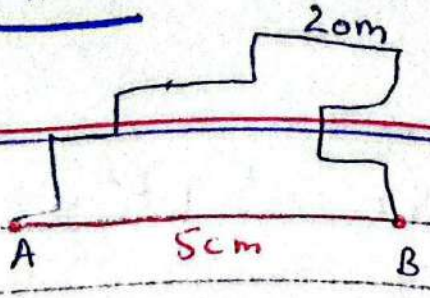
Chapter # 5



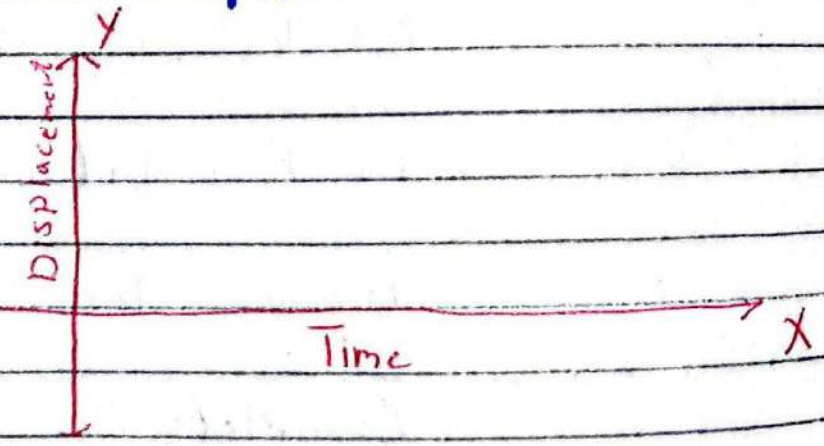
Distance = 20m

Displacement = 5cm (The shortest distance b/w two points is called displacement)

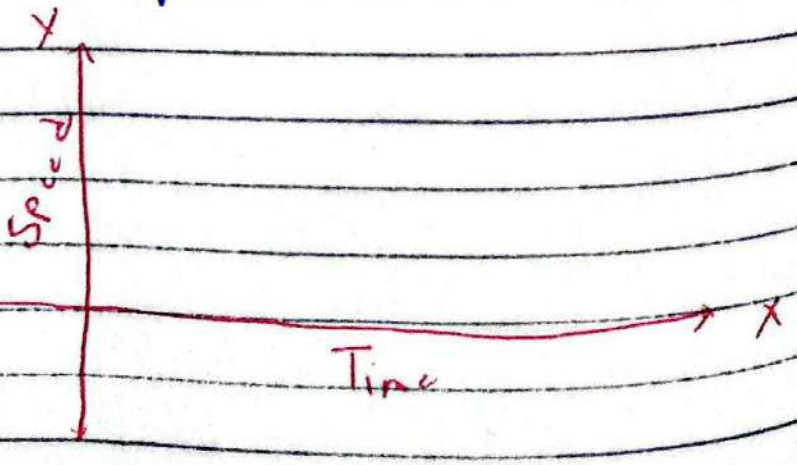
$$\text{Speed} = \frac{\text{Distance}}{\text{time}} \quad \text{(scalar)}$$

$$\text{Velocity} = \frac{\text{Displacement}}{\text{time}} \quad \text{(vector)}$$

Displacement Time Graph:



Speed Time Graph:



Exc 5.1

Q#1 A cyclist rides in a straight line for 20 minutes. He waits for half an hour, then return in a straight line to his starting point in 15 minutes. This is a displacement time graph for his journey.

i) Work out the average velocity for each stage of the journey in km/hr.

Stage 1 OA

(final - initial)

Average Velocity = $\frac{\text{Change in displacement}}{\text{time}}$

Change in displacement = 5km

Time of Journey = 20 min

Change in hour = $\frac{20}{60} = \frac{1}{3}$ hr

$= \frac{\Delta d}{t}$

$= \frac{5-0}{1/3\ hr} = \frac{5 \times 3}{1}$

$V = 15$ km/hr

Stage 2 AB (No change in displacement)

Average velocity = $\frac{\Delta d}{t}$

$= \frac{5-5}{1/2\ hr} = \frac{0}{1/2} = 0$ km/hr

Time of Journey = 30 min

Change in hour = $\frac{30}{60} = \frac{1}{2}$ hr

$V = 0$ km/hr

Stage 3 BC

Average velocity = $\frac{\Delta d}{t}$

$= \frac{0-5}{1/4} = -5 \times \frac{4}{1}$

$= -20$ km/hr

Time of Journey 15 min

Change in hours = $\frac{15}{60}$

$= \frac{1}{4}$ hr

(ii) Write down the average velocity for the whole journey.

Whole Journey = $\frac{\text{Total displacement}}{\text{Total time}}$ = Velocity

• Average Velocity = $\frac{5+0-5}{13/12} = \frac{0}{13/12} = 0$ km/hr

• Total time = $\frac{1}{3} + \frac{1}{4} + \frac{1}{2}$

$= \frac{4+3+6}{12}$

$= \frac{13}{12}$ hr

(iii) Work out the average speed for the whole journey.

• Displacement (-ve) ہو سکتا ہے۔ لیکن distance (-ve) نہیں ہوتا۔

Average Speed = $\frac{\text{Distance}}{\text{time}} = \frac{5+0+5}{13/12}$

$= \frac{10}{1} \times \frac{12}{13} = \frac{120}{13} = 9.23 \text{ km/hr}$

(2) This is a displacement - time graph for a car travelling along a straight road. The journey is — — — —

(i) Work out the average velocity for each stage of the journey.

