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EB Education Revision Guide

How to work with Speed and Velocity

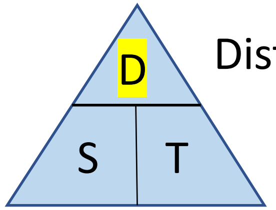
Speed

What is speed?

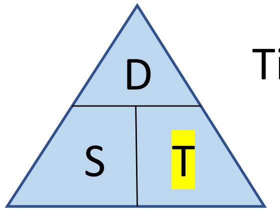
Speed is known as a **scalar** quantity. It has only a size (or magnitude) and no direction.

Speed will tell you the distance an object travels in a given time.

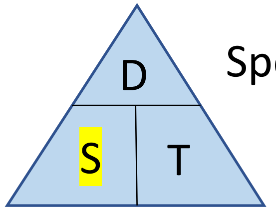
This equation is used for objects travelling at a constant speed.



Distance = Speed x Time



$$\text{Time} = \frac{\text{Distance}}{\text{Speed}}$$



$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

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Distance/Time Graphs

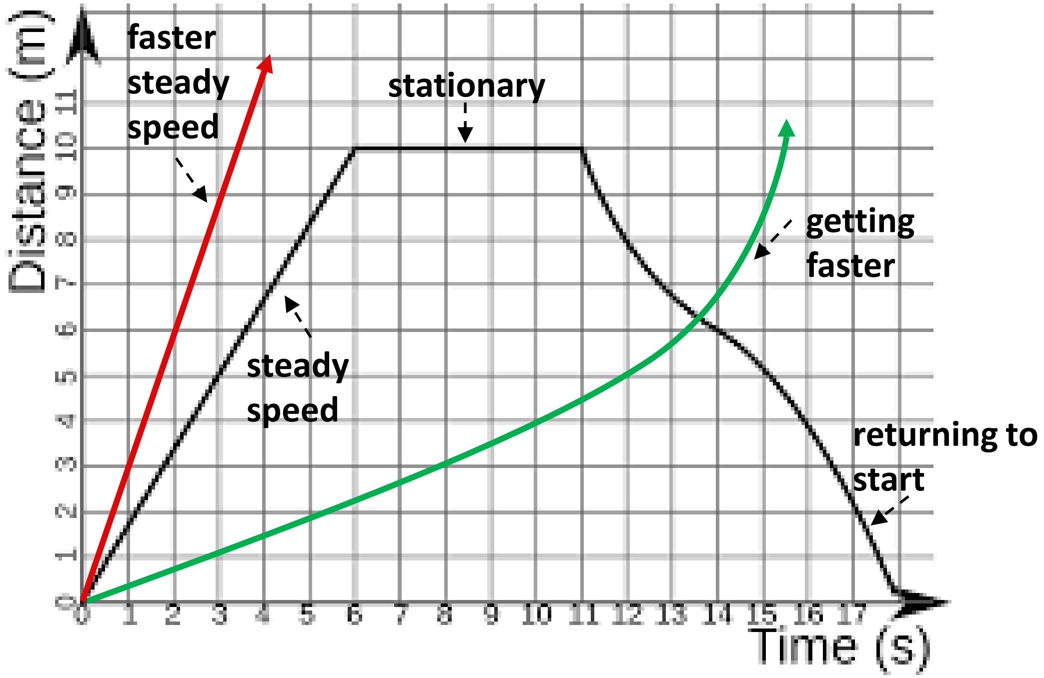
How they work

Distance/Time graphs describe the motion of an object.

- When the graph is horizontal or flat - the object has stopped.
- The **gradient** (slope) at any point on the graph will give you the speed the object is travelling on (distance ÷ time)
- If the graph curves – acceleration is happening. A curve which is getting steeper (the gradient is increasing) means that the object is speeding up. A curve which levelling off (the gradient is decreasing) means that the object is slowing down.

