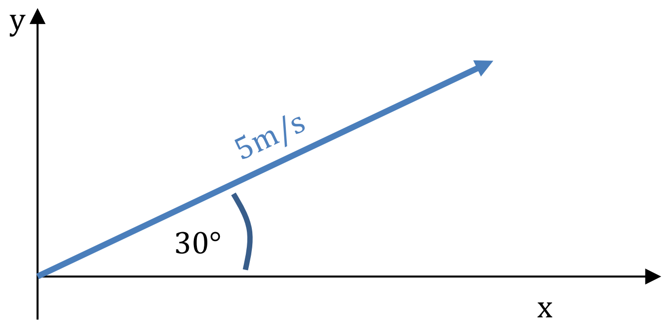
5.6.3 Speed-time and velocity-time graphs

Speed is a scalar quantity and is a measure of how fast something is moving. One example is the speedometer in a car. This shows how fast the car is travelling, but not in which direction.

videos

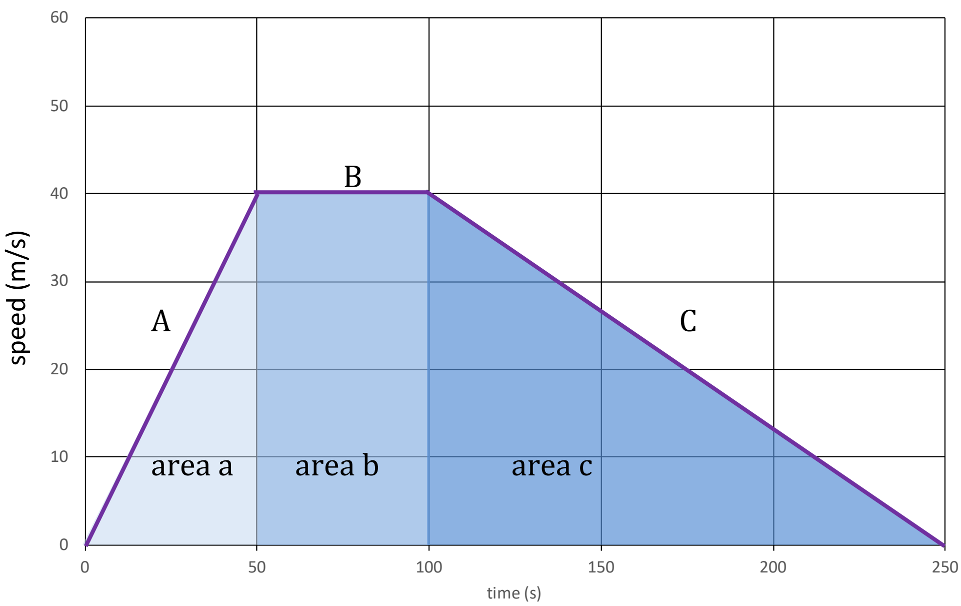
Velocity is a vector quantity and tells us the speed something is moving <u>in a particular direction</u>.



We would describe the velocity, above, as "5m/s at an angle of 30° to the x-axis".

(1)✏Draw a vector which represents a velocity of 5m/s north-east (use a scale of 1cm=1m/s).

Speed-time graphs



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

For section A, the car speeds up (accelerates) from 0m/s to 40m/s in 50seconds. In this case, acceleration is just a measure of much the speed changes every second:

$$acceleration = \frac{change\ of\ speed}{time} = \frac{40}{50} = \underline{0.80 m/s^2}$$

The car's speed changes by 0.80m/s every second – hence the unit for acceleration $\frac{m/s}{s} = m/s^2$.

For section B, the car's speed doesn't change, but stays constant at 40m/s.

For section C, we can see that the car's speed decreases from 40 to 0m/s in 150s.

(2)✏ Calculate the acceleration of the car for section C of the journey. (Hint: use the formula, above.)

(3)✏ What do you notice about the sign of your answer to question 2? What does this tell you?

We can calculate the distance that the car travels by taking the area under the speed-time graph.

Example

What distance does the car travel in the first 50 seconds?