Stage 1 OA

Average velocity = $\frac{\text{Change in displacent}}{\text{Find - initial Change in time.}}$

$V_{avg} = \frac{40 - 0}{1/2} = 80 \text{ Km/hr}$

• Time in minutes = 30 min

" " hours = $\frac{30}{60} = \frac{1}{2}$ hr

Stage 2 AB

Average velocity = $\frac{60-40}{\frac{1}{2}\text{hr}} = \frac{20}{\frac{1}{2}\text{hr}} = 40\text{km/hr}$

Time = 30 min

In hour = $\frac{30}{60} = \frac{1}{2}\text{hr}$

Vavg = 40m km/hr

Stage 3 BC

Average velocity = $\frac{60-60}{\frac{1}{2}\text{hr}} = \frac{0}{\frac{1}{2}} = 0\text{km/hr}$

Vavg = 0 km/hr

Stage 4 CD

Average velocity = $\frac{100-60}{1\text{hour}} = 40\text{ km/hr}$

Stage 5 DE

Average velocity = $\frac{0-100}{\frac{3}{2}\text{hr}}$

Time = 90 min

In hour = $\frac{90}{60} = \frac{3}{2}\text{hr}$

$= -100 \times \frac{2}{3}$

$= \frac{-200}{3}$

$= -66.67\text{ km/hr}$

(ii) State the average velocity for the whole Journey.

Whole Journey: $V_{avg} = \frac{\text{Total displacement}}{\text{Total time}}$

Total displacement $= 40 + 20 + 0 + 40 - 100 = 0$

Total time $= \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{1} + \frac{3}{2}$

$= \frac{1+1+1+2+3}{2}$

$= \frac{8}{2} = 4$ hour.

$V_{avg} = \frac{0}{4} = 0$ km/hr.

(iii) Work out the average speed for the whole journey.

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

$= \frac{40+20+0+40+100}{4}$

$= \frac{200}{4}$

$= 50$ km/hr.

imp

Q#3 Fatima Left home at 10:00 and cycled north east in a straight line.

(i) Find the Fatima velocity b/w 10:00 and 11:00. on her return journey, Fatima continued Passed here home before returning.

Sol

Velocity = OA

$$\text{Velocity} = \frac{\text{Change in displacement}}{\text{Change in time}}$$

$$V = \frac{\text{Final} - \text{initial}}{\Delta t}$$

$$V = \frac{12 - 0}{1\ hr}$$

$$V = 12\ km/hr$$

(ii) Estimate the time that Fatima Passed her home.

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

time = ?

$$\text{time} = \frac{\text{displacent}}{\text{velocity}}$$

$$= \frac{\text{Final} - \text{initial}}{\text{Velocity}}$$

time = $\frac{0-12}{-32/3}$ = $-12 \times \frac{-3}{32}$

= $\frac{36}{32}$ = 1.125 hr

time = 1.125 hr

Chang in minute and second.

= 1 hr + 0.125

= 1 + $\left(\frac{0.125}{100} \times 60\right)$ min

= 1 + $\frac{750}{100}$

= 1 hr + 7.5 min

= 1 hr + 7 min + 0.5 min

= 1 hr + 7 min + (0.5 × 60) sec

= 1 hr 7 min 30 sec

Velocity For BC

V_2 = $\frac{\text{displacent}}{\text{time}}$

V_2 = $\frac{\text{find} - \text{initid}}{\text{time}}$

V_2 = $\frac{-4-12}{1.5\,hr}$

V_2 = $\frac{-16}{1.5}$ = $-\frac{32}{3}$

V_2 = −10.667 km/hr

Time:

Start = 11:30

+ 1 hr

= 12:30

= + 7 min

= 12:37

= + 30 sec

= 12:37:30 Ans.

(iii) Find Fatima velocity for each of the last two stages for her journey.

Stage BC

$$V = \frac{\text{displacement}}{\text{time}}$$

$$V = \frac{-4 - 12}{1.5\text{hr}}$$

$$V = \frac{-16}{1.5}$$

$$V = -\frac{32}{3}$$

$$V = -10.667 \text{ km/hr}$$

Velocity CD

$$V = \frac{\text{displacement}}{\text{time}}$$

$$V = \frac{\text{final} - \text{initial}}{\text{time}}$$

$$V = \frac{0 - (-4)}{1}$$

$$V = \frac{4}{1}$$

$$V = 4 \text{ km/hr}$$

(iv) Calculate fatima average speed for her entire Journy.

Average speed = $\frac{\text{Distance}}{\text{time}}$

Distance = $\frac{12 + 0 + 16 + 4}{4\ hr}$ = 8 km/hr.

(iv) Calculate fatima average speed for her entire Journy.

$$\text{Average speed} = \frac{\text{Distance}}{\text{time}}$$

$$\text{Distance} = \frac{12 + 0 + 16 + 4}{4\ hr} = 8\ km/hr.$$

Q#4 An electric train starts from the rest at a station A and moves along a straight level track. The train — — .

Sol.

• $V_i = 0\ m/s$ (initial speed)	• acceleration $a = 0.4\ m/s^2$	• $V_f = 16\ m/s$ (Final speed)	• $t = ?$

i) Find the total time taken.

To find the total time taken. There are 3-stages in this journey.

Stage 1: Acceleration with initial and final velocity Given

• $V_f = V_i + at$ —(i) (First eq of motion)

$16 = 0 + 0.4t$

$\frac{16}{0.4} = t$

$t = 40\ sec$

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

$S = 0.t + \frac{1}{2}(0.4)(40)^2$

$S = 320\ m$

Stage 2 : Constant Speed with displacement Given.

Speed = 16 m/sec, Displacement = 2000m

t = ?

