

Maths in Science

Gradients



Gradients

Calculating the gradient at a particular point on a graph is a key skill required in International GCSE Science and sometimes appears in exam questions.

The gradient of a straight-line graph can be calculated using the below equation.

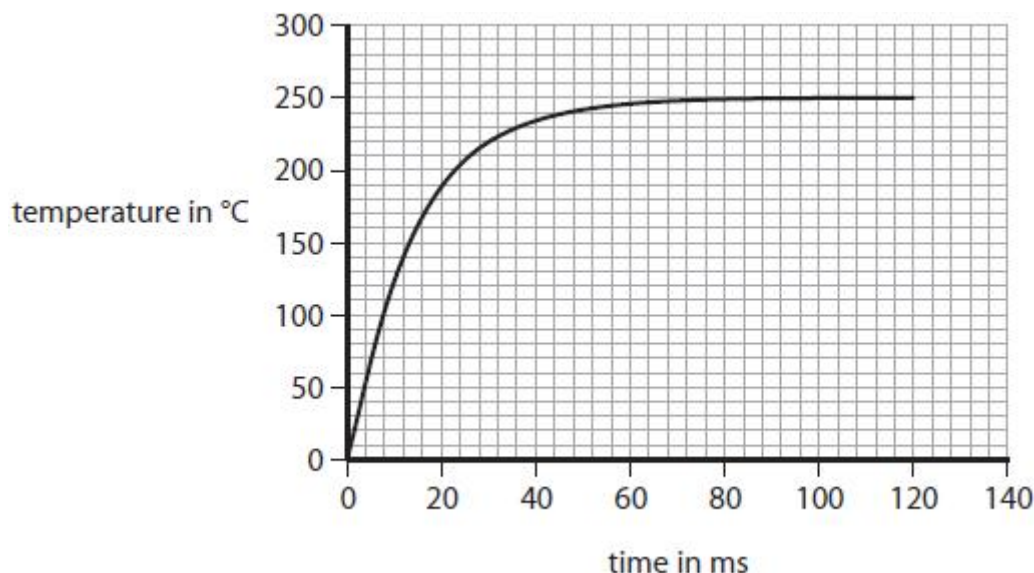
$$\text{Gradient} = \frac{\text{change in } y}{\text{change in } x}$$

However, for a curved graph, you will be required to draw a tangent to the curve before using the same equation. A tangent is a straight line that just touches the curve of the graph at a given point.

Worked example:

Let's try the following question, this would be worth 4 marks.

The graph below shows temperature against time for a halogen lamp for the first 120 ms after it has been switched on.



Calculate the gradient of the graph at a time of 30ms. State the unit.

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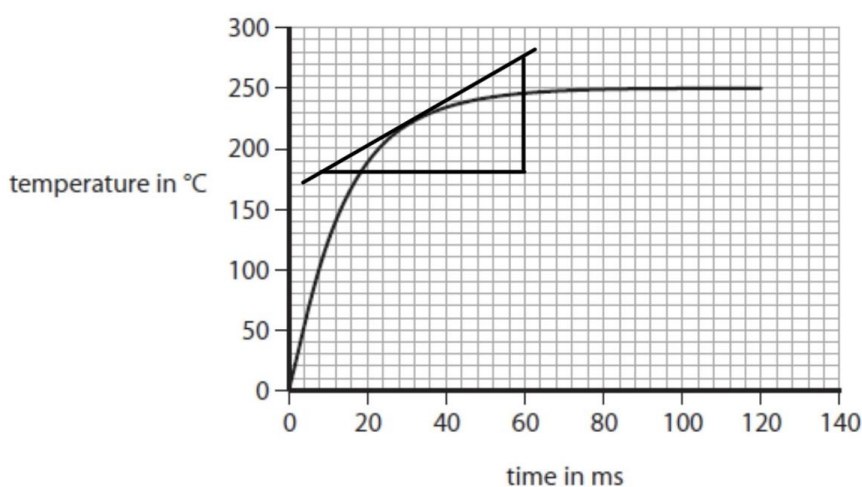
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The first step is to use a ruler to draw a tangent to the curve at time 30ms. This line should just touch the line at 30ms and be long enough to draw a large triangle on the graph to help choose appropriate data points to calculate the gradient.

Remember that the tangent must be touching the curve in order to gain this mark and should not be touching a whole section of the curve. Use a pencil to get it right before going over in pen if necessary.

