Key Concepts
Part 1 - Motion in a Straight Line (One Dimension)

After completing this chapter you will be able to:
• explain how distance, position, and displacement are different
• explain how speed, velocity, and acceleration are different
• explain how vectors and scalars are different
• add and subtract vectors using scale diagrams and algebraic methods
• obtain motion information from position–time, velocity–time, and acceleration–time graphs
• solve uniform velocity and uniform acceleration problems using algebraic methods
• describe how the acceleration due to gravity affects the motion of objects close to the surface of Earth
• assess the impact on society and the environment of a technology that applies concepts related to kinematics

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Learning Goal: By the end of today, I will be able to recognize the correct technique (read the graph, find the slope, find the area) needed to extract information from a graph (position-time, velocity-time, acceleration-time).

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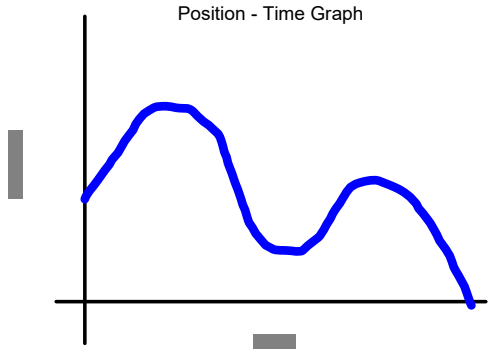
1.4 Comparing Graphs of **Linear** Motion

Position Time Graphs Recap

So far we have investigated position-time graphs and looked at the behaviour of the graph as objects move toward and away from a reference point, the object's starting position and the vertical axis on the graph and how uniform and non-uniform motion is represented. The rate of change on a position-time graph gave us the ave velocity over that interval.



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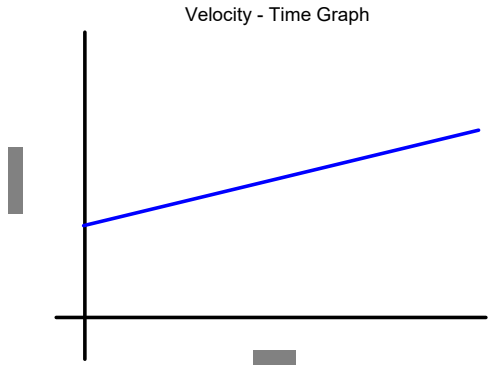
Velocity Time Graphs Recap

Velocity Time graphs illustrated the velocity of an object at exact times throughout an object's motion. The rate of change on a velocity-time graph gave us the average acceleration over that interval. The AREA under a velocity-time graph is the change in position over the given interval.



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Acceleration - Time Graphs

Acceleration - Time graphs describe the acceleration of an object with respect to time.

The graph to the right, represents uniform acceleration of an object at 4 m/s^2.

The AREA under the graph represents the change in velocity of an object over a given interval.

For the given example, for the first 5 seconds, the change in velocity is given by:

4 m/s^2 x 5 s = 20 m/s

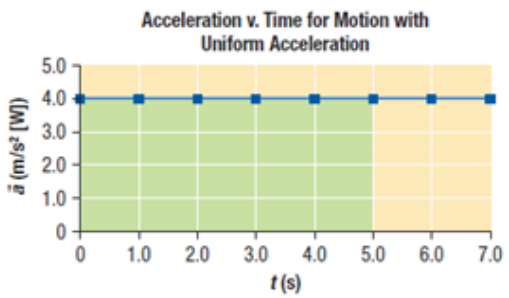

Figure 2 Acceleration–time graph showing motion with uniform acceleration

Note: we do not know the initial velocity of the object, so all we can determine is the CHANGE in velocity.

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Moving from Acceleration - Time Graph to Position - Time Graph Using Data

Find the area under the curve for each of the first 5 seconds.

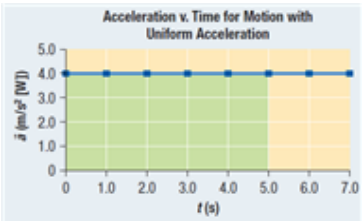

Figure 4 Using an acceleration–time graph to create other motion graphs

Table 1 Calculating the Velocity at Various Time Points in Figure 4

Time t (s)	Acceleration $\vec{a}$ (m/s^2 [W])	Equation $\vec{v} = (\Delta\vec{a})(\Delta t)$	Velocity $\vec{v}$ (m/s) [W]
0	4.0	$\vec{v} = \left(4.0 \frac{m}{s^2}[W]\right)(0\ s)$	0
1.0	4.0	$\vec{v} = \left(4.0 \frac{m}{s^2}[W]\right)(1.0\ s)$	4.0
2.0	4.0	$\vec{v} = \left(4.0 \frac{m}{s^2}[W]\right)(2.0\ s)$	8.0
3.0	4.0	$\vec{v} = \left(4.0 \frac{m}{s^2}[W]\right)(3.0\ s)$	12
4.0	4.0	$\vec{v} = \left(4.0 \frac{m}{s^2}[W]\right)(4.0\ s)$	16
5.0	4.0	$\vec{v} = \left(4.0 \frac{m}{s^2}[W]\right)(5.0\ s)$	20.0