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

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

$$t = \frac{2000}{16} = 125 \text{ sec.}$$

Stage 3 : رفتار کم ہو رہی ہے۔

Retards (De-Acceleration)

(At rest its final velocity is Zero)

$t = 20$ sec $\quad V_F = 0$

$V_i = 16$ m/sec

$S = V_i t + \frac{1}{2} a t^2$ (2nd eqn of motion)

$V_F = V_i + at$

$0 = 16 + a \cdot 20$

$\frac{-16}{20} = a \quad a = -0.8 \text{ m/sec}^2$

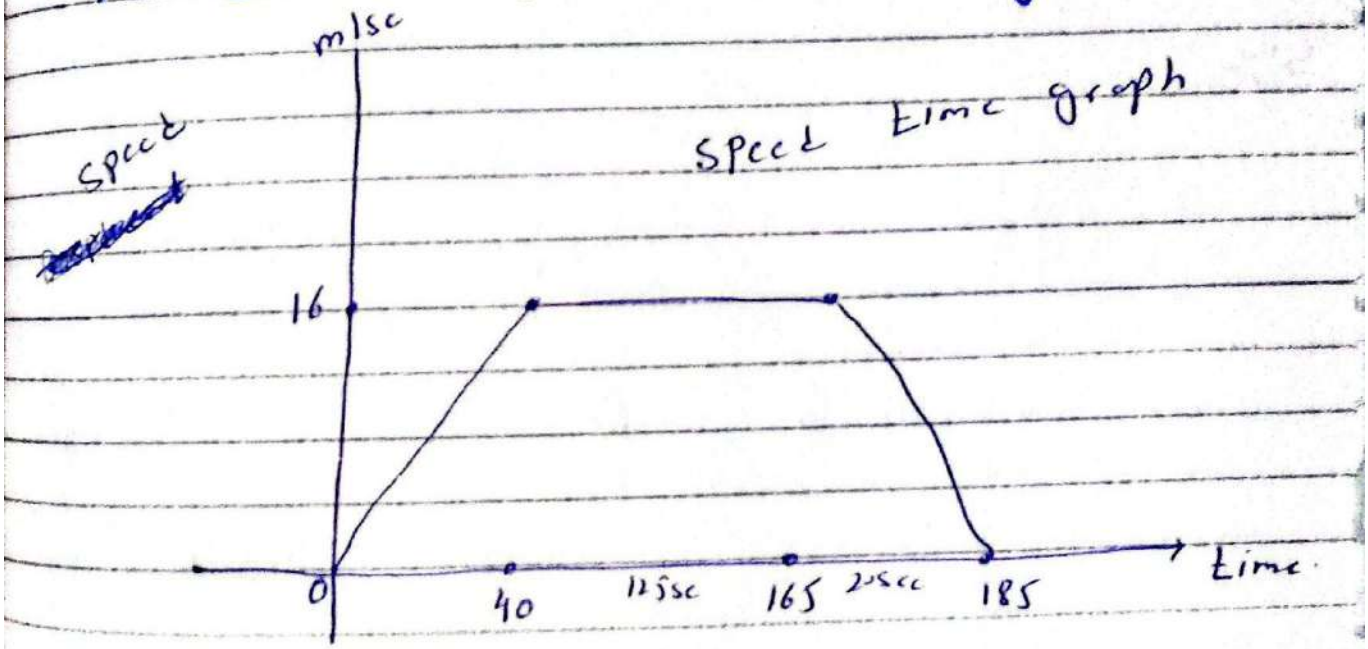
$S = 16 \cdot 20 + \frac{1}{2}(-0.8)(20)^2$

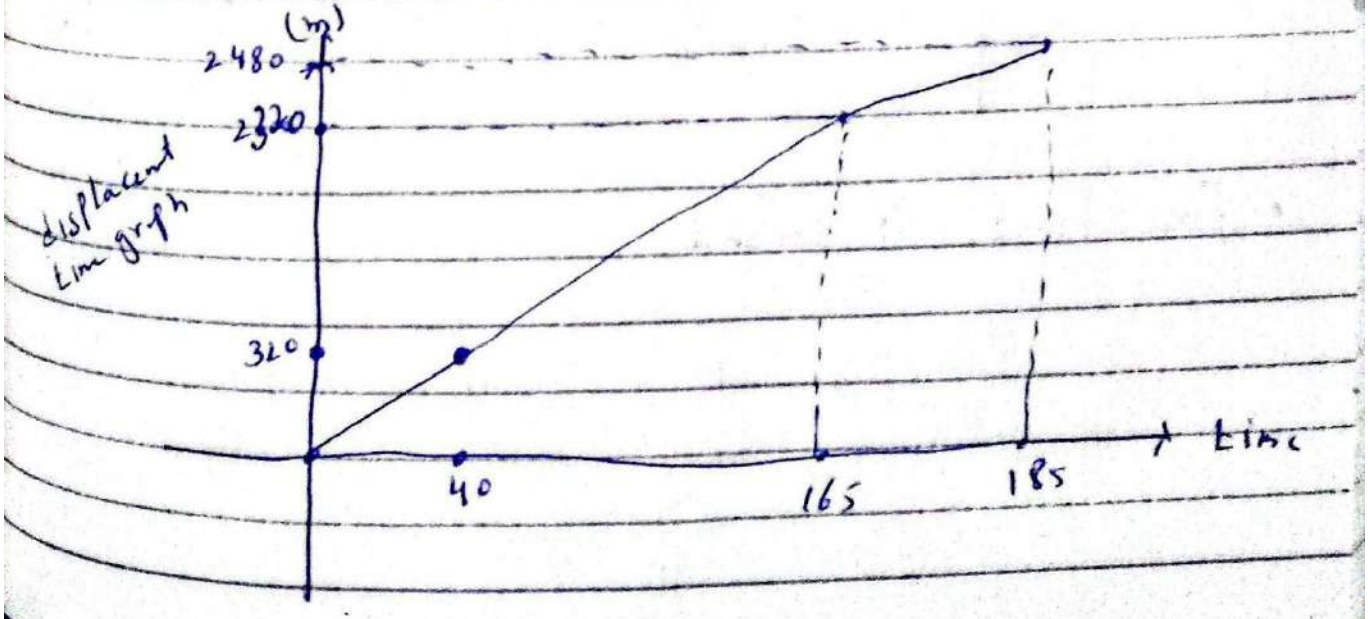
$\boxed{S = 160 \text{ m}}$

i) Total time = 40 + 125 + 20 = 185sec = 3min 5sec

ii) Find total displacent: 320 + 2000 + 160 = 2480 m

iii) Sketch the displacement time graph showing clearly the shape of the graph for each stage of the journey.



