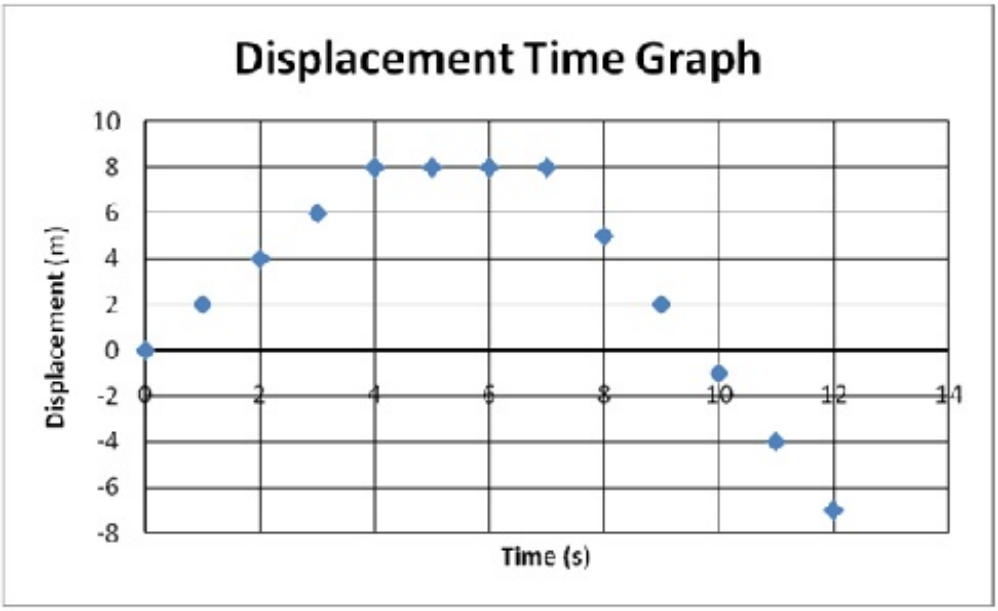
Graphing

Graphing displacement against time can be a useful tool in problem solving. To produce a displacement time graph, you'll need to start with a table of values indicating where an object is at different times. Place the displacement on the vertical y-axis and the time on the horizontal x-axis as shown in the graph below. Then place the points on the graph. Do not automatically connect the dots. How you connect the points may depend on the type of motion and the questions you're asked to complete. Graphs can be produced on the computer using Excel or Quattro Pro. Tutorials for graphing with these programs are listed at the bottom of this page.

Time (s)	Displacement (m)
0	0
1	2
2	4
3	6
4	8
5	8
6	8
7	8
8	5
9	2
10	-1
11	-4
12	-7



The slope of the line represents the velocity.

In general, slope tells you how steep a line is and in which direction it is angled. A positive slope goes up towards the right while a negative slope goes down towards the right. Slope is calculated using two points, (x1, y1) and (x2, y2), on a straight line. The formula to calculate slope (m) is:

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

This is also referred to as rise over run. When dealing with displacement time graphs, the points would be (d1, t1) and (d2, t2), and the formula would be:

$$\bar{v} = \frac{\overline{d_2} - \overline{d_1}}{t_2 - t_1}$$

By looking at the slope of the graph, you can determine what type of motion an object is undergoing.

The graph above starts at the origin and has a constant positive slope between 0 s and 4 s. This means that the object is moving away from the origin, in the positive direction, and with a constant velocity.

Between 4 s and 7 s, the graph is a horizontal line. This means that the object's position is not changing and it is at rest. If the slope is zero, the velocity is zero.

In the last section between 7 s and 12 s, the slope of the graph is constant and negative. This means that the object has changed direction and is now moving at a constant velocity in the negative direction. Note that at about 9.5 s, the line crosses the x-axis. This means that the object passes the origin and keeps going in the negative direction. The final position of the object is 7 m in the negative direction.

Average and instantaneous velocities can be calculated from displacement time graphs using slopes.

Average velocities:

To determine the average velocity between two points, draw a straight line between the points and determine the slope of the line. Remember that slope is calculated using any two points on the line.

Determine the average velocity of between 0 s and 7 s in the graph above.

$$\bar{v} = \frac{\vec{d_2} - \vec{d_1}}{t_2 - t_1}$$

$$\bar{v} = \frac{8.0\,m - 0\,m}{7.0\,s - 0\,s}$$

$$\bar{v} = 1.143 \frac{m}{s}$$

Instantaneous velocities:

To determine the instantaneous velocity at a particular point in time, determine the slope of the straight line segment in which the point is located. If by chance the point is located at a spot where the slope changes (e.g., at 4 s or 7 s in the graph above), the instantaneous speed cannot be found. Remember that slope is calculated using any two points on the line.

Example

Determine the instantaneous velocity at 10 s in the graph above.