Graph

Top tip:
Straight line means constant speed
Curved line means changing speed



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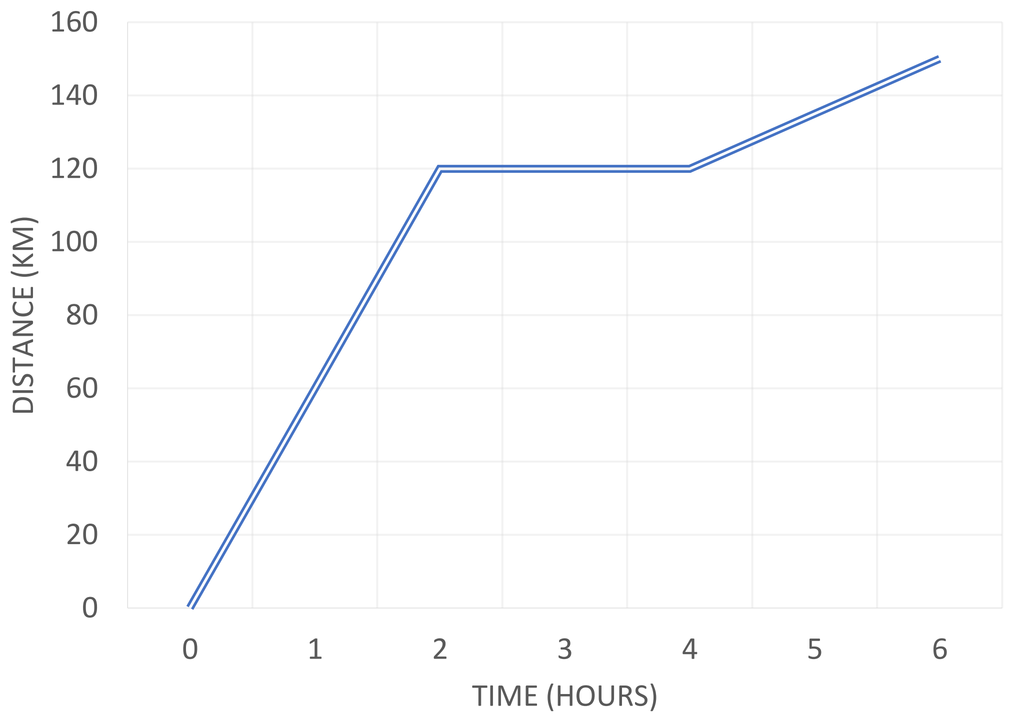
Using Distance/Time Graphs

Example

A car travels at 60 km/h for 2 hours on the motorway.

It then stops at the service station for 2 hours.

After 2 hours it continues travelling along the motorway in heavy traffic, at only 15 km/h for 30 km.



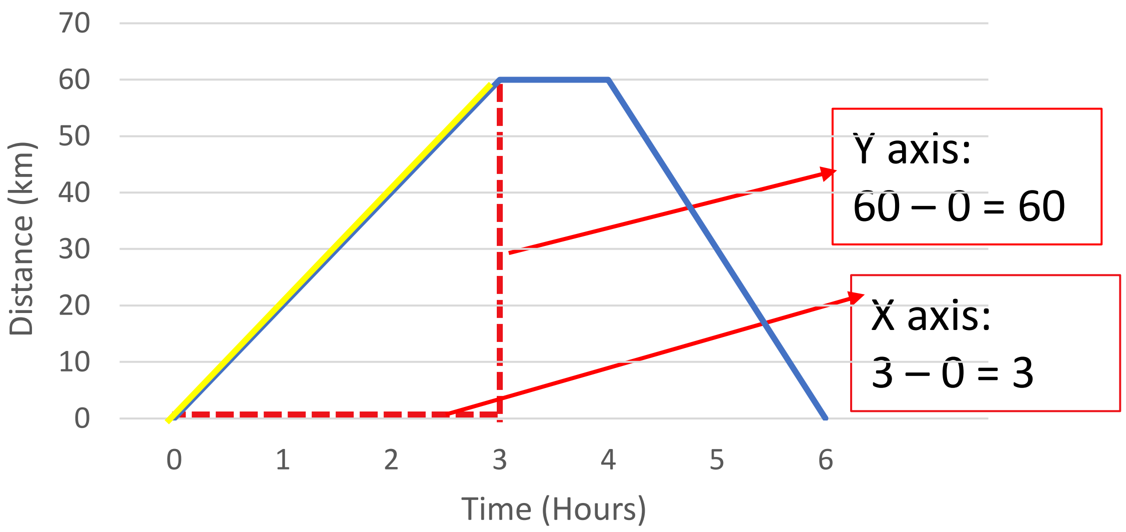
Using Distance/Time Graphs

Finding the speed

The speed can be found at any time on a distance/time graph.