Once your tangent is drawn, draw a large triangle to this line as shown below.



Now we have the triangle drawn, we need to read the data points from the graph. Remember that to calculate the gradient, we calculate the difference in y values and divide by the difference in x values. Also known as rise over run.

Now we can substitute the values into the equation,

Gradient = $\frac{\text{change in } y}{\text{change in } x}$

$$= \frac{275 - 180}{60 - 8}$$

$$= \frac{95}{52}$$

Using a calculator, we can then complete this calculation, to give an answer of 1.83°C/ms. The mark scheme will provide a range that the gradient must fall into.

The fourth mark available is given for providing the unit.

Quick tip – draw the tangent and triangle as big as possible to allow a more accurate calculation of gradient.

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Gradients: Checking understanding

Question 1:

Calculate the acceleration of the train in the 34s of its journey using the graph in Figure 8 below. Give your answer to two decimal places.

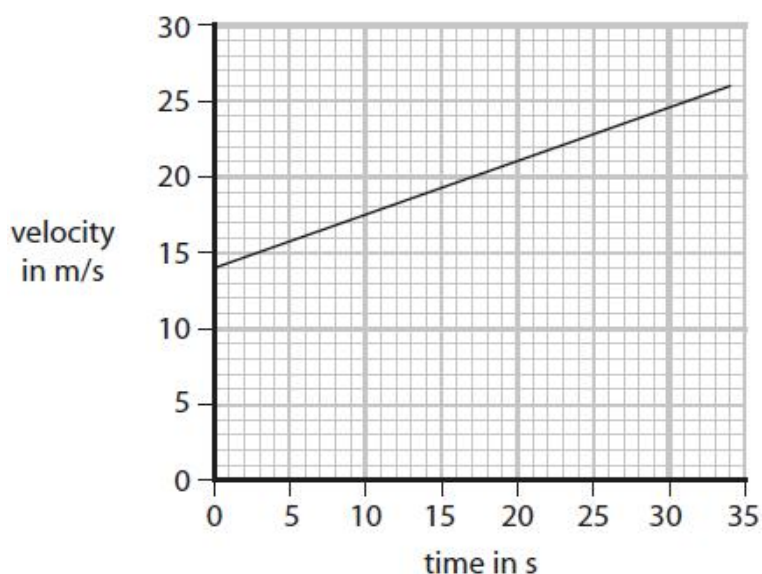
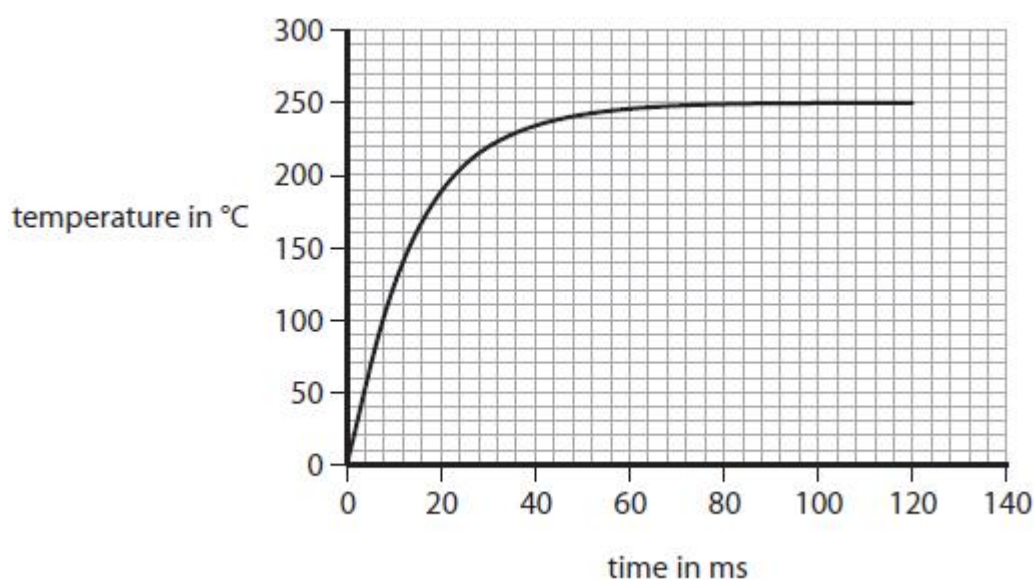


Figure 8

Question 2:

Using the graph below, calculate the gradient of the graph at a time of 20ms. Give your answer to 2 decimal places.



