

# A6 • Interpreting distance–time graphs

## Mathematical goals

To enable learners to:

- interpret and construct distance–time graphs, including:
  - relating speeds to gradients of these graphs;
  - relating accelerations to changes in these speeds.

## Starting points

Learners have often constructed distance–time graphs before. However, experience shows that many still interpret them as if they are pictures of situations rather than abstract representations. In addition, they also find it difficult to interpret the significance of the gradients of these graphs.

In this session, learners begin by discussing a question that is designed to reveal common misconceptions about distance–time graphs. They then work in pairs and threes to match descriptions, graphs and tables. As they do this, they will interpret their meaning and begin to link the representations together.

## Materials required

- OHT 1 – *Speed and acceleration: car*;
- OHT 2 – *Speed and acceleration: motorbike*.

For each learner you will need:

- Sheet 1 – *Journey to college; Motorbike and car*;
- Sheet 2 – *The race*;
- mini-whiteboard.

For each small group of learners you will need:

- Card set A – *Descriptions*;
- Card set B – *Distance–time graphs*;
- Card set C – *Distance–time tables*;
- Card set D – *Speeds and accelerations*.

## Time needed

Approximately 1 hour 30 minutes.

## Suggested approach **Beginning the session**

Ask learners to tackle the two questions on Sheet 1 – *Journey to college* and *Motorbike and car*, working in pairs. Both questions ask learners to interpret distance–time graphs.

As you listen to pairs tackling the first question, watch for evidence of misconceptions such as the following:

*When she gets out she starts walking fast to the bus stop, then she slows down, then she picks up speed again, and then the speed goes constant.*

*Jane walked along a road for 100 m. Instead of walking another 30 m she took a short cut down an alleyway which took her 20 minutes. She walked very quickly then she caught the bus to her college which took about 50 minutes.*

In the second question, many learners assume that the vehicles are travelling at the same speed at the point where the graphs cross.

Encourage learners to discuss their answers with other pairs. Do not comment at this stage. After a few have shared their ideas, begin to challenge them for more details, such as the speed at each point on the graphs. Ask learners to describe the evidence for each aspect of their description. If the errors in the two stories quoted above do not arise naturally, read the stories out and ask learners to explain the mistakes.

Finally, use OHTs 1 – *Speed and acceleration: car* and 2 – *Speed and acceleration: motorbike* to describe how the speeds and accelerations are related to the gradients of the graphs.

## **Working in groups**

Ask learners to work in groups of two or three and give out Card sets A – *Descriptions* and B – *Distance–time graphs*.

Ask learners to take it in turns to match pairs of cards from each set. This is not a one-to-one matching. If learners think that any cards are missing, they should create their own.

When learners have had enough time to tackle the task, give out Card sets C – *Distance–time tables* and D – *Speeds and accelerations*. These should be matched to the cards already on the table. Although there are no scales on the graphs on Card set D, learners may be able to work out the correct matching by considering the differences between successive terms in the tables.

## Reviewing and extending learning

Ask learners some ‘show me’ questions using mini-whiteboards:

Show me a distance–time graph for:

- a car travelling at a steady speed;
- a car speeding up;
- a car slowing down;
- a stationary car;
- two cars travelling at the same speed towards each other;
- a car is crawling along in the slow lane and a car overtakes very quickly;
- a child runs into the road, so the driver has to make an emergency stop;
- a car slows down as it goes over a speed bump, then goes quickly again.

Finally, encourage learners to tackle the problem in Sheet 2 – *The race*. This will help to consolidate what they have learned during the session.

### What learners might do next

Invite learners to create their own distance–time graph and a story that matches it.

Ask learners to exchange stories and try to recreate the graphs from the stories alone. Finally, compare the resulting graphs with the originals and discuss the discrepancies.

### Further ideas

This activity uses multiple representations to deepen understanding of distance–time graphs. This type of activity may be used in any topic where a range of representations is used. In this pack, other examples include:

