Table 4.2

Index (i)	t_i (s)	X_i (cm)	ΔX_i (cm)	$\bar{V}_i$ (cm/s)	$\Delta \bar{V}_i$ (cm/s)	$\bar{a}_i$ (cm/s^2)
0	0.00	0				
	0.05		2	20		
1	0.10	2			33	330
	0.15		5.3	53.		
2	0.20	7.3			7	70
	0.25		6	60		
3	0.30	13.3			-20	-200
	0.35		4	40		
4	0.40	17.3			-10	-100
	0.45		3	30		
5	0.50	20.3			-5	-50
	0.55		2.5	25		
6	0.60	22.8			4	40
	0.65		2.9	29		
7	0.70	25.7			22	220
	0.75		5.1	51		
8	0.80	30.8			59	590
	0.85		11	110		
9	0.90	41.8			8	80
	0.95		11.8	118		
10	1.00	53.6				

IV. Data Analysis

A) Average Velocities and Accelerations

► Answer the following questions

From your recorded measurements in Table 4.2, you should be able to determine during which time intervals the average velocities and accelerations are maximum? minimum? Record tour results in the following two frames.

Velocity

Time interval during which the average velocity is maximum: (0.9 → 0.7) ... s.

Time interval during which the average velocity is minimum: (0 → 0.1) s

Acceleration

Time interval during which the average acceleration is maximum: (0.7 → 0.9).

Time interval during which the average acceleration is minimum: (0.5 → 0.7)

1. Calculate $\overline{V}_i$, $\Delta\overline{V}_i$, and $\bar{a}_i$.
2. Record the calculations in Table 4.2.

B) Estimating The Instantaneous Velocity From The Approximation of Average Velocity.

1. For each time interval (3rd column in Table 4.3), calculate $\bar{V}$ and record your result in the last column of the table.
2. Record the displacements X_i in Table 4.3 as listed in Table 4.2.
3. Compute the instantaneous velocity at $t = 0.6$ s.

Table 4.3

t (s)	X (cm)	Δt (s)	ΔX (cm)	$\bar{V}$ (cm/s)
$T_5 = 0.3$ $T_7 = 0.9$	$X_3 = 13.3$ $X_9 = 41.8$	0.6 s	28.5 cm	47.5
$t_4 = 0.4$ $t_8 = 0.8$	$X_4 = 17.3$ $X_8 = 30.8$	0.4 s	13.5	33.75
$t_3 = 0.5$ $t_9 = 0.7$	$X_5 = 20.3$ $X_7 = 25.7$	0.2 s	5.4	27

C) *X-t* Graph

Using the data in Table 4.2, plot X versus t. Label your axes and include their units. Connect the points with a smooth curve (Don't use a ruler). The slope of the tangent to the X-t curve at a given instant represents the instantaneous velocity at that instant. The X-t graph can be used to determine:

- The instantaneous velocity at any time during the motion.
- The average velocity for any time interval during the motion.
- Time intervals during which the moving object is stationary, speeding up, or slowing down.

▶ *Answer the following*

a) Calculate the instantaneous velocity at $t = 0.6$ s from the slope of the tangent (Figure 4.3) to your X versus t graph at $t = 0.6$ s. Show your

calculations in detail on your graph.

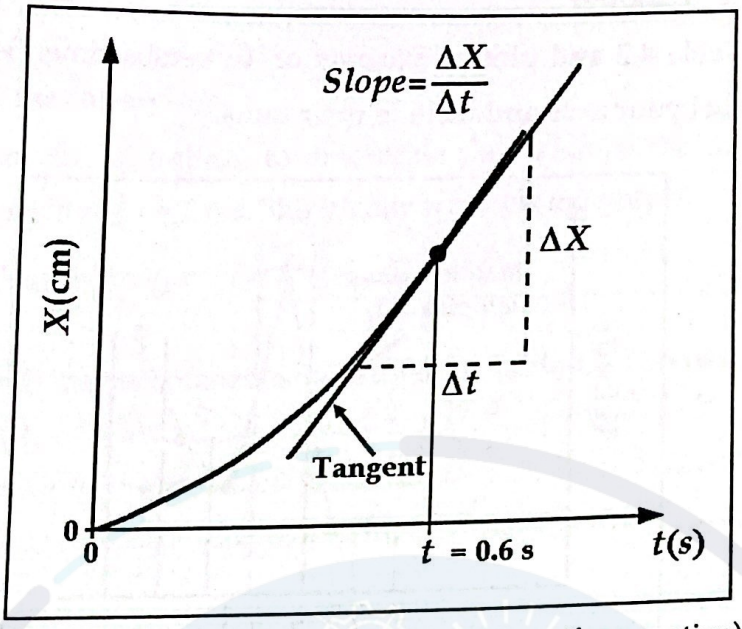

Figure 4.3: Displacement versus time (non-uniform motion).

t_i = ...0.6..... s.