- If the graph is a straight line, the speed anywhere on the line will be equal to the gradient.

$$\text{Gradient} = \frac{\text{change in y (vertical)}}{\text{change in x (horizontal)}}$$



$$\text{Gradient} = \frac{60}{3} = 20 \text{ km/h}$$

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Using Distance/Time Graphs

Finding the speed

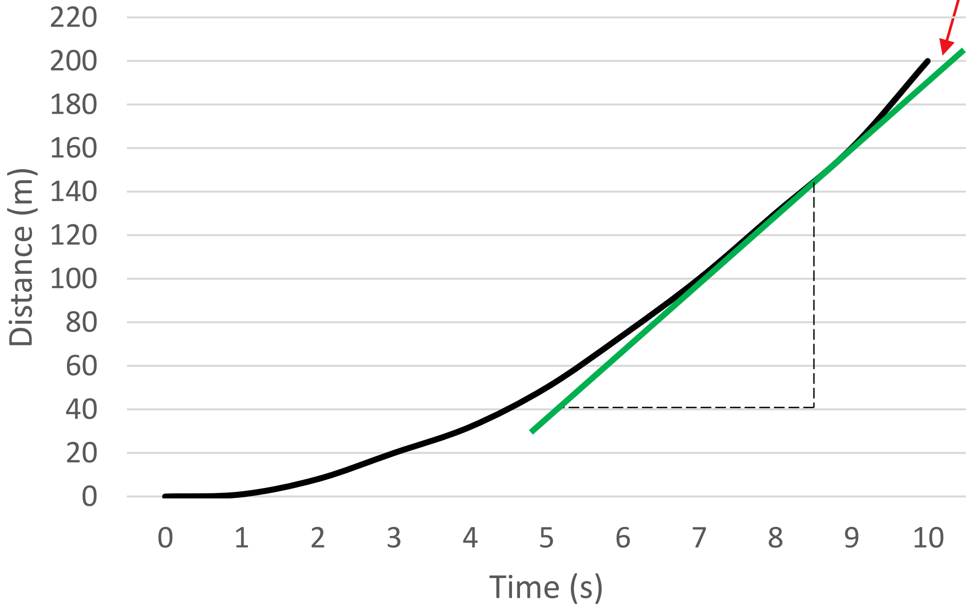
- If the graph is curved, in order to find the speed at a given time, you will need to draw a **tangent** to the curve at that point.

A tangent is a line that just touches the curve at one point.

- After drawing the tangent, you can find the gradient at that point.

You can also find the average speed of an object when it has **non-uniform motion** (i.e. if it is accelerating or decelerating) by dividing the total distance travelled by the time taken to travel that distance.

This is the tangent



Y axis:
140 – 40 = 100

X axis:
8.5 – 5 = 3.5

Gradient = $\frac{100}{3.5}$ = 28.6 km/h

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Velocity

What is velocity?

Velocity is known as a **vector** quantity.

It has a size (magnitude), and a direction.

Velocity is a measure of speed in a given direction, e.g. 25km/h south.

Objects can travel at a constant speed, with a changing velocity. This will happen if it travels at the same speed, but changes direction, for example if it is travelling in a circle.

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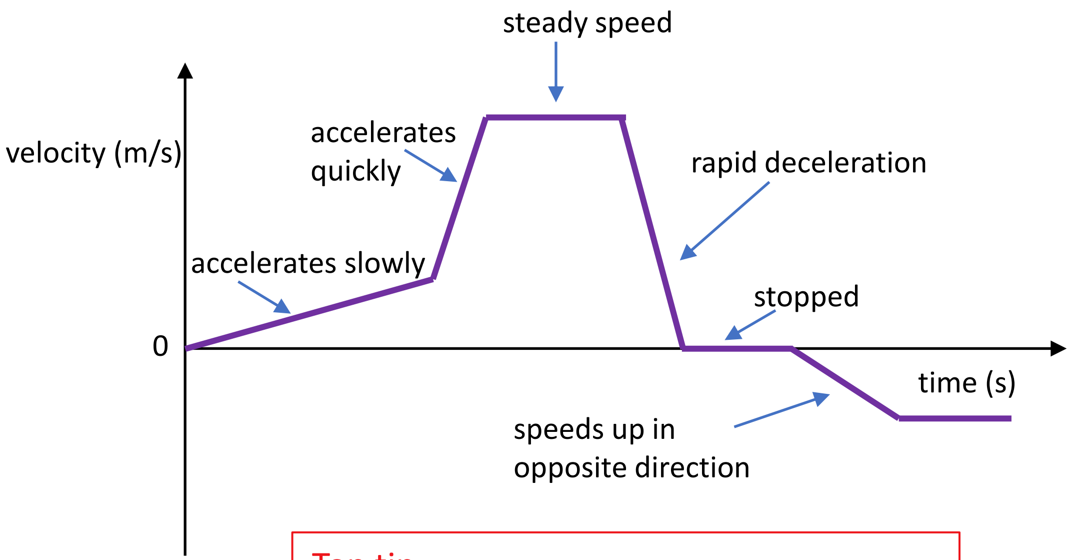
Velocity/Time Graphs

How they work

Velocity/Time graphs describe how an object's velocity changes over time.

