Summary of key points

1 Velocity is the **rate of change** of displacement.

On a displacement–time graph the **gradient** represents the velocity.

If the displacement–time graph is a straight line, then the velocity is constant.

2 Average velocity $= \dfrac{\text{displacement from starting point}}{\text{time taken}}$

3 Average speed $= \dfrac{\text{total distance travelled}}{\text{time taken}}$

4 Acceleration is the **rate of change** of velocity.

In a velocity–time graph the **gradient** represents the acceleration.

If the velocity–time graph is a straight line, then the acceleration is constant.

5 The area between a velocity–time graph and the horizontal axis represents the distance travelled.

For motion in a straight line with positive velocity, the area under the velocity–time graph up to a point t represents the displacement at time t.

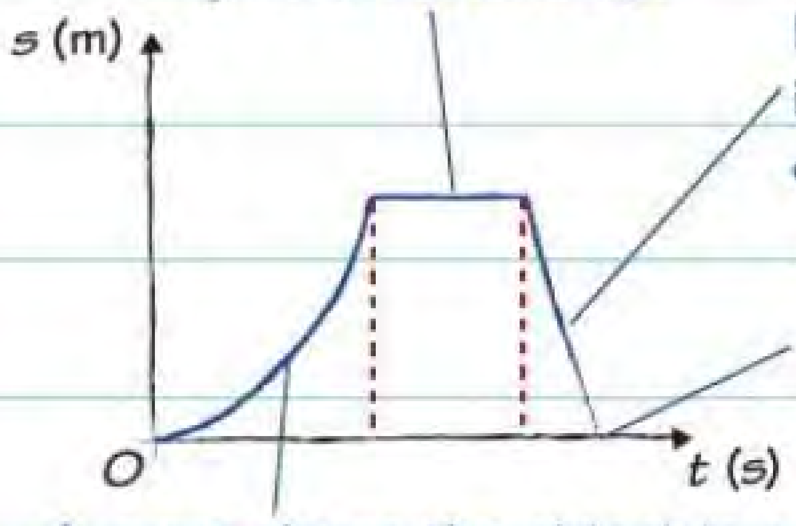
Had a look ☐ Nearly there ☐ Nailed it! ☐

Motion graphs

You need to understand and be able to sketch **displacement–time** graphs and **velocity–time** graphs for objects moving in straight lines.

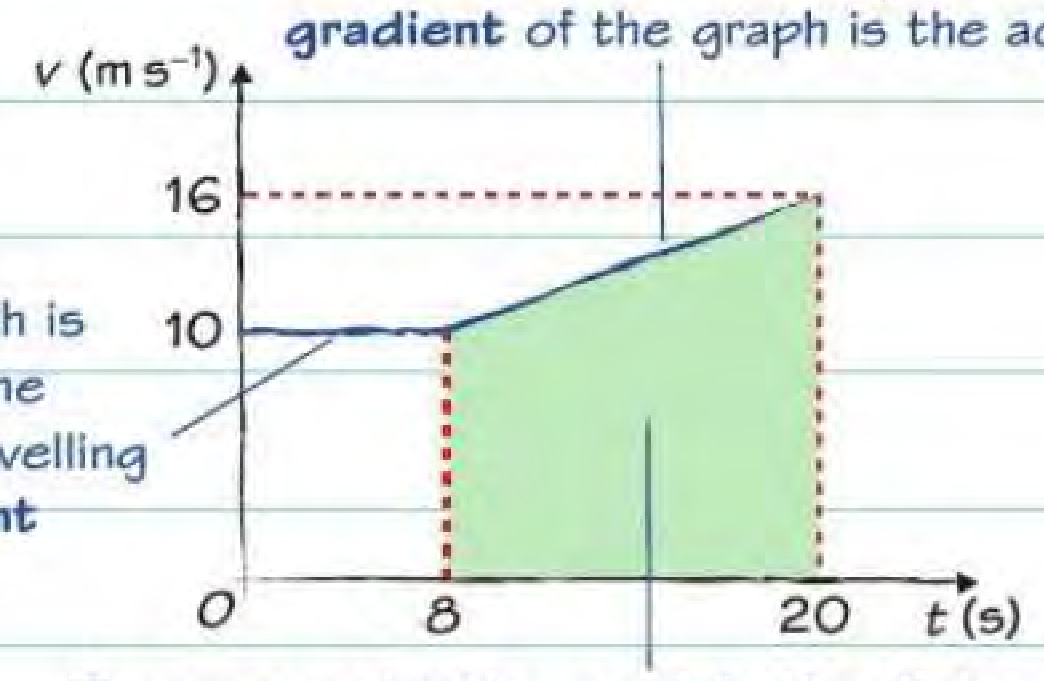
Displacement–time graphs

The gradient of a displacement–time graph tells you the **velocity** of an object.



