $\Rightarrow$ $\boxed{80\ m}$

Method of solving distance and displacement from graph

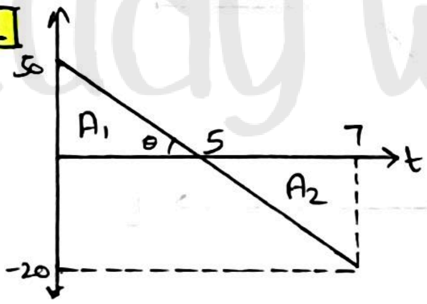


$\boxed{\begin{array}{l}\text{Distance} = A_1 + A_2 \\ \text{Displacement} = A_1 - A_2\end{array}}$



$\boxed{\begin{array}{l}\text{Distance} = A_1 + A_2 + A_3 \\ \text{Displacement} = A_1 - A_2 + A_3\end{array}}$

Q. 1



$\Rightarrow$ $A_1 = \frac{1}{2} \times 5 \times 50 = 125$

$A_2 = \frac{1}{2} \times 2 \times 20 = 20$

$\Rightarrow$ Distance $= A_1 + A_2 = 125 + 20$

$\Rightarrow$ $\boxed{145m}$

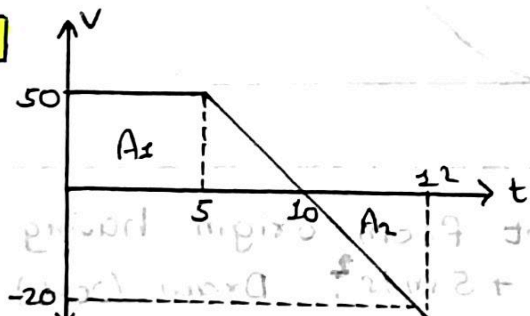
$\Rightarrow$ Displacement $= A_1 - A_2 = 125 - 20$

$\Rightarrow$ $\boxed{105m}$

$\Rightarrow$ Avg. Speed $= \boxed{145/7\ m/s}$

$\Rightarrow$ Avg. velocity $= \boxed{105/7\ m/s}$

Q. 2



Area of trapezium

$= \frac{1}{2}$ (sum of ∥ sides) × ⊥r distance

$\Rightarrow$ Distance $= A_1 + A_2 = 375 + 20$

$\Rightarrow$ $\boxed{395m}$

$\Rightarrow$ Displacement $= A_1 - A_2 = 375 - 20$

$\Rightarrow$ $\boxed{355m}$

$\Rightarrow$ $A_1 = 1/2\,(5+10) \times 50 = 375$

$A_2 = 1/2 \times 2 \times 20 = 20$

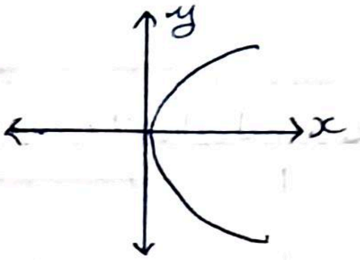
If a = constant $\Rightarrow$ (v-t) graph = straight line.

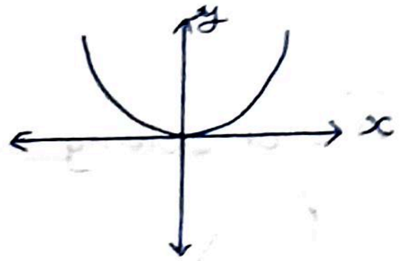
$\Rightarrow$ (x-t) graph = parabola.

$\Rightarrow a > 0 = \cup$

$\Rightarrow a < 0 = \cap$

Parabola : ① $\boxed{y^2 = x}$ ② $\boxed{x^2 = y}$





Q.3 A particle start motion from rest from origin such that its acceleration is $+10\ m/s^2$. Draw v-t, x-t graph.