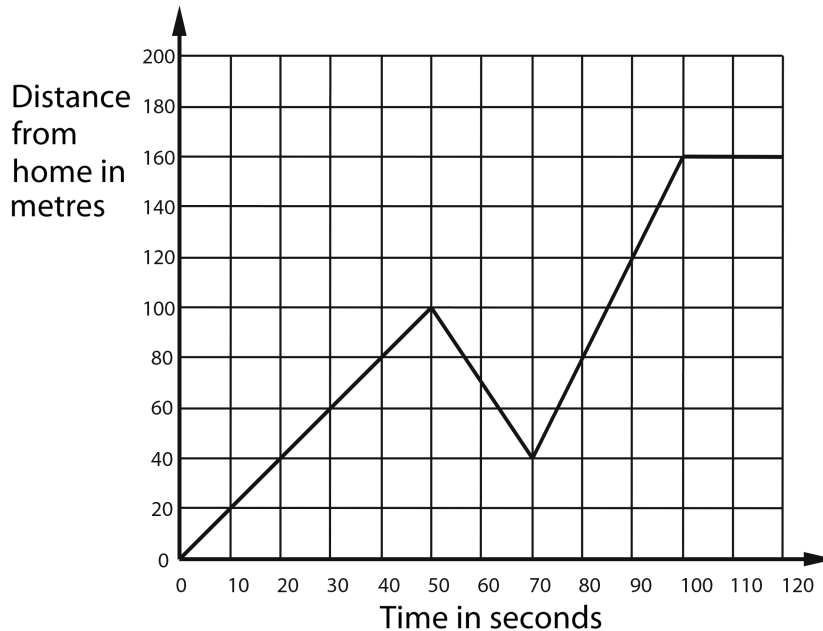
**N5 Understanding the laws of arithmetic;**

**A1 Interpreting algebraic expressions.**

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## A6 Sheet 1 – Journey to college; Motorbike and car

### Journey to college



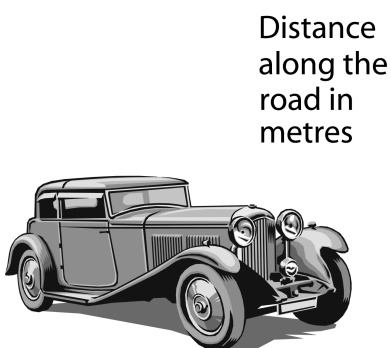
Every morning Jane walks along a straight road to a bus stop 160 metres from her home, where she catches a bus to college.

The graph shows her journey on one particular day.

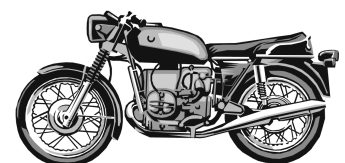
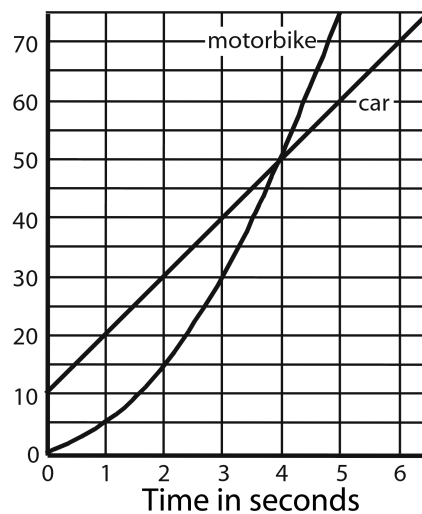
Write a description of what may have happened.

You should include details such as how fast she walked.