- When the graph is horizontal or flat - the object is travelling at a steady speed.
- The **gradient** (slope) at any point on the graph will give you the acceleration of the object (change in velocity ÷ time).
- The steeper the graph, the greater the acceleration or deceleration. If the line is moving upwards it is accelerating if it moves downwards it is decelerating (remember in the negative velocity this is the other way around).
- If the line is straight it is accelerating/decelerating at a constant rate.
- If the graph curves – acceleration/deceleration is changing.

Graph



Top tip:
Straight line means constant acceleration
Curved line means changing acceleration

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Using Velocity/Time Graphs

Finding the acceleration

The acceleration can be found at any time on a velocity/time graph.

- If the graph is a straight line, the acceleration anywhere on the line will be equal to the gradient.

$$\text{Gradient} = \frac{\text{change in y (vertical)}}{\text{change in x (horizontal)}}$$

If the graph is curved, you can use a tangent to the curve at that point.

Graph

Acceleration:

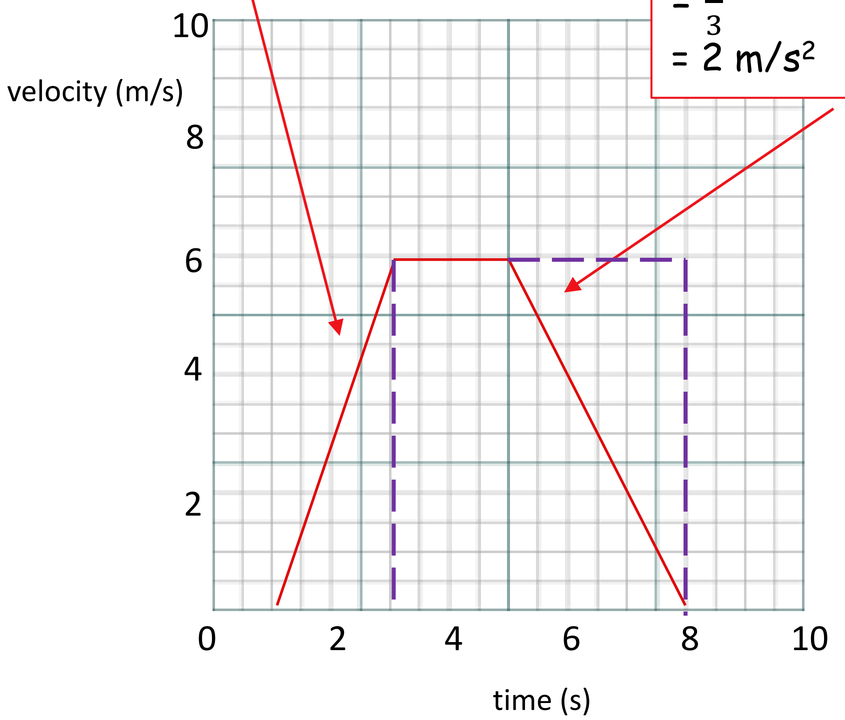
$= \frac{6}{2}$

$= 3\ m/s^2$

Deceleration:

$= \frac{6}{3}$

$= 2\ m/s^2$



Top tip: Remember deceleration can be written as negative acceleration i.e. $-2\ m/s^2$