$\Rightarrow$ $a = +10$

$\frac{dv}{dt} = 10$

$\int dv = \int 10\, dt$

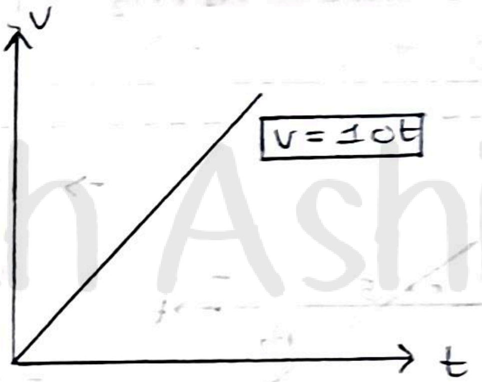
$v = 10t + c$

$\Rightarrow$ at $t = 0, v = 0$

$\therefore 0 = 0 + c$

$c = 0$

$\therefore \boxed{v = 10t}$



$\Rightarrow$ $\frac{dx}{dt} = 10t$

$\int dx = \int 10t \cdot dt$

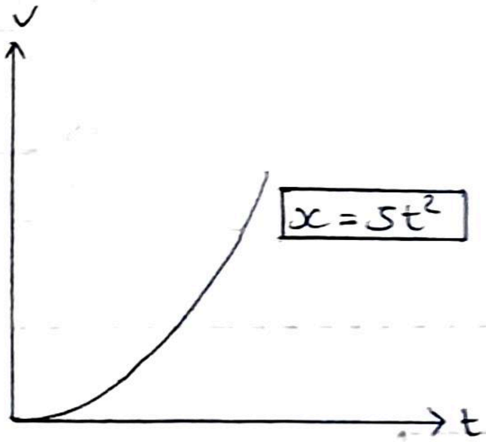
$x = 5t^2 + c$

$\Rightarrow$ at $t = 0, x = 0$

$\therefore 0 = 5 \times 0 + c$

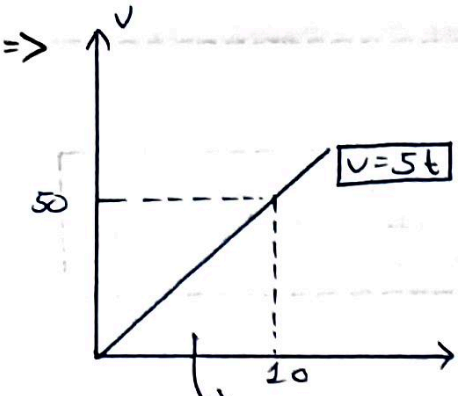
$c = 0$

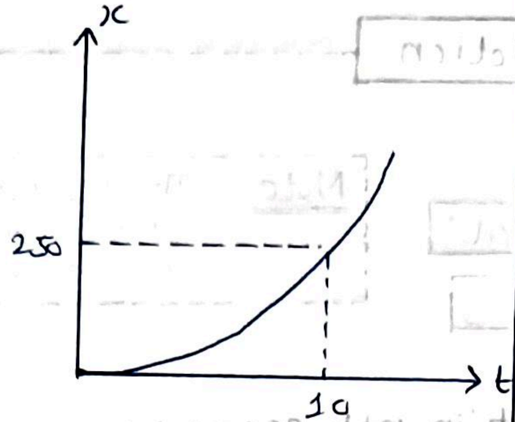
$\therefore \boxed{x = 5t^2}$



Q.4 A particle start from rest from origin having constant acceleration of $+5\ m/s^2$. Draw (x-t) and (v-t) graph from $t = 0$ to $t = 10$ sec

$\Rightarrow$





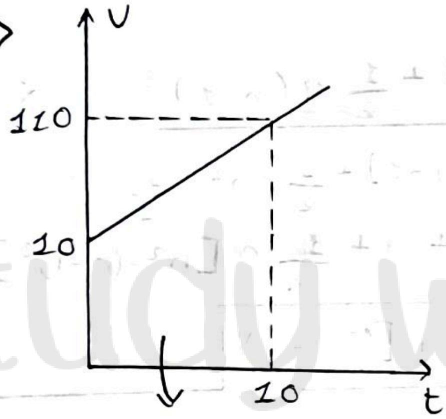
$\Rightarrow v = u + at$
$= 0 + 5 \times 10$
$\therefore \boxed{v = 50}$