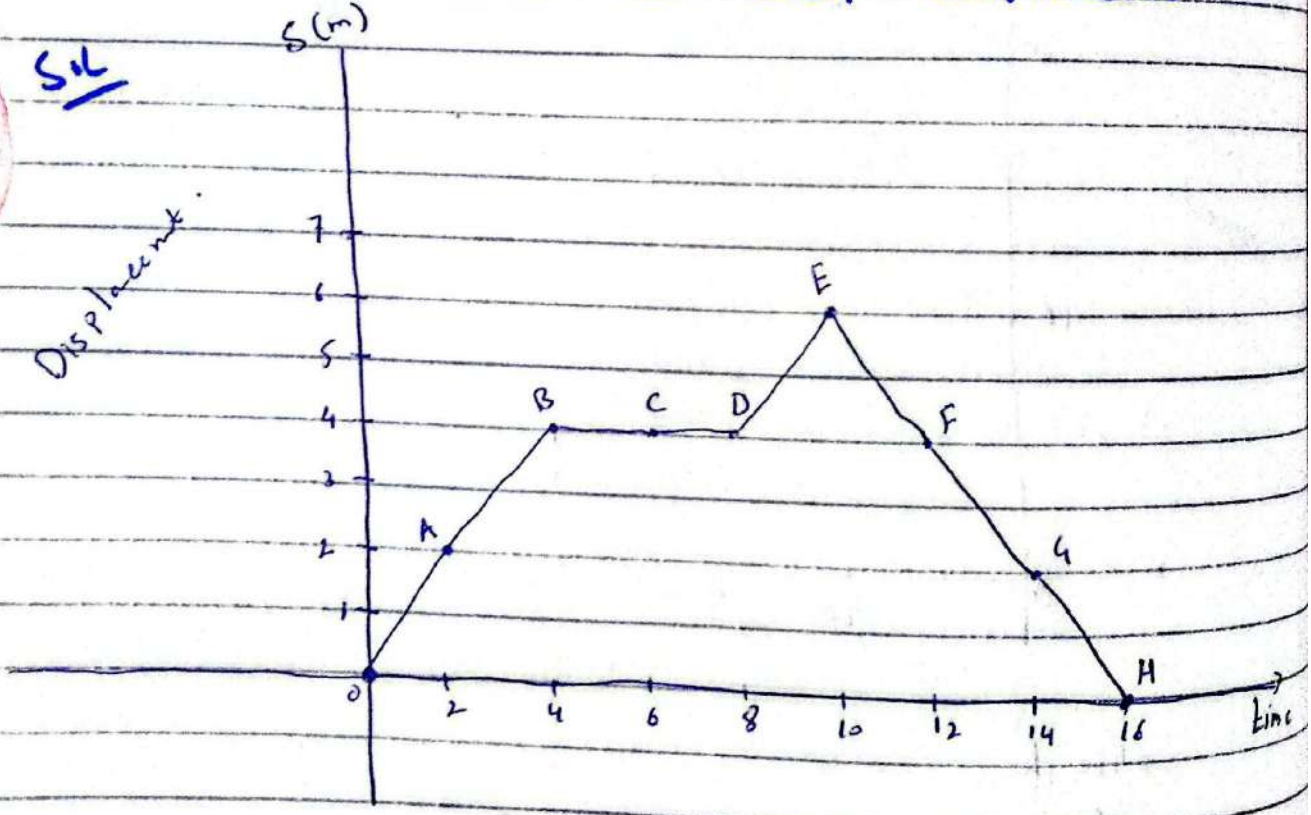


(5) Using th following data, draw time displacemet graph For a moving object.

Time	0	2	4	6	8	10	12	14	16
Displacement	0	2	4	4	4	6	4	2	0

Use the graph to find average velocity For First 4 sec, For next 4 sec and For Last 6 sec and th total displacemt.

Sol



- For First 4 second

$$\text{Velocity} = \frac{\text{Displacement}}{\text{time}} = \frac{\Delta S}{\Delta t}$$

$$= \frac{4-0}{4-0} = 1 \text{ m/sec}$$

• Next 4 second

Velocity = $\frac{\text{Change in displacent}}{\text{time}}$

= $\frac{4-4}{8-4}$ = $\frac{0}{4}$ = 0m/sec

• for Last 6 second (10sec to 16sec)

velocity = $\frac{\text{final} - \text{initial}}{\text{time}}$ = $\frac{0-6}{16-10}$