Given and Required Choose any two points on the straight line segment in which the 10 s point is located. For this question, 10 s and 12 s were chosen.

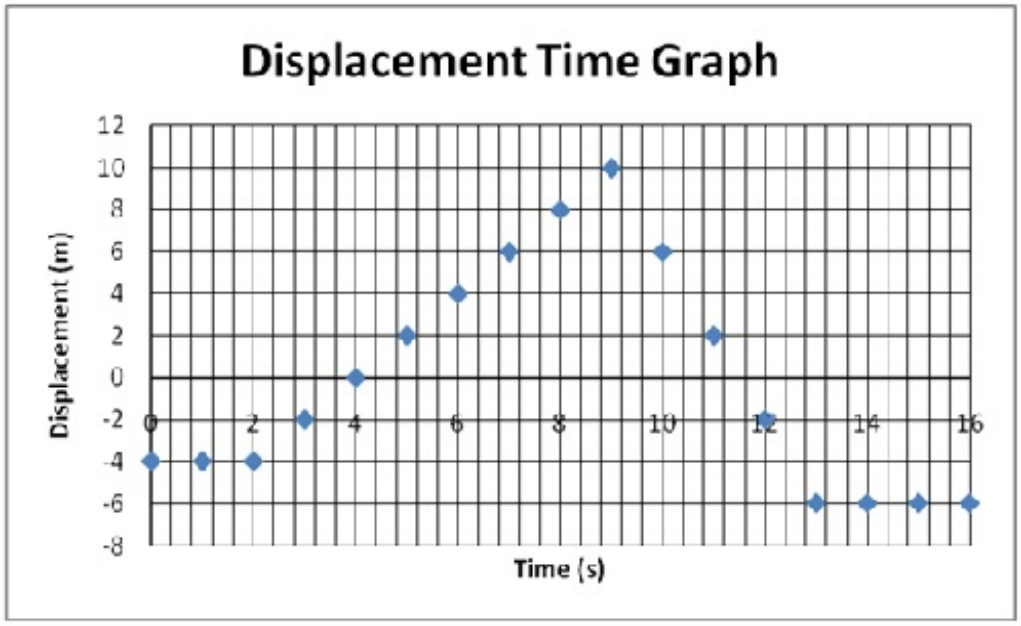
$$\vec{d_1} = -1.0\,m$$
$$t_1 = 10\,s$$
$$\vec{d_2} = -7.0\,m$$
$$t_2 = 12\,s$$

$$\bar{v} = \frac{\vec{d_2} - \vec{d_1}}{t_2 - t_1}$$

$$\bar{v} = \frac{-7.0\,m - (-1.0\,m)}{12\,s - 10\,s}$$

$$\bar{v} = -3.0 \frac{m}{s}$$

The instantaneous velocity at 10 s is 3.0 m/s in the negative direction.



1. Describe the motion in the graph above.
2. Determine the average velocity from 6.0 s to 14 s.
3. Determine the instantaneous velocity at 10 s.
4. Can you determine the instantaneous velocity at 13 s?

1. Assuming that left is negative and right is positive, the object starts out at rest 4 m to the left of the reference point. At 2.0 s, the object starts to move to the right at a constant speed. At 4.0 s it crosses the origin and continues to move right until it reaches a position 10 m from the reference point. It immediately starts moving to the left at an increased speed. At about 11.5 s it crosses the point of reference and continues moving left until it reaches a position 6.0 m to the left of the reference point. The object remains at rest for the last 3.0 s
2. The average velocity between 6.0 s and 14 s is 2.5 m/s to the left
3. The instantaneous velocity at 10 s is 4.0 m/s to the left.

$$\bar{v} = \frac{\overline{d_2} - \overline{d_1}}{t_2 - t_1}$$

$$\bar{v} = \frac{2.0\,m - 10m}{11\,s - 9.0\,s}$$

$$\bar{v} = -4.0\frac{m}{s}$$

4. No, the instantaneous velocity cannot be found since the slope changes at this point.

Practice Questions Assignment

Be sure to provide explanations to ensure maximum part marks.

1. Explain in your own words the differences between distance and displacement, speed and velocity.

2. A police officer stops you while you're travelling in a 50 km/h zone and says you were going 17 m/s. Were you speeding?

2. A person completes one full loop of a 400 m circular track in 82 s.

A) What is her speed? B) What is her velocity?

C) At this speed, how long would it take her to run 5.0 km?

4. From school, a girl walks 520 m [S] to drop off homework for a sick friend and then walks 730 m [N] to get home. If the entire trip takes her 35 min:

A) What is her average speed in m/s? B) What is her average velocity in m/s?

5. Sketch a graph for the following table of values and then determine the total average velocity and the instantaneous velocities at 5.0 s and 10.0 s.

Time (s)	Displacement (m)
0	0
1	12
2	24
3	36
4	48
5	48
6	48
7	48
8	24
9	0
10	-24
11	-48
12	-60