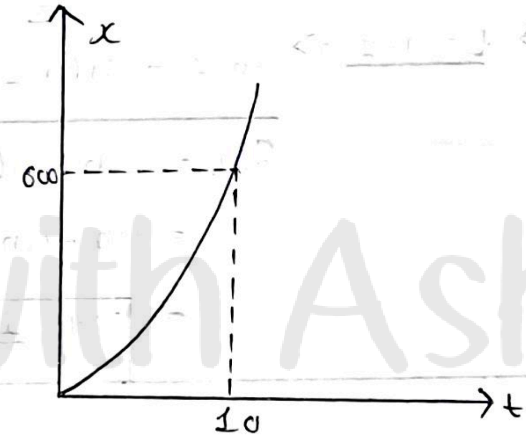
$\Rightarrow s = ut + \frac{1}{2}at^2$
$= 0 + \frac{1}{2} \times 5 \times 1($
$\Rightarrow \boxed{250 = x}$

Area $= 1/2 \times 10 \times 50$
$= \underline{250} = x$

Q.5 A particle start motion having initial velocity +10 m/s and acceleration is +10 m/s. Find v and x by mathematical as well as graphical method.

$\Rightarrow$





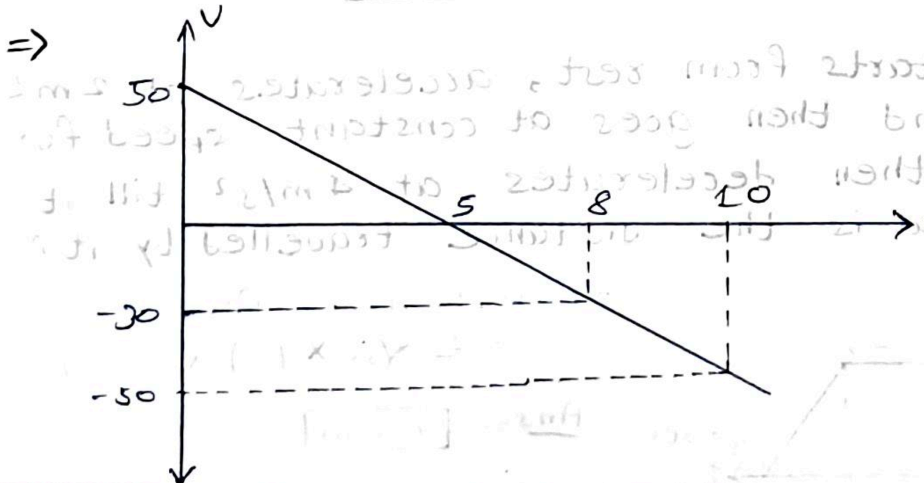
Area $= \frac{1}{2} \times (10 + 110) \times 10$
$= \underline{600} = x$

$\Rightarrow v = u + at = 10 + 10 \times 10 = \boxed{110 \text{ m/s}}$

$\Rightarrow s = ut + \frac{1}{2}at^2 = 10 \times 10 + \frac{1}{2} \times 10 \times 10^2 = 600\text{m}$

Q.6 A particle start motion having initial velocity +50 m/s and acceleration is -10 m/s².

$\Rightarrow$



Equations of Motion

1) $\boxed{v = u + at}$
2) $\boxed{s = ut + \frac{1}{2}at^2}$
3) $\boxed{v^2 = u^2 + 2as}$

Note: These equations are used only if acceleration is constant.

For displacement in nth second :-

$$\boxed{S_{nth} = u + \frac{1}{2}(2n-1)a}$$

Proof

$S_{nth} = S_n - S_{n-1}$

$t=0 \rightarrow t=n \Rightarrow S_n = un + \frac{1}{2}an^2$

$t=0 \rightarrow t=n-1 \Rightarrow S_{n-1} = u(n-1) + \frac{1}{2}a(n-1)^2$

$$S_{nth} = un - u(n-1) + \frac{1}{2}an^2 - \frac{1}{2}a(n-1)^2$$

$$= un - un + u + \frac{1}{2}a[n^2 - (n-1)^2]$$

$$\Rightarrow \boxed{u + \frac{1}{2}a[(2n-1)]}$$

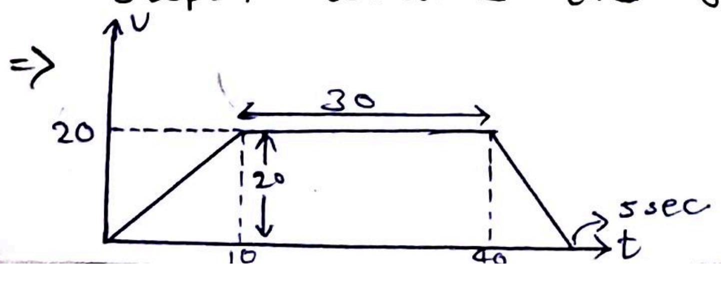
Here in all equations :-

u = initial velocity
v = final velocity
a = acceleration
s = displacement

Question Practice on Equations of Motion

[1] A particle starts from rest, accelerates at $2 m/s^2$ for 10 s and then goes at constant speed for 30 s and then decelerates at $4 m/s^2$ till it stops. What is the distance travelled by it?