Plot the velocities

t(s)	vel
0	0
1	4
2	8
3	12
4	16
5	20

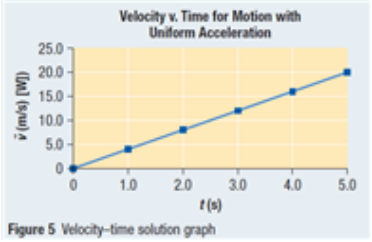

Figure 5 Velocity–time solution graph

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Use the velocities and the Velocity - Time graph to determine the Position Values

t(s)	vel
0	0
1	4
2	8
3	12
4	16
5	20

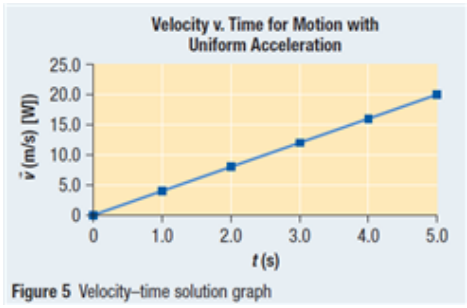
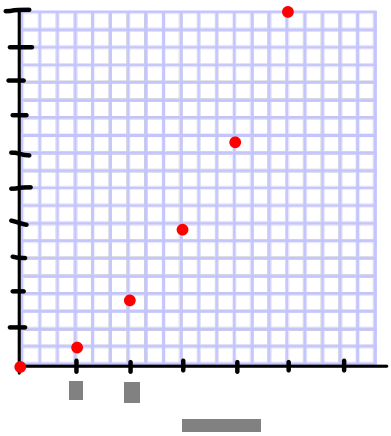


Figure 5 Velocity–time solution graph

$$A = \frac{1}{2}bh$$

t(s)	position
0	0
1	2
2	8
3	18
4	32
5	50

$$A = \frac{1}{2}(0)(4)$$
$$A = \frac{1}{2}(1)(4)$$
$$A = \frac{1}{2}(2)(8)$$
$$A = \frac{1}{2}(3)(12)$$
$$A = \frac{1}{2}(4)(16)$$
$$A = \frac{1}{2}(5)(20)$$



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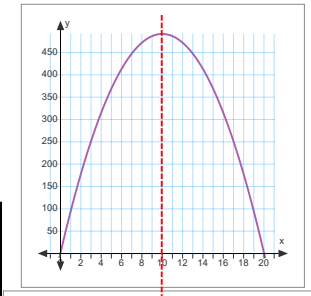
Summary of Relationship Amongst the Graphs

Position - Time Graph

$s = -4.9t^2 + 98t + 1.5$

Second degree power



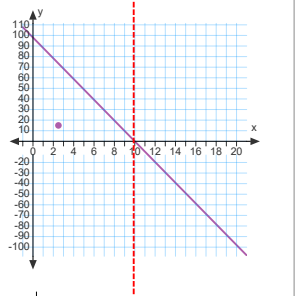
Rate of Change

Area under Curve

Velocity - Time Graph

$v = -9.8t + 98$

First degree power



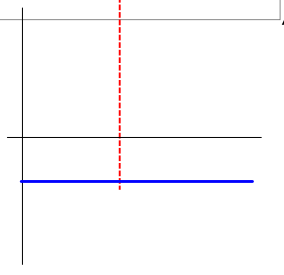
Rate of Change

Area under Curve

Acceleration - Time Graph

$a = -9.8$

Constant



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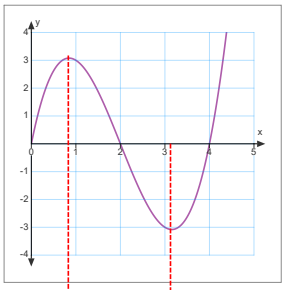
Moving from Graph to Graph

Position - Time Graph

$s = (t)(t-2)(t-4)$

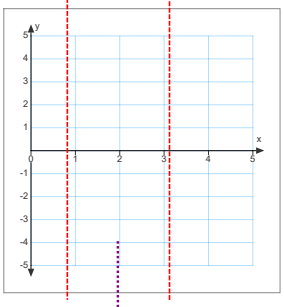
Third degree power



Velocity - Time Graph

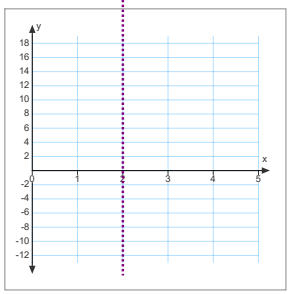
$v = 3t^2 - 12t + 8$

First degree power



Acceleration - Time Graph

$a = 6t - 12$



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1.4 Questions

1. Copy and complete **Table 2** in your notebook by adding a check mark in each column that applies.

Table 2

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. From the velocity–time graph in **Figure 9**, generate position–time data and then plot the corresponding position–time graph, assuming the initial position is 0 m.

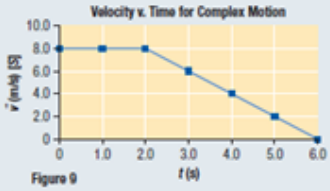

Figure 9

Figure 10

3. Consider the position–time graph shown in **Figure 10**.
   (a) What is the position of the object at $t = 5.0$ s?
   (b) What is the instantaneous velocity of the object at $t = 3.0$ s?
   (c) What is the average velocity for the object's motion from 0 s to 6.0 s?

4. Use the data in the velocity–time graph shown in **Figure 11** to plot the corresponding acceleration–time graph.

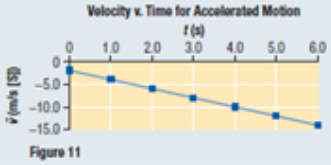

Figure 11

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