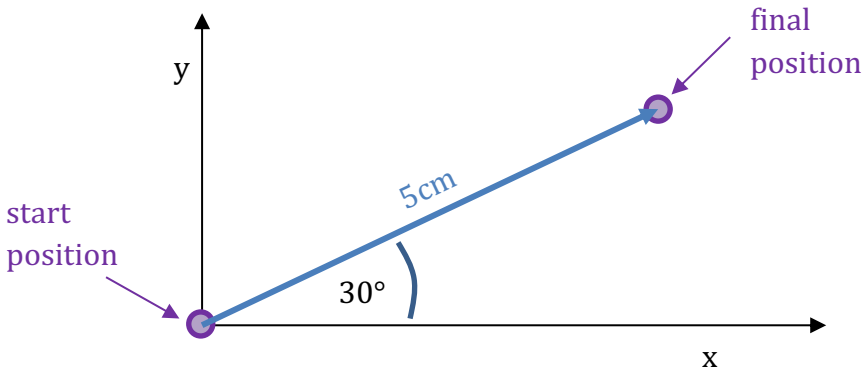
5.6.2 Distance-time and displacement-time graphs

videos

Distance is a scalar quantity and is a measure of how far something has moved. One example is the milometer in a car. This shows how far the car has travelled, but not in which direction.

Displacement is a vector quantity and tells us the distance something has been moved in a particular direction. We find the displacement by drawing a straight line from the start position to the final position.



We would describe the displacement, above, as "5cm at an angle of 30° to the x-axis".

(1) Draw a vector which represents a displacement of 5km south-east (use a scale of 1cm=1km).

At GCSE we often analyse objects that move in one dimension, either forward or backward. In this case, the convention is to take the forward direction as positive and the backward direction as negative. If the object is displaced a number of times, we can just add together each displacement to find the overall displacement.

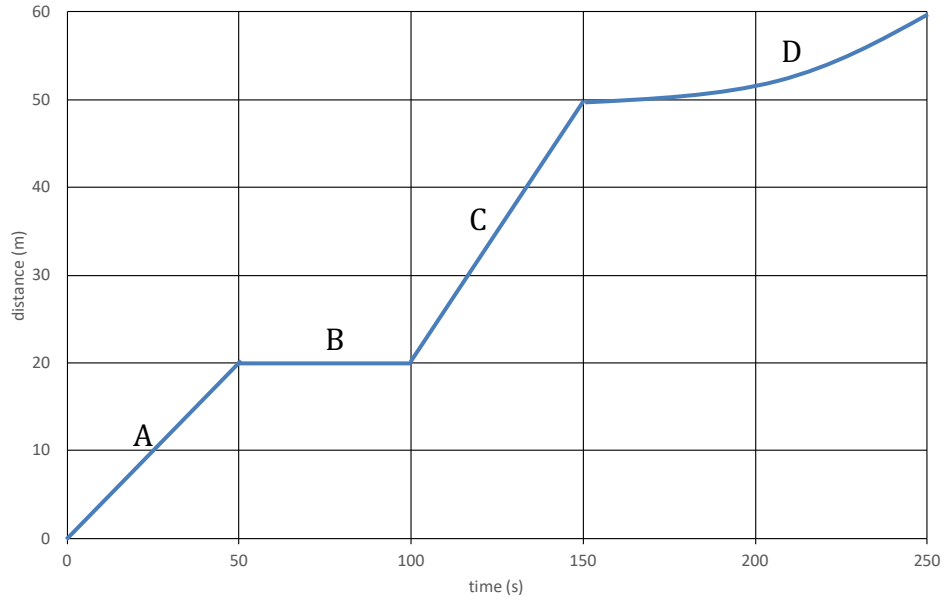
Example

If an object is displaced 7cm in the forward direction, followed by 4cm in the backward direction, followed by 2cm in the forward direction, what is the overall displacement?

Answer: 7-4+2=+5 Overall the object is displaced 5cm in the forward direction.

(2) A car is displaced 14km west, followed by 30km east, followed be 5km west. What is its overall displacement? (Hint: Remember to include a distance and a direction for your answer.)

Distant-time graphs



The graph, above, is a distance-time graph for a car journey. We can see that the motion of the car changes with time.