$\Rightarrow$



$\Rightarrow$ Distance = Area of graph

$= \frac{1}{2} \times (30 + 45) \times 20 = 750$

Ans $\Rightarrow$ $\boxed{750 m}$

2 A particle start motion having initial velocity 20 m/s and it move with constant acceleration of 10 m/s²

=> (i) Find velocity at $t = 4$ sec.

=> $u = 20\ m/s$

$a = 10\ m/s^2$

$t = 4$ sec.

=> Velocity (v) at 4 sec. $= u + at$

$= 20 + 10 \times 4$

Ans => $\boxed{60\ m/s}$

(ii) Find displacement of particle from $t=0 \rightarrow t = 4$ sec

=> $s = ut + \frac{1}{2} at^2$

$= 20 \times 4 + \frac{1}{\cancel{2}} \times \cancel{10}^{5} \times 4^2$

$= 80 + 80$

Ans => $\boxed{160\ m}$

(iii) Find displacement in 4^{th} second.

M-1 => $S_4 = u + \frac{1}{2}(2n-1)a$

$= 20 + \frac{1}{2}(2 \times 4 - 1) \times 10$

$= 20 + 35$

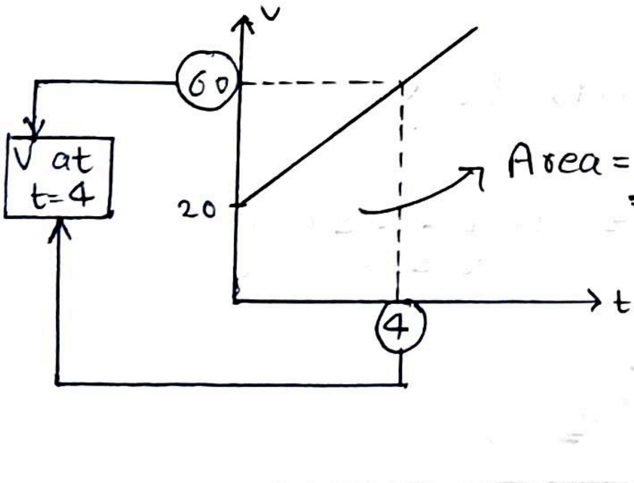
Ans => $\boxed{55\ m}$

M-2 (Without formula) => $t = 0 \rightarrow t = 4$, $S_4 = 20 \times 4 + \frac{1}{2} \times 10 \times 4^2 = 160$

$t = 0 \rightarrow t = 3$, $S_3 = 20 \times 3 + \frac{1}{2} \times 10 \times 3^2 = 105$

=> $S_{4th} = 160 - 105$ => $\boxed{55\ m}$ Ans

=> Solving question (i) and (ii) by graphical method:



Area = displacement from $t = 0 \rightarrow t = 4$ sec.

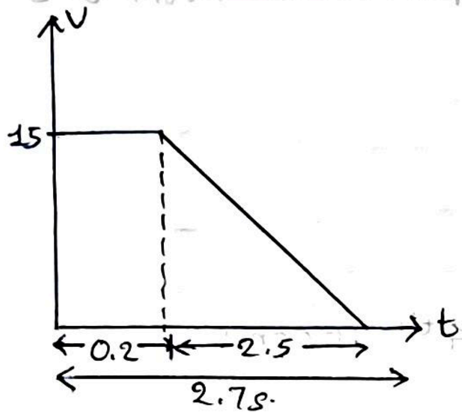
$= \frac{1}{2} \times (20 + 60) \times 4 = 40 \times 4$

$= \boxed{160}$

[3] A driver takes 0.20 s to apply the brakes after he sees a need for it. This is called the reaction time of the driver. If he is driving a car at a speed of 54 km/h and the brakes cause a deceleration of 6.0 m/s², find the distance travelled by the car after he sees the need to put the brakes on.