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Question 3:

Calculate the rate of increase in temperature at a time of 120s using the graph in Figure 11.

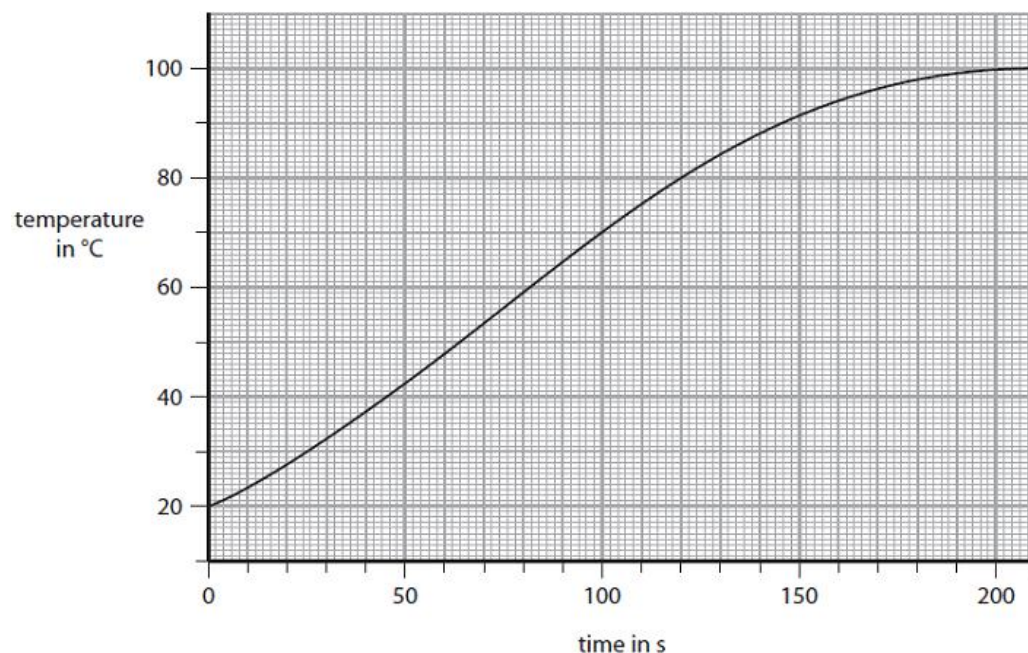


Figure 11

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Gradients: Checking understanding (Answers)

Question 1:

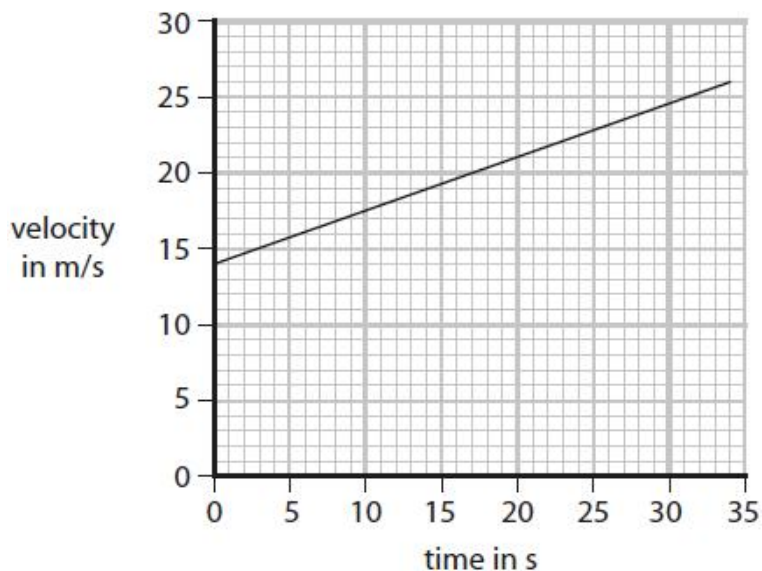


Figure 8

Acceleration = velocity / time, therefore, acceleration is the gradient of the graph.