For section A, the car travels a distance of 20m in a time of 50 seconds. From this we can calculate the speed of the car:

$$speed = \frac{distance}{time} = \frac{20}{50} = 0.40m/s$$

For section B, the car doesn't move any distance, so its speed is zero.

For section C, we can see that the car travels a distance of 30m in a time of 50 seconds.

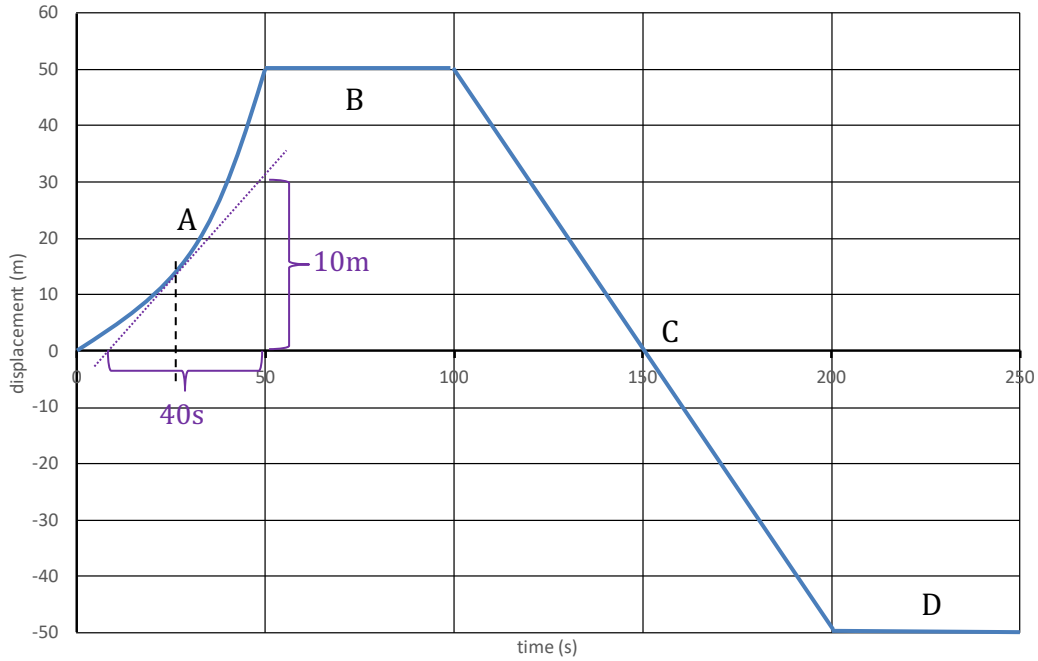
(3)✎ Calculate the speed of the car for section C of the journey.

For section D, the line is not straight. This is because the speed is not constant but increases during this interval. We can work out an average speed for this interval:

$$average\ speed = \frac{distance\ travelled}{time\ taken} = \frac{10}{50} = 0.2m/s$$

(4)✎ Calculate an average speed for the whole journey.

Displacement-time graphs



The graph, above, is a displacement-time graph for a car moving forwards and backwards.

(5) Which section(s) show the car moving forwards?

(6) Which section(s) show the car moving backwards?

(7) Which section(s) show the car is stationary?

(8) What is the overall displacement of the car for this journey?

The gradient of the displacement-time graph is the velocity. Velocity is a vector quantity and tells us the speed in a given direction. For this graph, a positive gradient tells us that the velocity is in the forward direction. If the gradient is negative (i.e. sloping down) then the velocity is in the reverse direction.

(9) Which section(s) show the car is moving with a velocity in the backwards direction?

To calculate the velocity, we use the formula:

$$velocity = \frac{change\ in\ displacement}{time} = \frac{final\ displacement - initial\ displacement}{time}$$

(10)✎ Calculate the velocity for section C. (Hint: Use the equation, above, and remember that the final displacement is negative.)

For section A, the velocity changes because the gradient of the line changes. To find the velocity at a particular time ("instantaneous velocity"), we draw a tangent to the line at this point and measure the gradient of the tangent.

On the graph you can see this method being used to calculate the instantaneous velocity at 25 seconds.

$$instantaneous\ velocity = gradient\ of\ tangent = \frac{10}{40} = 0.25m/s$$

(11)✎ Calculate the instantaneous velocity at 40s. (Hint. Draw a tangent to the graph at 40s and work out the gradient of the tangent.)