=> $54 \text{ km/h} = 54 \times \boxed{\frac{5}{18}} = 15 \text{ m/s}$

=>



Putting 2.5sec.
because :-

$a = 6 \text{ m/s}^2$

That means :-

1 sec = 6m

∴ 2.5 sec = 15m

$[15/6 = 2.5]$

=> Distance travelled = Area of trapezium formed

$= \frac{1}{2}(0.2+2.5) \times 15 = \frac{1}{2} \times 2.7 \times 15$

Ans => $\boxed{21.75 \text{ m}}$

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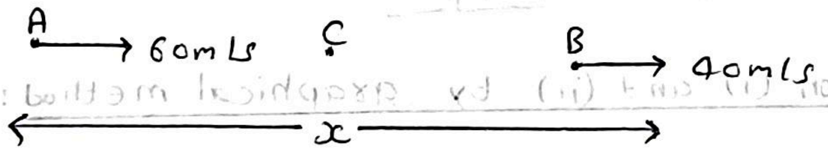
[4] A truck travelling with uniform acceleration crosses two points A and B with velocities 60 m/s and 40 m/s respectively. The speed of the body at the midpoint of A and B is nearest to:

=>



=> Let at middle point C velocity be V_c

=> $A \to B = v^2 = u^2 + 2ax$

$40^2 = 60^2 + 2ax \quad = \quad 2ax = -2000$

$ax = -1000$

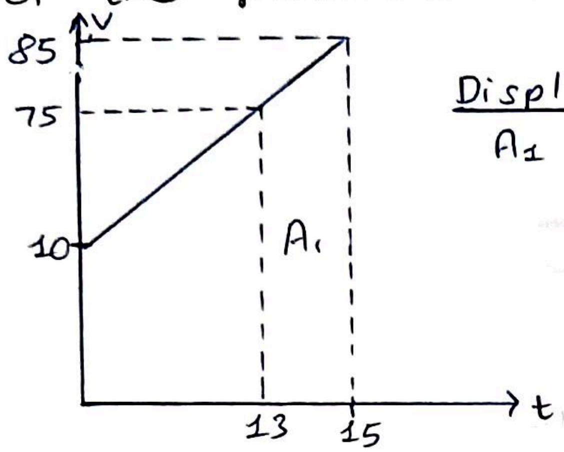
=> $A \to C = V_c^2 = 60^2 - \cancel{2}a\frac{x}{\cancel{2}}$

$V_c^2 = 3600 - 1000 = 2600$

$V_c^2 = 10\sqrt{26} = \boxed{50.9 \text{ m/s approx}}$ Ans

[5] A particle having initial velocity 10 m/s moves with a constant acceleration 5 m/s², for a time 15 s along a straight line, what is the displacement of the particle in the last 2 second?

=>



<u>Displacement in last 2 second:</u>

$$A_1 = \frac{1}{2}(75+85)\times 2 \Rightarrow \boxed{160\,m} \text{ Ans}$$

=> <u>By Mathematical Method:-</u>

$$S_{15} = 10\times 15 + \frac{1}{2}\times 5(15^2)$$

$$S_{13} = 10\times 13 + \frac{1}{2}\times 5(13^2)$$

$$S_{15} - S_{13} = 20 + \frac{5}{2}\left[15^2 - 13^2\right]$$

$$= 20 + 140 \Rightarrow \boxed{160\,m} \text{ Ans}$$

---

[6] A bullet moving with velocity of 200 cm/s penetrates a wooden block and comes to rest after travelling 4 cm inside it. What velocity is needed for travelling distance of 9 cm in same block?

=> $u = 200\,cm/s = 2\,m/s$

$v = 0\,m/s$

$s = 4\,cm = \frac{4}{100}\,m$

=> $v^2 = u^2 + 2as$

$0^2 = 2^2 + 2a\times\frac{4}{100}$

$-4 = \frac{8}{100}a$

$\therefore \boxed{a = -50\,m/s^2}$

=> Now, required velocity $\Rightarrow 0^2 = u^2 + \cancel{2}\times(-\cancel{50})(9/\cancel{100})$

$\Rightarrow 0^2 = u^2 + (-9)$

$u^2 = 9$

$\therefore \boxed{u = 3\,m/s}$

7 A bullet going with speed 350 m/s enters a concrete wall and penetrates a distance of 5 cm before coming to rest. Find the deceleration.