$V_{inst}(t_i)$ = ...23..... cm/s.

Compare the calculated instantaneous velocity with the value from Table 4.3.

From table 4.3 instantaneous velocity (@ .6) = .27 cm/s.

The calculated instantaneous velocity = 23 cm/s

$\frac{27-23}{23} \times 100 = 17.3\%$ [difference percent]

b) During which intervals does the velocity increase, decrease, or remain constant? Mark the correct answer for each time interval by a (✓) in Table 4.4.

Table 4.4

t (s)	0.0 - 0.1	0.1 - 0.2	0.2 - 0.3	0.3 - 0.4	0.4 - 0.5	0.5 - 0.6	0.6 - 0.7	0.7 - 0.8	0.8 - 0.9	0.9 - 1.0
Increase	✓	✓	✓				✓	✓	✓	✓
Decrease				✓	✓	✓				
Constant										

▶ **Answer the following:**

a) Use the histogram to determine the value of the instantaneous velocity at t = 0.6 s. Show your work on the graph.

V_{inst} (t = 0.6 s) = ...27.5......... cm/s.

Compare with the instantaneous velocity from Table 4.3. Discuss.

....from table 4.3 v ins (t = 0.6 s) = 27.0 cm/s....

....⇒ D. Instantaneous velocity = 27.5 cm/s.........

....

b) Determine where the velocity is increasing, decreasing, or constant. Indicate the correct answer for each time interval by a (✓) in Table 4.5.

Table 4.5

t (s)	0.05 - 0.15	0.15 - 0.25	0.25 - 0.35	0.35 - 0.45	0.4 5 - 0.55	0.55 - 0.65	0.65 - 0.75	0.75 - 0.85	0.85 - 0.95
Increase	✓	✓				✓	✓	✓	✓
Decrease			✓	✓	✓				
Constant									

c) Ask your instructor for which time interval [t_i,t_f] to use for calculating the area under the $\bar{V} - t$ curve; see Figure 4.5 below. Record the area in Table 4.6. This area represents the displacement made by the 0th point during the chosen time interval.

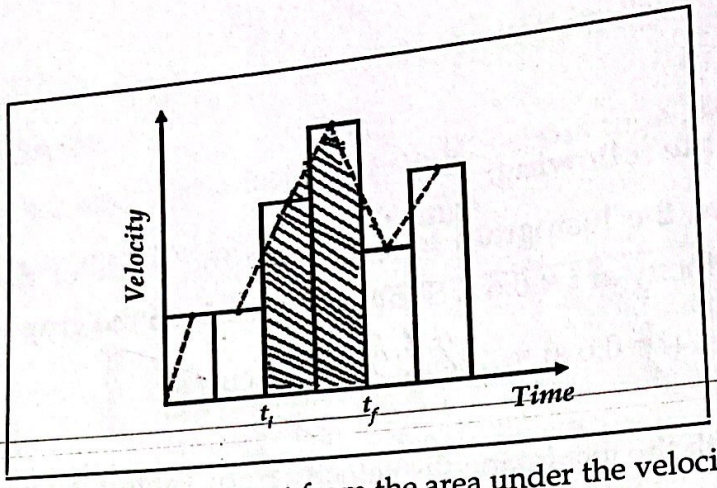

Figure 4.5: Finding the displacement from the area under the velocity-time graph.

Table 4.6

t_i = 0.4	t_f = 0.5
Area under the curve from $\bar{v}$ – t graph = (0.1) × (30) = 3 cm	
Displacement from the paper tape = 3 cm	
Do the two measurements agree? Discuss. yes area under the curve = displacement	

E) $\bar{a}-t$ GRAPH

- Refer to Table 4.2 and plot $\bar{a}$ versus t. Label your axes.
- The $\bar{a}-t$ graph can be used to determine the maximum and minimum accelerations.

Record your results in Table 4.7.

Table 4.7

Maximum Acceleration	Minimum Acceleration
a_{max} = 596 cm/s²	a_{min} = 40 cm/s²
$t(a_{max})$ = 0.8 s	$t(a_{min})$ = 0.6 s