### Motorbike and car



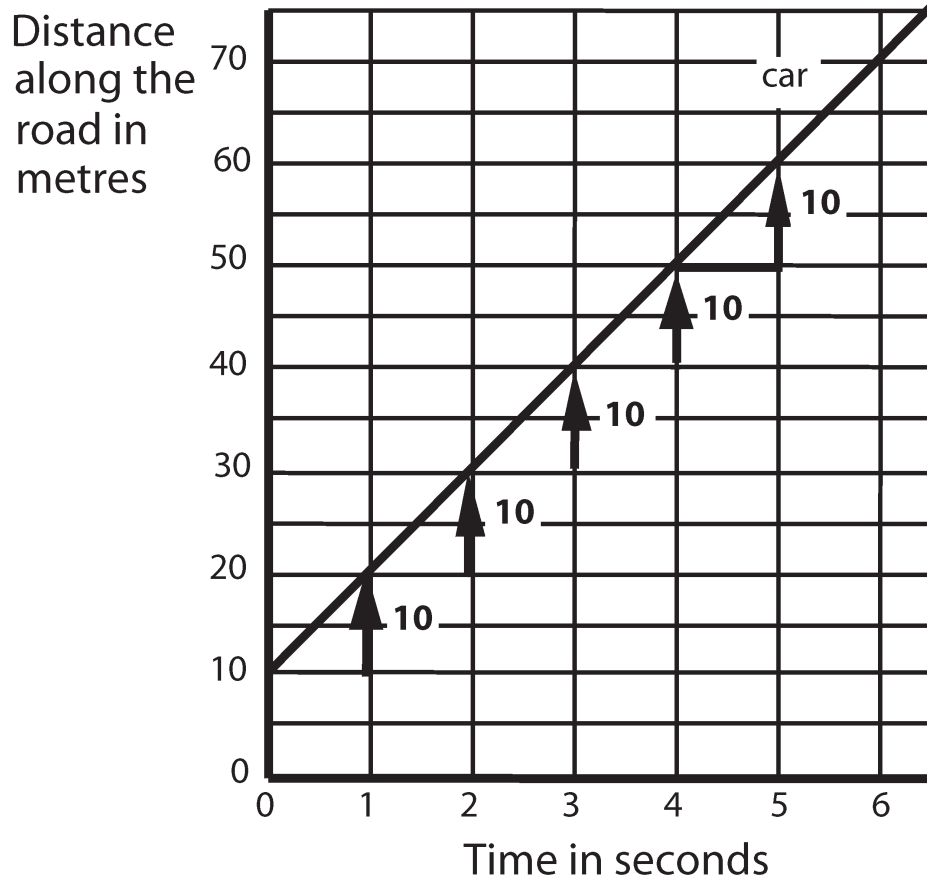
Distance along the road in metres



This graph shows a vintage car and a motorbike travelling along a country road.

Write a description of what is happening. At what time are they travelling at the same speed?

**A6 OHT 1 – Speed and acceleration: car**



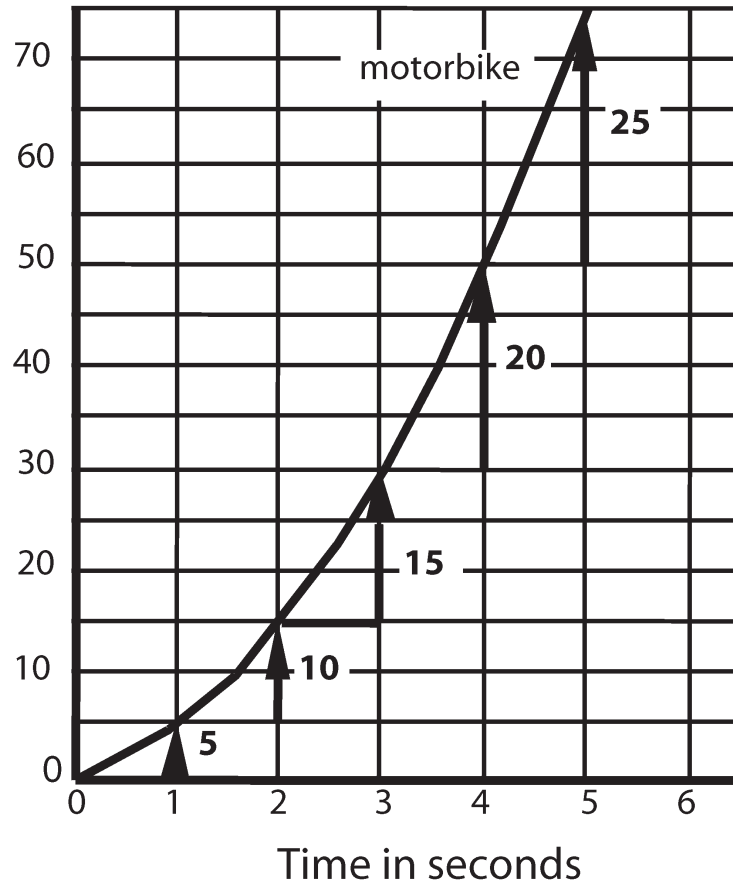
<b>Time (s)</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>
<b>Distance (m)</b>	<b>10</b>	<b>20</b>	<b>30</b>	<b>40</b>	<b>50</b>	<b>60</b>	<b>70</b>

→ +10    → +10    → +10    → +10    → +10    → +10

**Car travels at a constant speed of  $10 \text{ m s}^{-1}$ .**

**A6 OHT 2 – Speed and acceleration: motorbike**

Distance along the road in metres



<b>Time (s)</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>
<b>Distance (m)</b>	<b>0</b>	<b>5</b>	<b>15</b>	<b>30</b>	<b>50</b>	<b>75</b>	<b>?</b>

→ +5      → +10      → +15      → +20      → +25      → +?