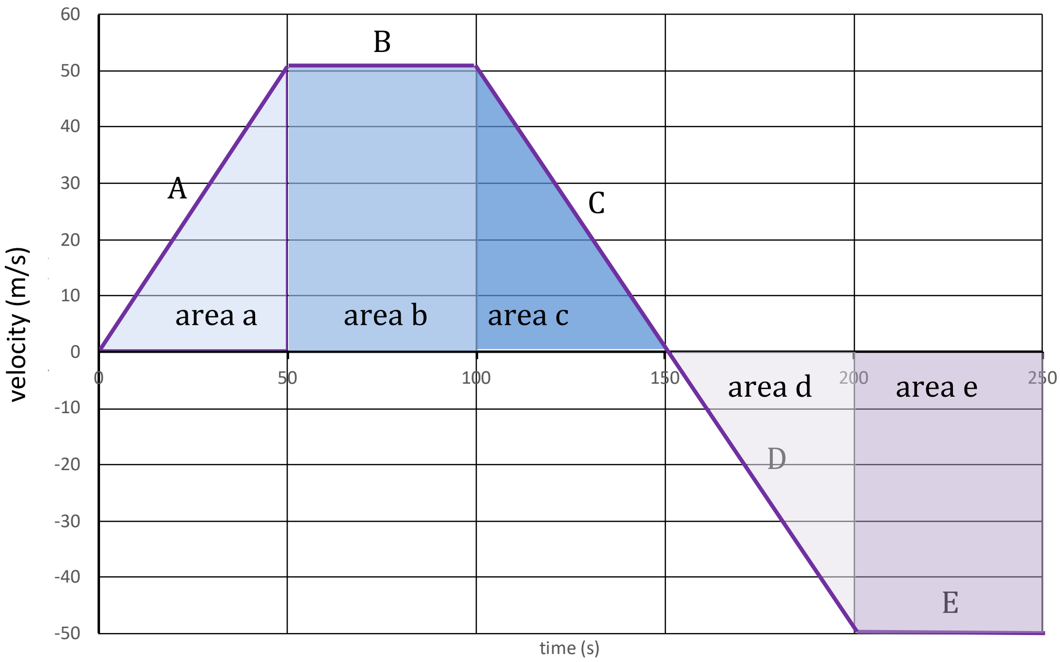
Answer

We take the area under the graph (area a).

$$distance = area\ under\ graph = \frac{1}{2} \times 50 \times 40 = \underline{1000m}$$

(4)✏ What is the total distance travelled by the car for the whole journey? (Hint: Just add up areas a, b and c.)

Velocity-time graphs



The graph, above, is a velocity-time graph for a car moving forwards and backwards. At GCSE we analyse objects that move in one dimension, either forward or backward. In this case, the convention is to take forward velocities as positive and backward velocities as negative.

(5)✐ Which section(s) show the car with a forward velocity?

(6)✐ Which section(s) show the car with a backward velocity?

(7)✐ Which section(s) show the car with a constant forward velocity?

(8)✐ Which section(s) show the car with a constant backward velocity?

(9)✐ Which section(s) show the car is slowing down?

(10)✐ Which section(s) show the car speeding up?

(11)✐ Describe the change in motion from section C to D.

The gradient of the velocity-time graph is the acceleration.

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

(12)✐ Calculate the acceleration for section A.

As we discussed for speed-time graphs, the distance travelled is the area under the graph. For velocity-time graphs, any area above the x-axis is positive, and any area below the axis is negative.

(13) Calculate the total distance travelled from the velocity-time graph, above. (Hint: Add together the areas a, b, c, d, e, remembering that d and e are negative.)

Acceleration is a vector quantity. It tells us how the velocity changes every second. As velocity is a vector quantity, two things can change – speed and direction.

Consider the following motions:

velocity before	**velocity after**	**Acceleration?**
		No. Direction and size the same.
		Yes. Size is smaller (speed has decreased)
		Yes. The size is the same, but the direction has changed.

(14) Explain why someone on a Ferris wheel can have a constant speed but a changing velocity?