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Using Velocity/Time Graphs

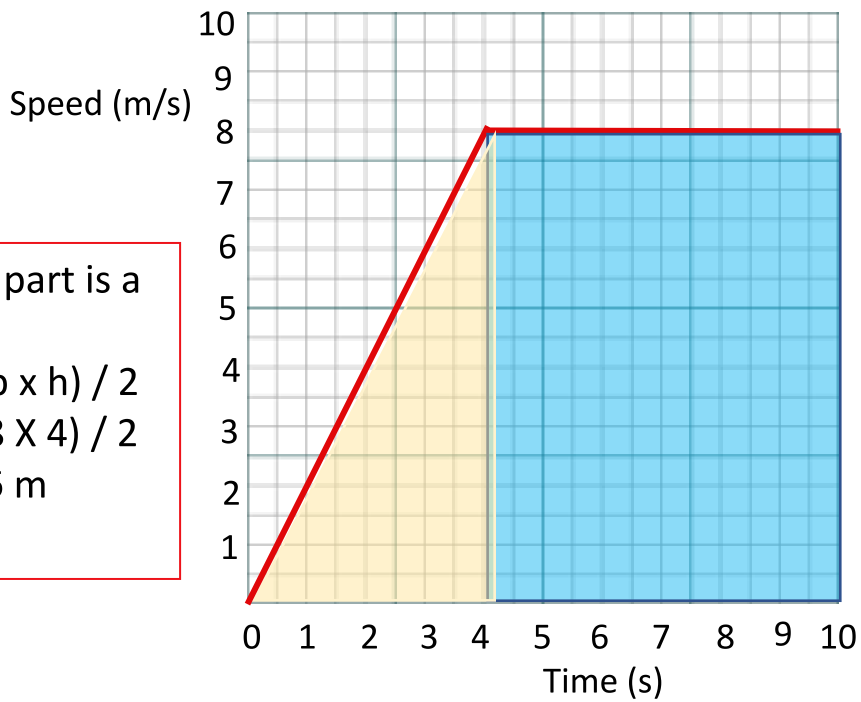
Finding the distance travelled

You can find the distance travelled in a certain time by calculating the area under any section of the graph.

- If the acceleration is constant - the area underneath the graph can be split into rectangles and triangles.
- You can count the squares under the line and multiply the number by the value of one square.

Graph

The second part is a rectangle
Area =b x h
= 8 X 6
= 48 m



The first part is a triangle
Area = (b x h) / 2
= (8 X 4) / 2
= 16 m

Total distance
16 + 48
= 64 m

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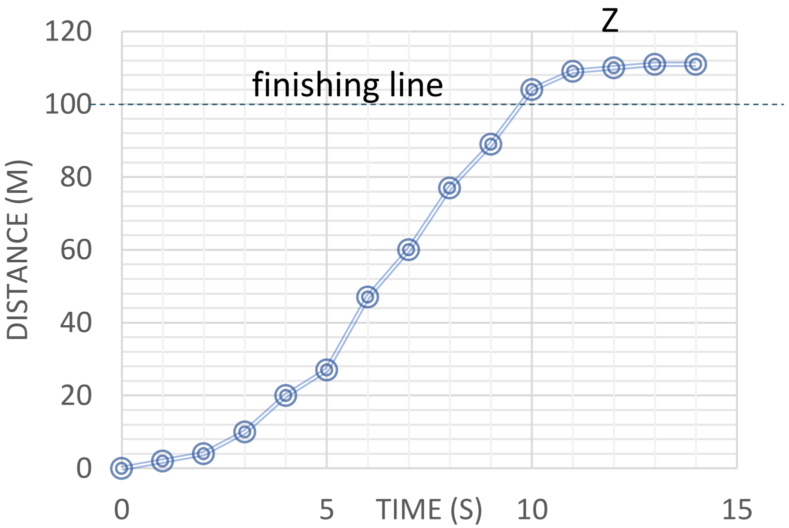
Your turn:

1. The photograph below shows the start of a 100 m race.

Sophie wins the race. The graph shows Sophie's distance-time graph.



a) Using the graph, find the distance Sophie ran in the first 4 seconds.

…………………………………………………………………………………………………….

b) Sophie runs 100 m in 9.80 seconds
Calculate her average speed.

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c) Explain why her average speed is less than her top speed.

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Your turn:

d. Complete the sentences below.

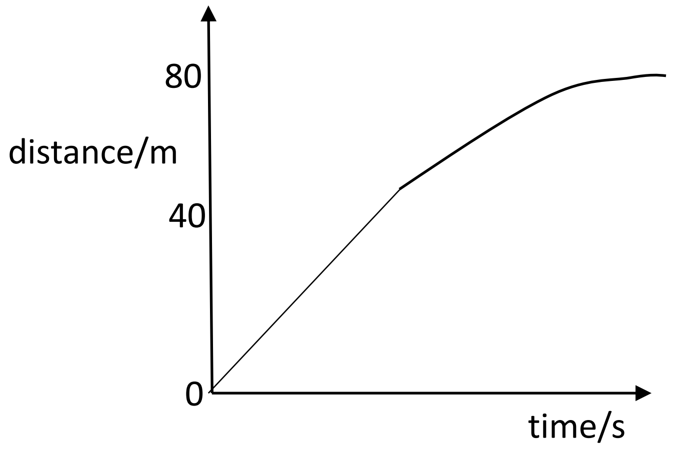
(i) In the section of the graph marked Z, Sophie is

A stationary
B running at a constant speed
C speeding up
D slowing down

(ii) Velocity is

A the same as speed
B speed in a circle
C speed in a stated direction
D constant speed

2. Below is a distance-time graph for a car.



Describe what the graph shows about the speed of the car as it travels the 80 metres.