⇒ $u = 350\ m/s$

$v = 0\ m/s$

$s = \frac{5}{100}\ m = \frac{1}{20}\ m$

$a = ?$

⇒ $\boxed{v^2 = u^2 + 2as}$

$0 = 350^2 + \cancel{2}a \times \frac{1}{\cancel{20}\,10}$

$0 = 350^2 + \frac{a}{10}$

$a = -(350)^2 \times 10$

$\therefore \boxed{a = -1225000\ m/s^2}$ Ans

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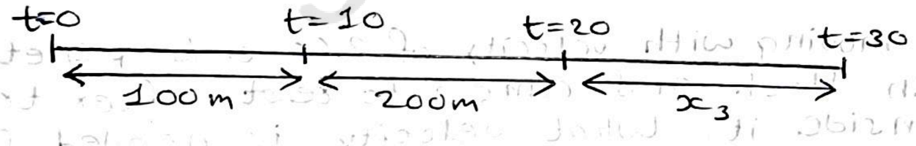
8 A particle covered 100 m distance in first 10 s. In next 10 s it travel 200 m. Find distance ~~ta~~ travelled in next 10 sec.

⇒



⇒ Let initial velocity be '~~a~~u' and acceleration be 'a'

⇒ let required distance be x_3

⇒ $t=0 \rightarrow t=10$ ⇒ $100 = u \times 10 + \frac{1}{2} a\, 10^2$

$\boxed{100 = 10u + 50a}$ ... (1)

⇒ $t=0 \rightarrow t=20$ ⇒ $200 = u \times 20 + \frac{1}{2} a\, 20^2$

$\boxed{300 = 20u + 200a}$ ... (2)

$\boxed{150 = 10u + 100a}$ ... (3)

=> Subtracting ③ - ①:-

$50 = 50a$

$\therefore \boxed{a = 1}$
$\boxed{u = 5}$

=> $t = 0 \rightarrow t = 30$ => $300 + x_3 = 5 \times 30 + \frac{1}{2} \times 1 \times 30^2$

=> $300 + x_3 = 150 + 450$

$\therefore \boxed{x_3 = 300\,m}$ Ans

$\boxed{9}$ A particle, after starting from rest, experiences constant acceleration for 20 seconds. If it covers a distance s_1, in first 10 seconds, and distance s_2 in next 10 seconds, then

(a) $s_2 = s_1/2$ (b) $s_2 = s_1$ (c) $s_2 = 2s_1$ (d) $s_2 = 3s_1$

=> $s_1 = 0 + \frac{1}{2} . a . 10^2$

$s_1 + s_2 = 0 + \frac{1}{2} . a . 20^2$

=> $\frac{s_1 + s_2}{s_1} = \frac{400}{100}$

=> $1 + \frac{s_2}{s_1} = 4$

=> $\frac{s_2}{s_1} = 3$

$\therefore \boxed{s_2 = 3s_1} \Leftarrow$ Ans => $\boxed{\text{Option (d)}}$

$\boxed{10}$ A particle start motion from origin towards +x axis with initial velocity 60 m/s and constant acceleration $-10\,m/s^2$.

(i) When particle will come to at rest?

=> $v = u + at$

$0 = 60 + (-10)t$

$-60 = -10t$

$\therefore \boxed{t = 6\,sec}$ Ans

(ii) Find 'v' at $t=2$ and 'v' at $t=10$ sec.

$\Rightarrow$ at $t=2$ $\Rightarrow$ $v = 60 + (-10)2$

$v = 60 - 20$

$v = \boxed{40 m/s}$ Ans

$\Rightarrow$ at $t=10$ $\Rightarrow$ $v = 60 + (-10)10$

$v = 60 - 100$

$v = \boxed{-40 m/s}$ Ans

(iii) Displacement in 10 second.

$\Rightarrow$ $s = 60 \times 10 + \frac{1}{2}(-10) \times 10^2$

$= 600 - 500 = \boxed{100 m}$ Ans