Section 1.4: Comparing Graphs of Linear Motion

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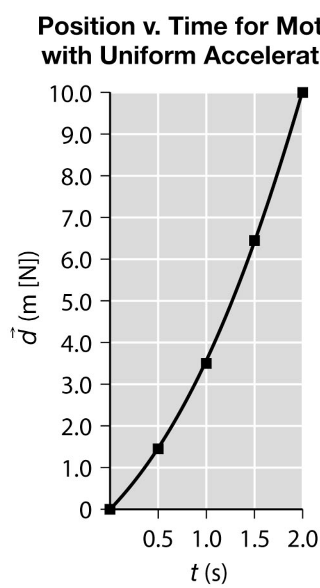
1. Step 1: The data plotted on the velocity–time graph in Figure 8 form an increasing straight-line graph. You can determine acceleration from a velocity–time graph by calculating its slope. Since the velocity–time graph in Figure 8 is a straight line, its slope does not change. So we can calculate the slope or acceleration over any time interval.

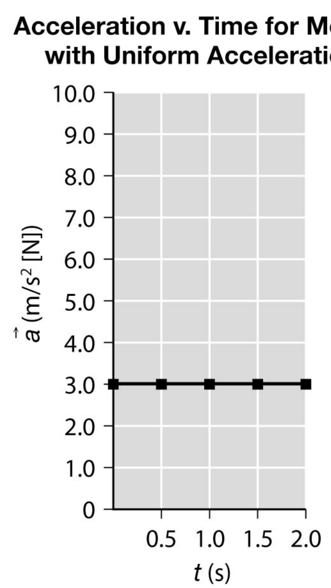
$$\begin{aligned}\text{slope} &= \frac{\text{rise}}{\text{run}}\\ \vec{a}_{\text{av}} &= \frac{\Delta\vec{v}}{\Delta t}\\ &= \frac{6.0\text{ m/s [N]}}{2.0\text{ s}}\\ \vec{a}_{\text{av}} &= 3.0\text{ m/s}^2\text{ [N]}\end{aligned}$$

Step 2: The table shows the calculations for the area under the curve in Figure 8 at 0.5 s intervals from $t = 0$ s to $t = 2.0$ s.

Time (s)	**Equation** $\Delta\vec{d} = \vec{v}_{\text{i}}\Delta t + \frac{1}{2}\Delta\vec{v}\,\Delta t$	**Displacement** (m [N])	**Acceleration** (m/s^2 [N])
0.0		0.0	3.0
0.5	$\Delta\vec{d} = \left(2.0\,\frac{\text{m}}{\cancel{\text{s}}}\text{ [N]}\right)(0.5\,\cancel{\text{s}}) + \frac{1}{2}\left(1.5\,\frac{\text{m}}{\cancel{\text{s}}}\text{ [N]}\right)(0.5\,\cancel{\text{s}})$	1.4	3.0
1.0	$\Delta\vec{d} = \left(2.0\,\frac{\text{m}}{\cancel{\text{s}}}\text{ [N]}\right)(1.0\,\cancel{\text{s}}) + \frac{1}{2}\left(3.0\,\frac{\text{m}}{\cancel{\text{s}}}\text{ [N]}\right)(1.0\,\cancel{\text{s}})$	3.5	3.0
1.5	$\Delta\vec{d} = \left(2.0\,\frac{\text{m}}{\cancel{\text{s}}}\text{ [N]}\right)(1.5\,\cancel{\text{s}}) + \frac{1}{2}\left(4.5\,\frac{\text{m}}{\cancel{\text{s}}}\text{ [N]}\right)(1.5\,\cancel{\text{s}})$	6.4	3.0
2.0	$\Delta\vec{d} = \left(2.0\,\frac{\text{m}}{\cancel{\text{s}}}\text{ [N]}\right)(2.0\,\cancel{\text{s}}) + \frac{1}{2}\left(6.0\,\frac{\text{m}}{\cancel{\text{s}}}\text{ [N]}\right)(2.0\,\cancel{\text{s}})$	10.0	3.0

Step 3: Use these values to create position–time and acceleration–time graphs.