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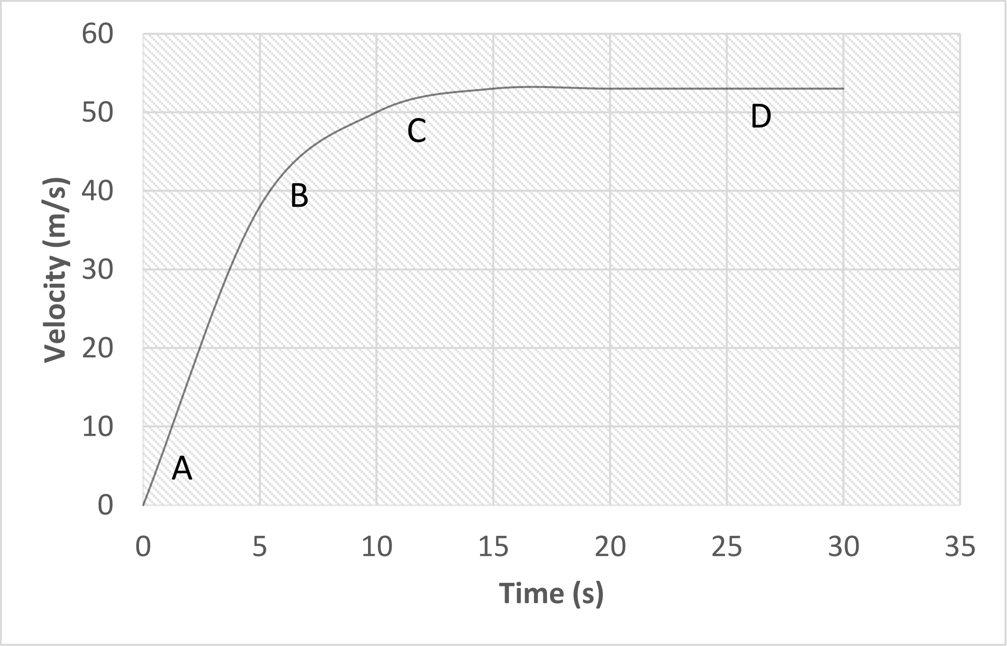
Your turn:

3. Oliver is a free-fall parachutist.

Below is a velocity-time graph for his jump.



a) Where on the graph is the greatest acceleration, A, B , C or D?

....

b) Estimate how far Oliver falls in the first 2 seconds.

....
.

c) Explain the difference between velocity and speed.

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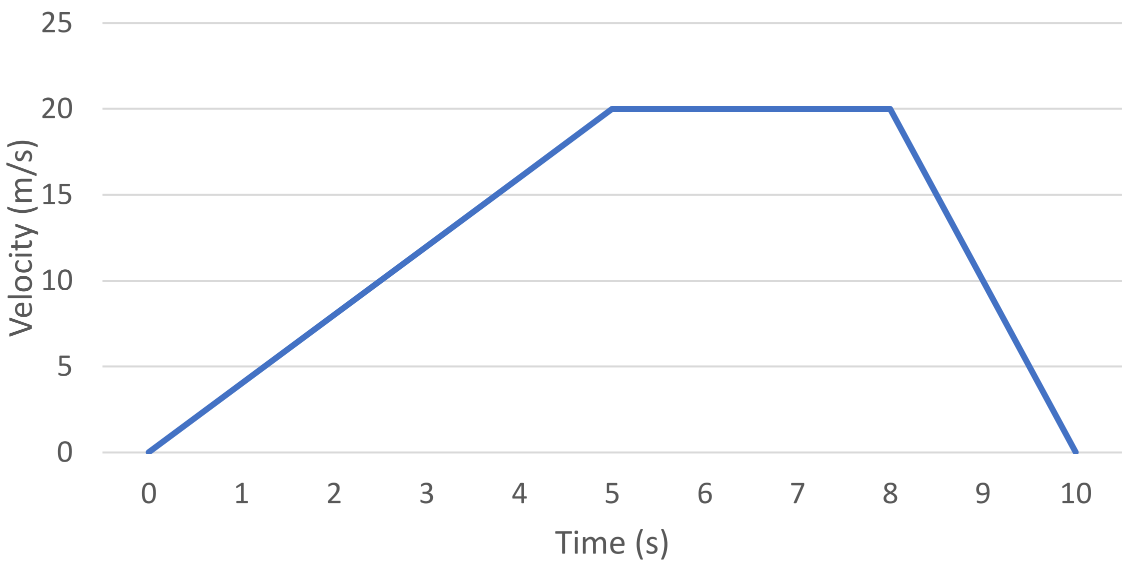
....
....

Your turn:

4. The graph below shows how the velocity of a small car changes with time.



a) Describe the movement of the car when the resultant force on the car is zero.