Acceleration (gradient) = $\frac{\text{change in velocity (change in y)}}{\text{change in time (change in x)}}$

$$= \frac{26 - 14}{34 - 0}$$

$$= \frac{12}{34}$$

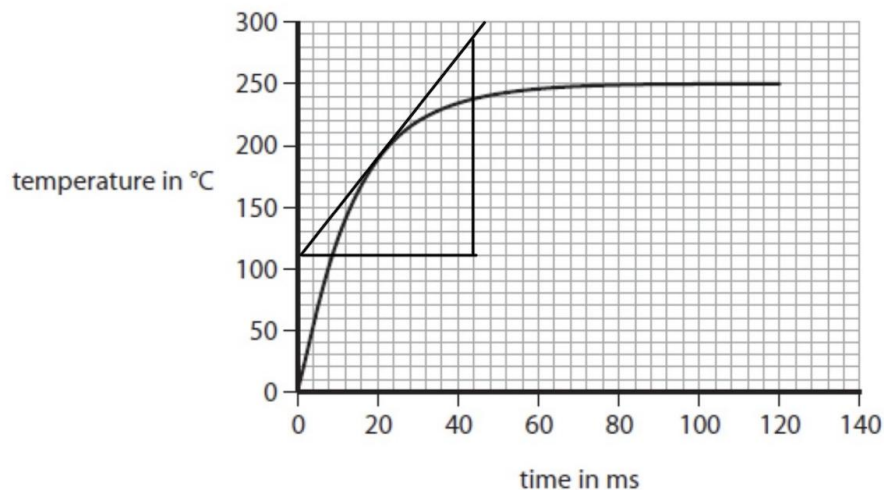
$$= 0.35 \text{ m/s}^2$$

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Question 2:



Gradient = $\frac{\text{change in } y}{\text{change in } x}$

$$= \frac{285 - 110}{44 - 0}$$

$$= \frac{175}{44}$$

$$= 3.98 \text{ }^{\circ}\text{C/ms}$$

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Question 3:

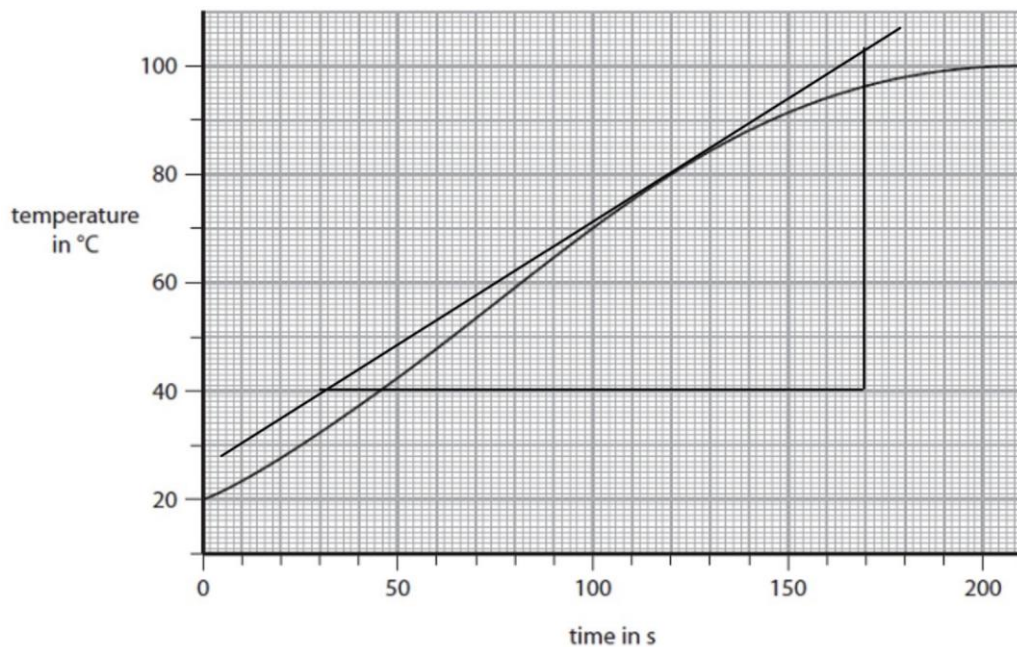


Figure 11

Gradient = $\frac{\text{change in } y}{\text{change in } x}$

$$= \frac{103 - 40}{170 - 30}$$

$$= \frac{63}{140}$$

$$= 0.45 \text{ m/s}^2$$