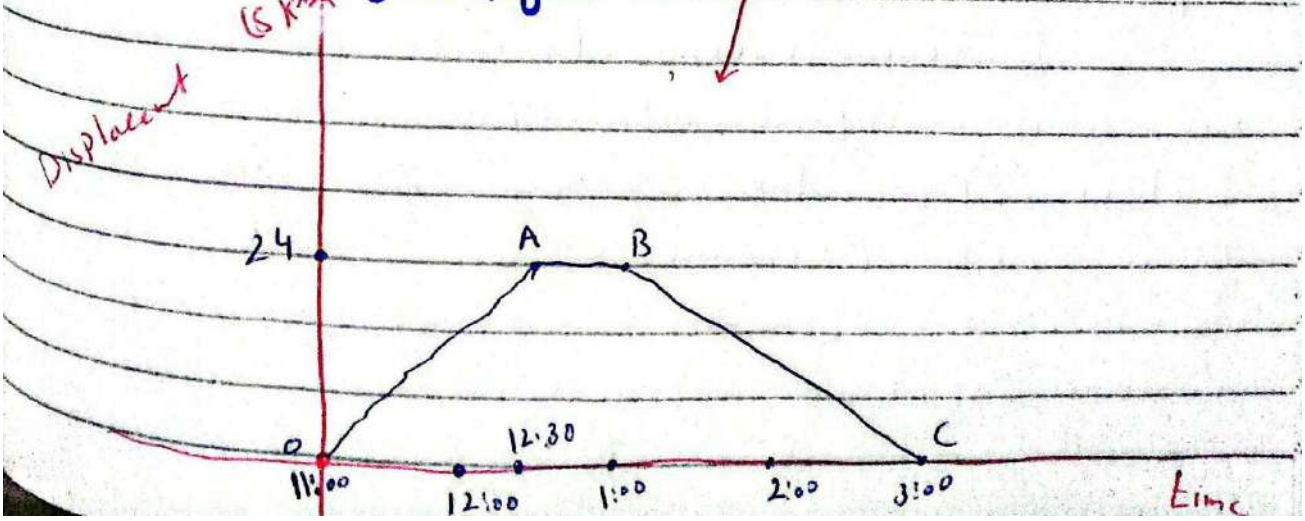
$\frac{-6}{6}$ = -1m/sec

Total displacent = 2+2+0+2+(-2)-2-2

= 0m

⑥ Ahmed Leaves home at 11:00 am. He cycles at a speed of 16 Km/hr for 90 min. He stops for half an hour

i) Draw a displacement time graph to show Ahmed's journey.



Stage 1 : 90 min

$\frac{90}{60} = 1.5$ hr

Displacement = ?

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

Displacement = velocity x time

= 16 x (1.5 hr)

$S = 24$ km

(ii) What is Ahmed's average speed on the return part of his cycle.

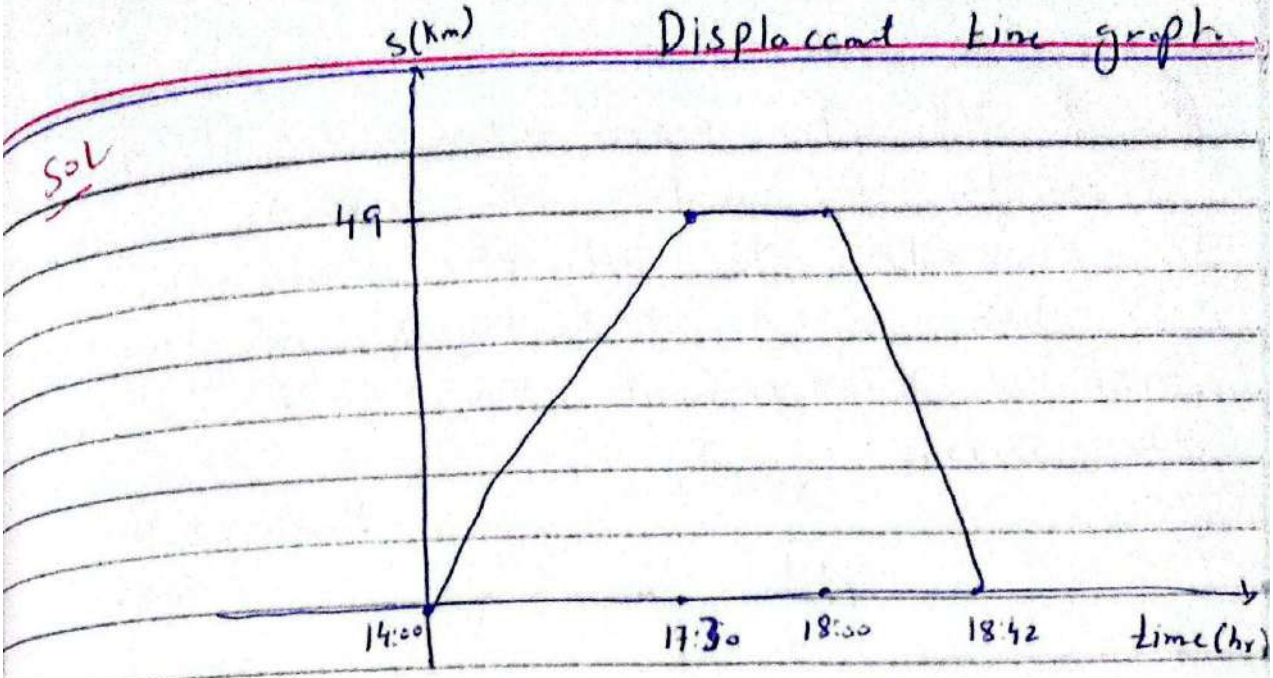
Speed = $\frac{\text{Distance}}{\text{time}}$

= $\frac{24}{2} = 12$ km/hr

Q#7

Dabeer leaves at 14:00. He drives at an average speed of 14 km/hr for $3\frac{1}{2}$ hours. Dabeer stops for 30 min. He then drives home at 70 km/hr.

Draw a displacement - time graph to show dabee's journey.



- time : 3.5 hr

Speed : 14 km/hr

Displacement: velocity x time

$S = 14 \times 3.5$

$\boxed{S = 49 \text{ km}}$

- Speed = 70 km/hr time = ?

displacement = 49

Speed = $\frac{\text{displacement / distance}}{\text{time}}$

time = ?