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1.

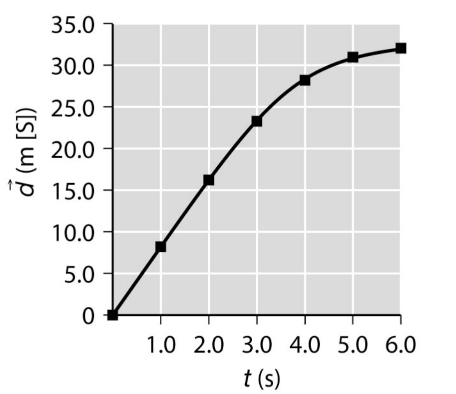
How do you determine ...	Given a ...	Read information from graph	Take the slope	Find the area
position	position–time graph	√		
velocity	position–time graph		√	
velocity	velocity–time graph	√		
velocity	acceleration–time graph			√
acceleration	velocity–time graph		√	
acceleration	acceleration–time graph	√		

2. Step 1: Use the area under the graph to determine the position at each time. Since each rectangle on the grid is 1.0 s by 2.0 m/s [S], they each represent 2.0 m [S]. You can count the grid rectangles to determine the area.

Time (s)	Grid Rectangles	Position (m [S])
0.0	0	0
1.0	4	8
2.0	8	16
3.0	11.5	23
4.0	14	28
5.0	15.5	31
6.0	16	32

Step 2: Use these values to create a position–time graph.

Position v. Time for Complex Motion



3. (a) Reading from the graph, at $t = 5.0$ s, $\vec{d} = 45.0$ m [S].

(b) Given: $t = 3.0$ s; position–time graph

Required: $\vec{v}_{\text{inst}}$

Analysis: $\vec{v}_{\text{inst}}$ is equal to the slope, m, of the tangent to the curve at $t = 3.0$ s; $m = \dfrac{\Delta \vec{d}}{\Delta t}$.

By placing a ruler along the curve in Figure 10 at $t = 3.0$ s, I can picture the tangent. The tangent has a rise of about 45.0 m [S] over a run of 4.0 s.

Solution:
$$m = \frac{\Delta \vec{d}}{\Delta t}$$
$$m = \frac{45.0 \text{ m [S]}}{4.0 \text{ s}}$$
$$\vec{v}_{\text{inst}} = 11 \text{ m/s [S]}$$

Statement: The instantaneous velocity of the object at 3.0 s is 11 m/s [S].

(c) Given: $\Delta \vec{d} = 65$ m [S]; $\Delta t = 6.0$ s

Required: $\vec{v}_{\text{av}}$

Analysis: $\vec{v}_{\text{av}} = \dfrac{\Delta \vec{d}}{\Delta t}$

Solution:
$$\vec{v}_{\text{av}} = \frac{\Delta \vec{d}}{\Delta t}$$
$$= \frac{65 \text{ m [S]}}{6.0 \text{ s}}$$
$$\vec{v}_{\text{av}} = 11 \text{ m/s [S]}$$

Statement: The average velocity of the object over the time interval from 0.0 s to 6.0 s is 11 m/s [S].

4. Step 1: The data plotted on the velocity–time graph in Figure 11 form a decreasing straight-line graph. You can determine acceleration from a velocity–time graph by calculating its slope. Since the velocity–time graph in Figure 11 is a straight line, its slope does not change. So we can calculate the slope or acceleration over any time interval.

$$\text{slope} = \frac{\text{rise}}{\text{run}}$$
$$\vec{a}_{\text{av}} = \frac{\Delta \vec{v}}{\Delta t}$$
$$= \frac{-12 \text{ m/s [S]}}{6.0 \text{ s}}$$
$$\vec{a}_{\text{av}} = -2.0 \text{ m/s}^2 \text{ [S]}$$

Step 2: Use this value to create an acceleration–time graph.