Velocity–time graphs

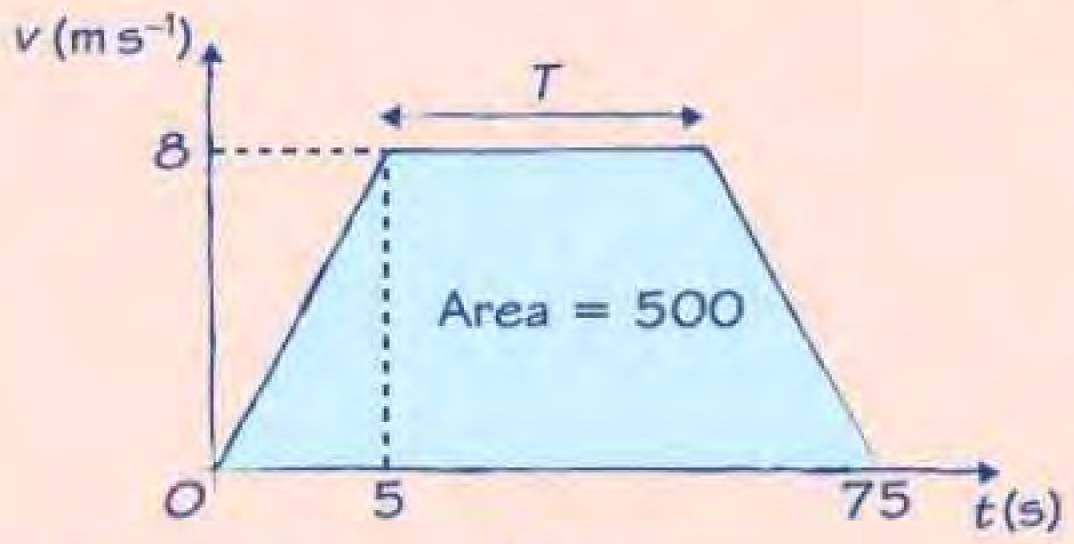
This velocity–time graph shows motion of a train:



Worked example

An athlete runs along a straight road. She starts from rest and moves with constant acceleration for 5 seconds, reaching a speed of $8\,\text{m}\,\text{s}^{-1}$. This speed is then maintained for T seconds. She then decelerates at a constant rate until she stops. She has run a total of 500 m in 75 s.

Find the value of T. **(3 marks)**



Area under graph = 500

$500 = \frac{1}{2}(75 + T) \times 8$

$1000 = 600 + 8T$

$8T = 400$

$T = 50$

Golden rules

Here are two important facts about velocity–time graphs.

1. Distance travelled = area under graph

In the example above, the train travels $\frac{1}{2}(10 + 16) \times 12 = 156\,\text{m}$ between 8 s and 20 s.

2. Acceleration = gradient of graph

In the example above, between 8 s and 20 s the train is accelerating at $\frac{v}{t} = \frac{6}{12} = 0.5\,\text{m}\,\text{s}^{-2}$.

Problem solved!

You can solve this problem by sketching a velocity–time graph for the motion of the athlete. Use the formula for the area of a trapezium, $A = \frac{1}{2}(a + b)h$, to write an equation involving T.

You will need to use problem-solving skills throughout your exam – **be prepared!**

Now try this

A truck is moving along a straight horizontal road. At time $t = 0$, the truck passes a point A with speed $18\,\text{m}\,\text{s}^{-1}$. The truck moves with constant speed $18\,\text{m}\,\text{s}^{-1}$ until $t = 10\,\text{s}$. It then decelerates uniformly for 6 s. At time $t = 16\,\text{s}$, the speed of the truck is $V\,\text{m}\,\text{s}^{-1}$, and this speed is maintained until the truck reaches the point B at time $t = 30\,\text{s}$.

(a) Sketch a velocity–time graph to show the motion of the truck from A to B. **(3 marks)** Answer

(b) Given that $AB = 455\,\text{m}$, find the value of V. **(5 marks)** Answer

If the truck **decelerates**, the graph will slope down.