....

b) Use the graph to estimate the velocity of the car at three seconds.

....

c) Calculate the acceleration of the car when it is speeding up.

....

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....

d) Explain why the units of acceleration are m/s^2

....

....

....

....

e) Show that the car travels further at a constant velocity than it does when it is slowing down.

....

....

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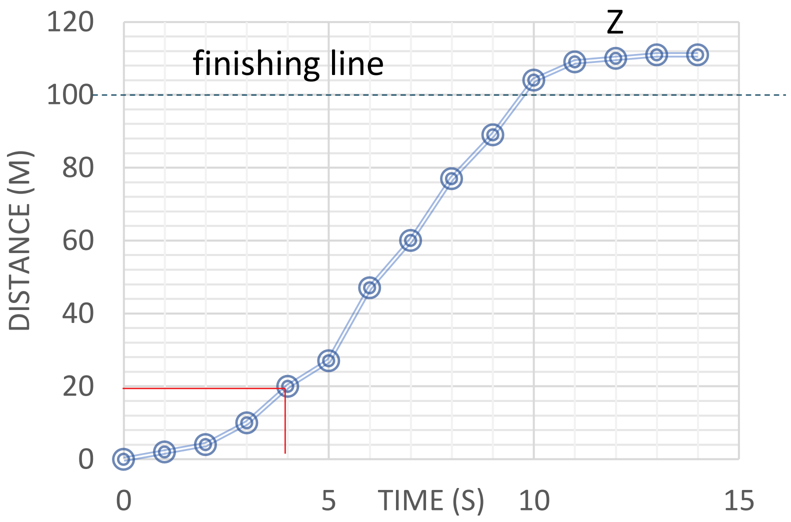
Answers:

1. The photograph below shows the start of a 100 m race.

Sophie wins the race. The graph shows Sophie's distance-time graph.



a) Using the graph, find the distance Sophie ran in the first 4 seconds.

20 metres

b) Sophie runs 100 m in 9.80 seconds
Calculate her average speed.

$\frac{100}{9.8}$ 10.2 m/s

c) Explain why her average speed is less than her top speed.

The speed changes, it is slower to begin with, faster at the end.

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Answers:

d. Complete the sentences below.

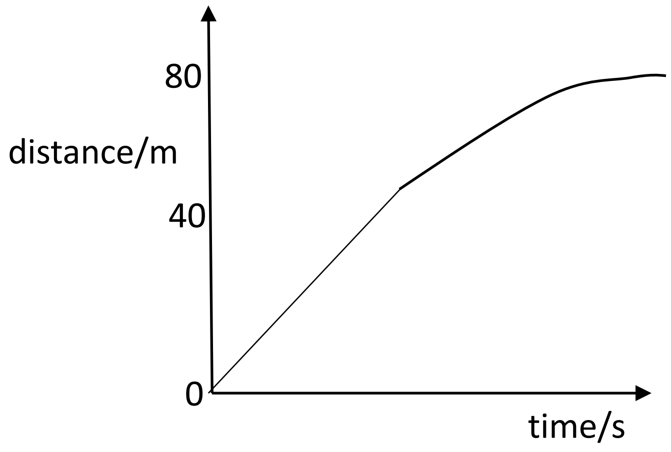
(i) In the section of the graph marked Z, Sophie is

A stationary
B running at a constant speed
C speeding up
D slowing down X

(ii) Velocity is

A the same as speed
B speed in a circle
C speed in a stated direction X
D constant speed

2. Below is a distance-time graph for a car.



Describe what the graph shows about the speed of the car as it travels the 80 metres.

It initially travels at a constant speed, but then starts slowing down.