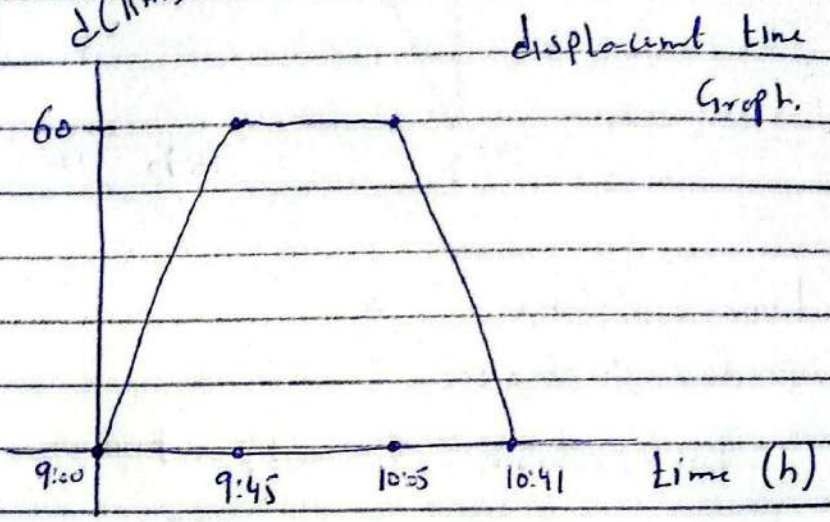
$\text{time} = \frac{\text{distance}}{\text{speed}} = \frac{49}{70} = 0.7 \text{ hr}$

$t = \frac{0.7}{1\phi} \times 6\phi$

$t = 42 \text{ min}$

(8) A helicopter leaves islamabad at 9:00. It flies for 45 minutes at 80 km/hr. It lands for 20 minutes. The helicopter then return to its base in islamabad, flying at 100 km/hr. Draw a displacement - time graph to show the journey.

Sol



displacement time Graph.

- time = 45 min = $45/60$ hr = 0.75 hr

Speed = 80 km/hr

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

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

$$= 80 \times \frac{45}{60}$$

$$= 80 \times 0.75$$

$$\boxed{\text{Distance} = 60 \text{ km}}$$

- Return

$d = 60$ km $t = ?$ Speed = 100 km/hr

$$\text{Time} = \frac{\text{Distance}}{\text{Speed}} = \frac{60}{100} = 0.6 \text{ hr}$$

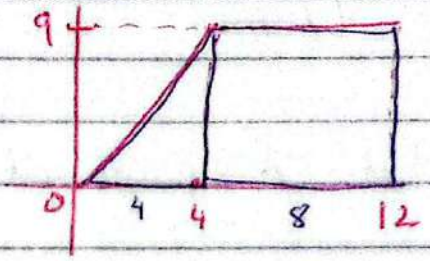
time = $\frac{0.6}{10} \times 60$

time = 36 min.

time = $\frac{0.6}{10} \times 60$

time = 36 min.

Q The diagram shows the velocity time graph of the motion of an athlete running along a straight track. For the first 4 sec, he accelerates uniformly from rest to - - - - -



(i)

Sol Acceleration = ?

$$a = \frac{\text{change in velocity}}{\text{Change in time}} = \frac{\Delta v}{\Delta t}$$

$$a = \frac{9-0}{4-0} = \frac{9}{4} = 2.25\ m/s^2$$

(ii)

$V = \frac{d}{t}$: For constant velocity

displacement

We cannot use this formula for finding

First we calculate displacement of First 4 seconds (0 - 4) sec

Find Area Under the curve.

Area of A = $\frac{1}{2}$ (L) (W)

Displacement = $\frac{1}{2}$ (4) · (9) = 18m

d = 18m

• Second we calculate the displacement for last 8 second. (4-12)

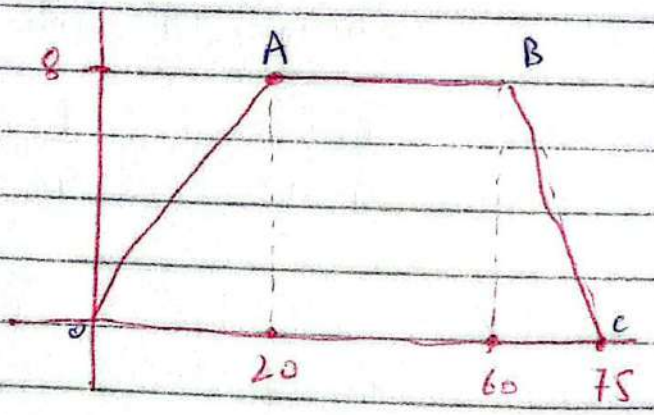
Two methods

Velocity: Displacement / time	Area of rectangle: L x W
D = V . t	= 8 x 9
D = 9 . 8	= 72 m
D = 72 m	

Total displacement: d = 72 + 18

d = 90 m.

(10)



(i) The acceleration of the cyclist in the first 20 second of motion.

(0 to 20)

$$a = \frac{\Delta v}{\Delta t} = \frac{8-0}{20} = \frac{8}{20} = 0.4\ m/sec^2$$

iii) The deceleration of the cyclist in the last 15 sec of the motion (60 to 75)

$$a = \frac{\Delta v}{\Delta t} = \frac{0 - 8}{75 - 60} = \frac{-8}{15} = -0.53 m/s^2$$

iii) The displacement from the starting point of the cyclist after 75 sec.

- Displacement (0 to 20)

Area of triangle = $\Delta = \frac{1}{2} L \times W$

Displacement = $\frac{1}{\cancel{2}_1} \times \cancel{20}^{10} \times 8 = 80 m.$

- Displacement (20 to 60)

Area of rectangle = $L \times W$.

Displacement = $40 \times 8 = 320 m.$

- Displacement (60 to 75)