**Each second, the average speed of the bike increases by  $5 \text{ m s}^{-1}$ .**

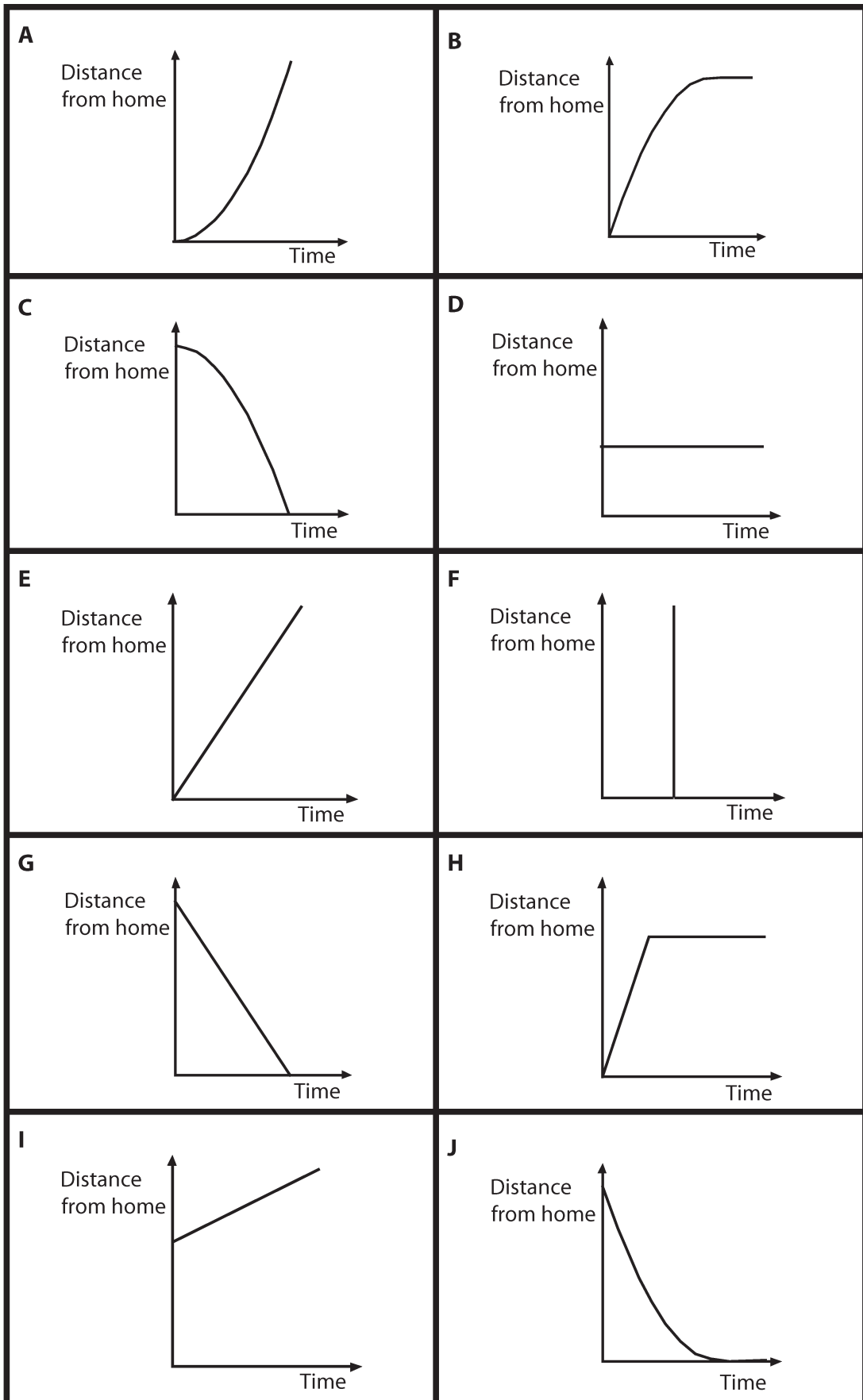
**Acceleration is  $5 \text{ m s}^{-2}$ .**

**A6 Card set A – Descriptions**

<b>Travels towards home</b>	<b>Travels away from home</b>
<b>Goes at a steady, slow speed</b>	<b>Not moving</b>
<b>Impossible journey</b>	<b>Goes at a steady, fast speed</b>
<b>Stops suddenly</b>	<b>Slows down and stops</b>
<b>Speeds up</b>	



**A6 Card set B – Distance–time graphs**



## A6 Card set C – Distance–time tables

A						
<b>Time</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Distance</b>	<b>0</b>	<b>45</b>	<b>80</b>	<b>105</b>	<b>120</b>	<b>125</b>

B						
<b>Time</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Distance</b>	<b>125</b>	<b>120</b>	<b>105</b>	<b>80</b>	<b>45</b>	<b>0</b>

C						
<b>Time</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Distance</b>	<b>0</b>	<b>5</b>	<b>20</b>	<b>45</b>	<b>80</b>	<b>125</b>

D						
<b>Time</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Distance</b>	<b>125</b>	<b>80</b>	<b>45</b>	<b>20</b>	<b>5</b>	<b>0</b>