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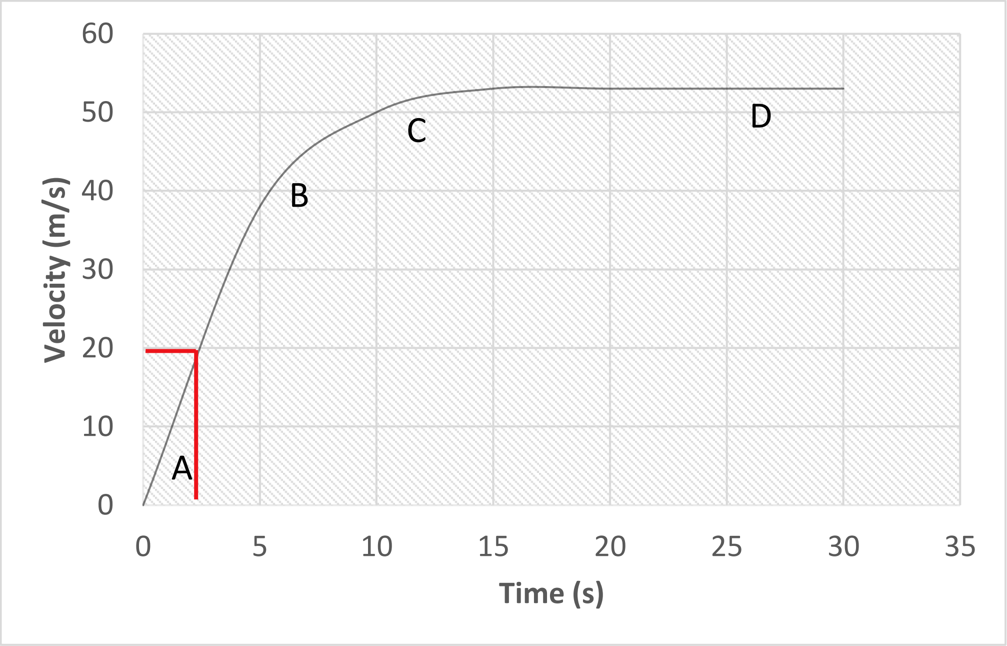
Answers:

3. Oliver is a free-fall parachutist.

Below is a velocity-time graph for his jump.



a) Where on the graph is the greatest acceleration, A, B , C or D?

A

b) Estimate how far Oliver falls in the first 2 seconds.

Distance travelled = area of triangle under graph

½ x 20 x 2 = 20m

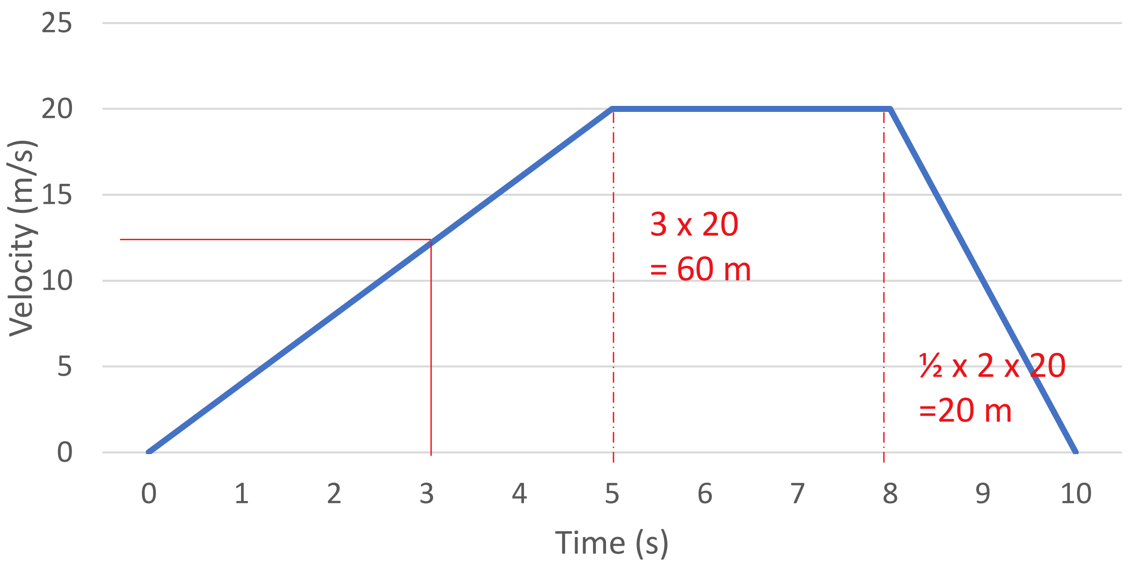
c) Explain the difference between velocity and speed.

Speed is a scalar quantity (just a size)

Velocity is a vector quantity (has a size and direction)

Your turn:

4. The graph below shows how the velocity of a small car changes with time.



a) Describe the movement of the car when the resultant force on the car is zero.

Moving at a constant velocity ....

b) Use the graph to estimate the velocity of the car at three seconds.

12m/s ....

c) Calculate the acceleration of the car when it is speeding up.

$\frac{\text{Final velocity – initial velocity}}{\text{time}}$ $\frac{20 - 0}{5} = 4\text{m/s}^2$

d) Explain why the units of acceleration are m/s^2

Velocity is measured in m/s divided by time in s

i.e. it is the rate of change of velocity

e) Show that the car travels further at a constant velocity than it does when it is slowing down.

Constant velocity – travels 60 m (3 x 20)

Slowing down – travels ½ x 2 x 20 = 20 m

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For more help and resources, or to work with us as a tutor, please contact us

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