Area of triangle = $\frac{1}{2} L \times W$

$= \frac{1}{\cancel{2}_1} 15 \times \cancel{8}^4$

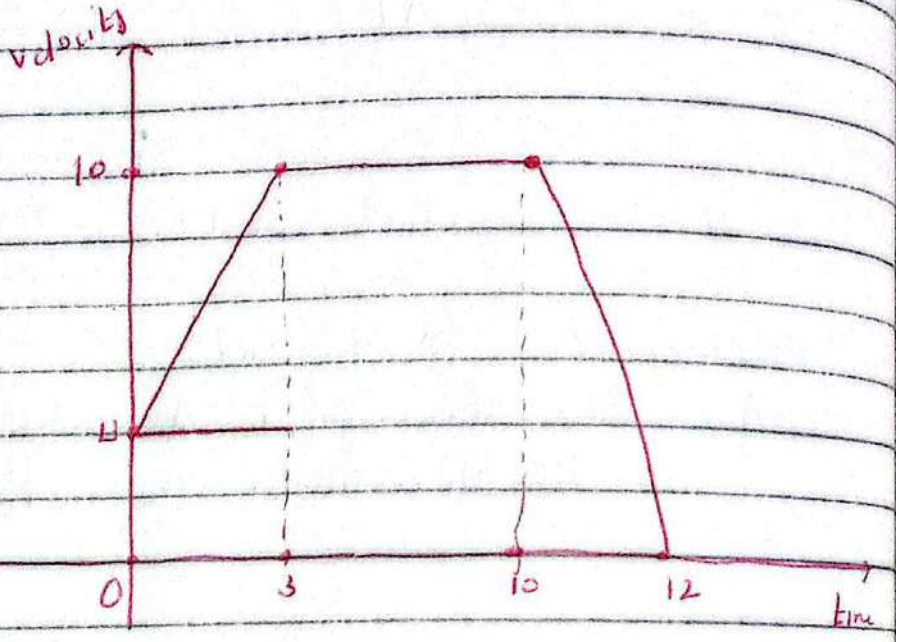
$= 60 m.$

Total displacement = $80 + 320 + 60$

$= 460 m.$

(11) A particle moves loom in a straight Line. The diagram is a sketch of velocity time graph of the motion

Sol:



(i) First Find displacement From (0 to 3)
(From 0 to 3) Two diagrams.

Rectangle	+	Triangle
d_1 = L x W	+	$d_2 = \frac{1}{2}$ L x W
$d_1 = 3 \times 4$	+	$d_2 = \frac{1}{2} \cdot 3 \times (10-4)$
$d_1 = 3U$	+	$d_2 = \frac{30}{2}(10-4)$

$d_1 + d_2 = 3U + \frac{3}{2}(10-4)$

$$d_1 = \frac{3}{2}U + 15$$

. Second find displacement from 3 to 10.

Area of rectangle = L x W

$d_2 = 7 \times 10$

$d_2 = 70\,m$

. Third find displacement from 10 to 12

Area of triangle = $\frac{1}{2}$ L x W

$d_3 = \frac{1}{2} \cdot 2 \cdot 10$

$d_3 = 10\,m$

Total distance = $d_1 + d_2 + d_3$

$100 = \frac{3}{2}U + 15 + 70 + 10$

$100 - 95 = \frac{3}{2}U$

$\frac{10}{3} = U$ $\quad U = \frac{10}{3}$ m/sec.

(ii) The acceleration of the particle in the first phase of motion.

Acceleration = $\frac{\Delta V}{\Delta t}$

$= \frac{10 - 0}{3 - 0}$

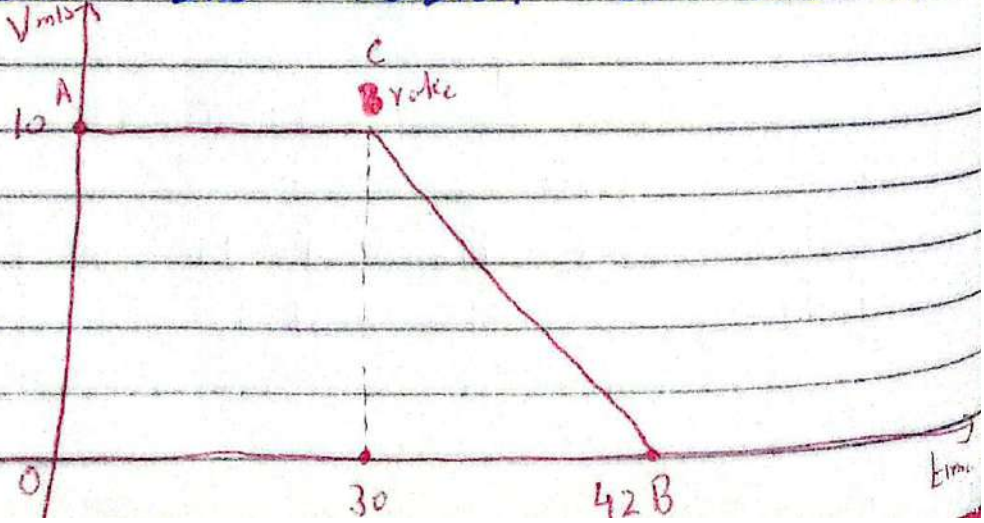
$a = \frac{10 - 0}{3}$

$a = \frac{10 - 10}{\frac{1}{3}}$

$a = \frac{20}{3} \times \frac{1}{3} = \frac{20}{9}\ m/sec^2$

(12) A car is moving along a straight road. When $t = 0s$, the car passes a point A with velocity 10m/sec and this velocity is maintained until $t = 30sec$

(i) Sketch a velocity time graph to illustrate the motion of the car.