E						
<b>Time</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Distance</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>50</b>

F						
<b>Time</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Distance</b>	<b>0</b>	<b>25</b>	<b>50</b>	<b>75</b>	<b>100</b>	<b>125</b>

G						
<b>Time</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Distance</b>	<b>125</b>	<b>117</b>	<b>109</b>	<b>101</b>	<b>93</b>	<b>85</b>

**A6 Card set C – Distance–time tables**

**H**

<b>Time</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Distance</b>	<b>85</b>	<b>93</b>	<b>101</b>	<b>109</b>	<b>117</b>	<b>125</b>

**I**

<b>Time</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Distance</b>	<b>125</b>	<b>100</b>	<b>75</b>	<b>50</b>	<b>25</b>	<b>0</b>

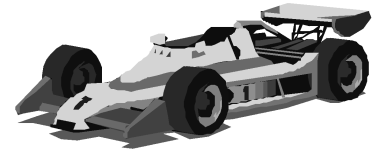
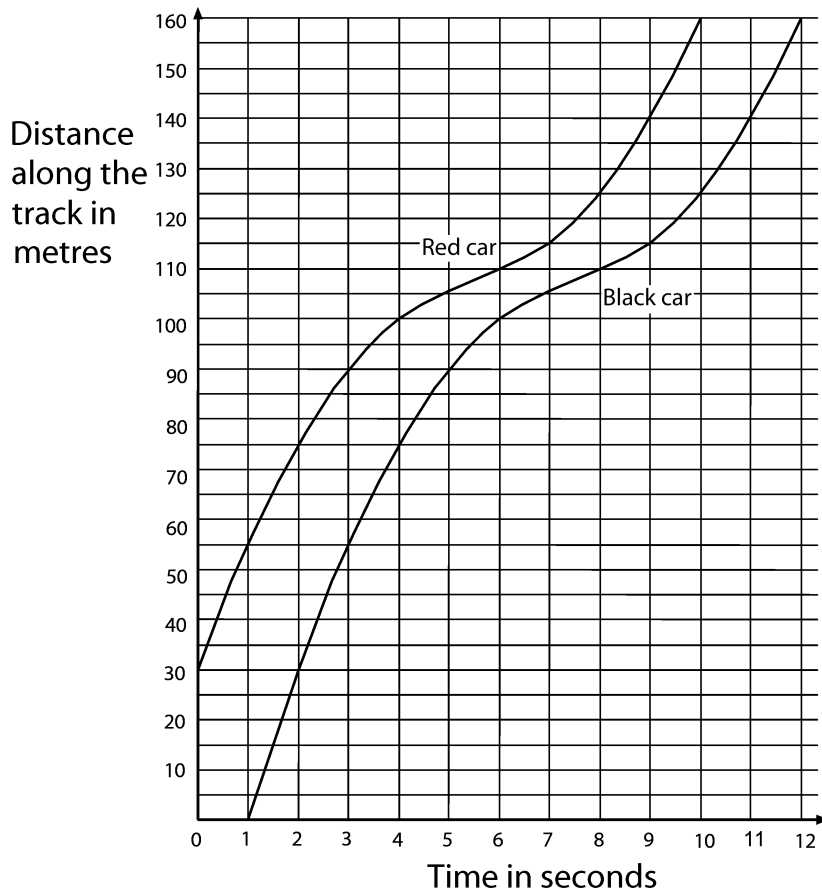
**J**

<b>Time</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Distance</b>						

**A6 Card set D – Speeds and accelerations**

<b>Speed</b> <b><math>25 \text{ m s}^{-1}</math></b>	<b>Acceleration</b> <b><math>10 \text{ m s}^{-2}</math></b>
<b>Speed</b> <b><math>8 \text{ m s}^{-1}</math></b>	<b>Deceleration</b> <b><math>10 \text{ m s}^{-2}</math></b>
<b>Speed</b> <b><math>0 \text{ m s}^{-1}</math></b>	<b>Acceleration</b> <b><math>0 \text{ m s}^{-2}</math></b>

## A6 Sheet 2 – The race



The graph shows the motion of two racing cars as they approach and go round a bend on a racetrack.

1. How far along the track is the bend?
2. Make tables to show how the distance travelled by each car changes with time.
3. How does the distance between the two cars vary?
4. How does the time interval between the two cars vary?
5. Can you work out the deceleration and acceleration of each car?
6. During motor racing events, it seems that the car in front loses some of its lead when it approaches a bend, and then opens up a gap again afterwards. Why is this? Are the chasing cars really catching up?