(iii) Find the distance From A to B

. Distance (0 to 30) sec

Area of rectangle = L x W

$d_1 = 30 \times 10$

$d_1 = 300$ m

. Distance (30 to 42) sec

Area of triangle = $\frac{1}{2}$ L x W

$d_2 = \frac{1}{2} \times 12^6 \times 10$

$d_2 = 60$ m

Total distance From A to B

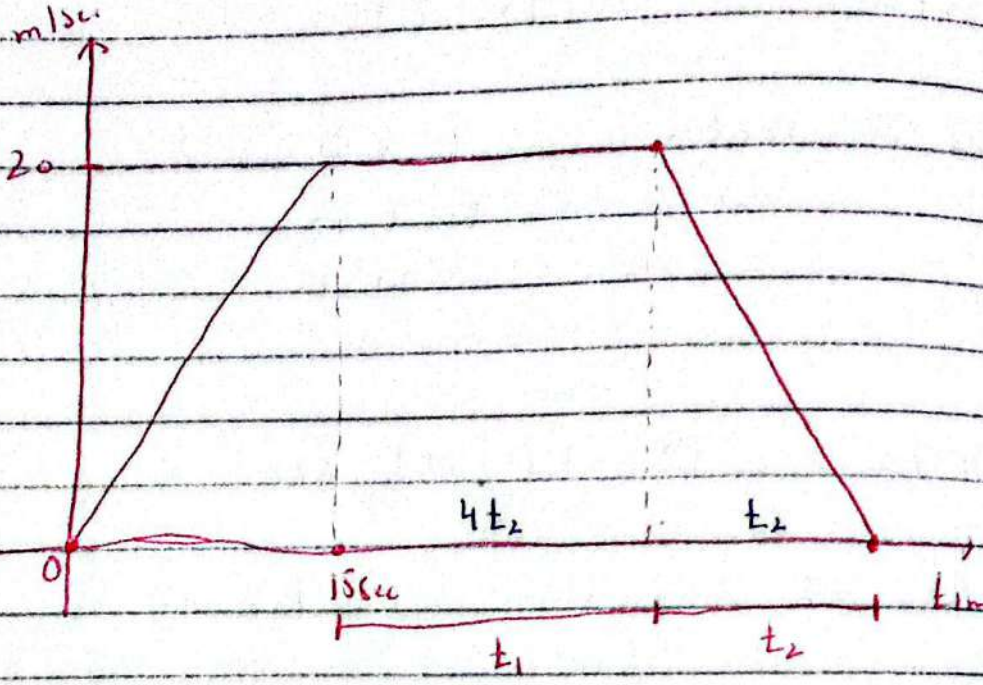
$d = d_1 + d_2$

$d = 300 + 60$

$d = 360$ m. Ans.

(13) A particle moves along a straight line. The particle accelerates From rest to a velocity of 20m/sec in 15 sec. The Particle then moves at a constant velocity of 20m/sec For a period of time

(i) Sketch a velocity time graph to illustrate the motion of the particle.



sol

time decelerating = t_2

time Constant velocity = $t_1 = 4t_2$

Total displacement = 480

$d_1 + d_2 + d_3 = 480$

triangle + rectangle + triangle = 480

$$\left[\frac{1}{2} \times 15 \times \frac{10}{20}\right] + \left[t_1 \times 20\right] + \left[\frac{1}{2} t_2 \times \frac{10}{20}\right] = 480$$

$$\left[150 + 4t_2 \times 20 + \frac{1}{2} 10 t_2\right] = 480$$

$$150 + 80t_2 + 10t_2 = 480$$

$90 t_2 = 480 - 150$

$90 t_2 = 330$

$t_2 = \frac{330}{90} = \frac{11}{3} = 3.67 \text{ sec}$

$t_1 = 4 t_2$

$t_1 = 4(3.67)$

$t_1 = 14.68$

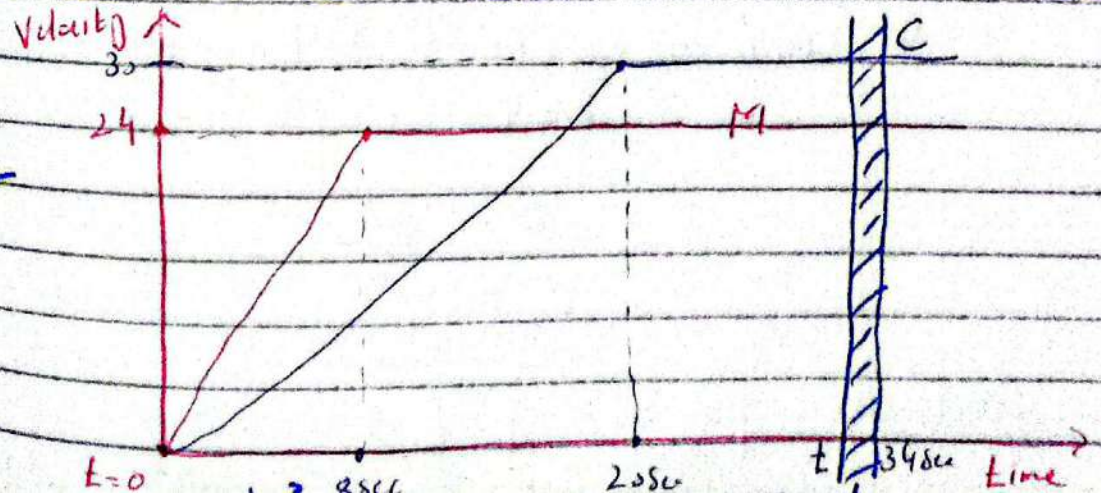
(iii) Find total time.

$= 15 + 14.68 + 3.67$

$t = 33.35 \text{ sec}$ Ans

(14) A motorcyclist M leaves a road junction at time $t=0$. He accelerates from rest at a rate of $3 m/sec^2$ for 8sec and then maintain the velocity he has reached

Sol



For M (Motorcyclist)

$a = 3\,m/sec^2 \quad t = 8\,sec \quad V = ?$

$a = \frac{\Delta V}{\Delta t} \Rightarrow 3 = \frac{V}{8} \quad V = 3 \times 8$

$V = 24\,m/sec$

For C (Car)

$V = 30\,m/sec \quad t = 20\,sec$

(iii) Find the distance of the Pedestrian From the road junction.

$d_M = d_C$

$$\left[\frac{1}{2}(8)(24)\right] + \left[(t-8) \times 24\right] = \left[\frac{1}{2} 20 \times 30\right] + \left[t-20 \times 30\right]$$

$$96 + 24t - 192 = 300 + 30t - 600$$

$$96 - 192 - 300 + 600 = 30t - 24t$$

$$204 = 6t$$

$$t = \frac{204}{6}$$

$$\boxed{t = 34\,sec}$$

Car

$$\text{Distance} = \left[\frac{1}{2} \times 20 \times 30\right] + \left[34 - 20 \times 30\right]$$

$$300 + 420 = 720\,m$$