A5 • Interpreting distance–time graphs with a computer

Mathematical goals

To enable learners to:

- interpret linear and non-linear distance–time graphs.

Starting points

No prior knowledge is needed.

This session requires the computer program *Traffic* that is supplied with this pack. This program provides a simple yet powerful way of helping learners to visualise distance–time graphs from first principles. The program generates situations involving traffic moving up and down a straight section of road. It then allows the user to take 'photographs' of this situation at one-second intervals, places these side-by-side, and then gradually transforms this sequence of pictures into a distance–time graph. In this way, direct correspondences between speeds and gradients are obtained.

Learners are asked to describe situations, and draw and interpret distance–time graphs. Later, examples are offered that involve cars travelling at non-uniform speeds.

Materials required

An interactive whiteboard or data projector is very useful for demonstrating the computer program and discussing the problems it raises. This is not essential, however.

For each small group of learners you will need:

- a computer loaded with the program *Traffic*.

For each learner you will need one copy of each of the following:

- Sheet 1 – *Traffic situations*;
- Sheet 4 – *Interpreting graphs of traffic situations*;
- Sheet 6 – *The swimming race.*

For each learner you will need several copies of each of the following:

- Sheet 2 – *Blank photographs*;
- Sheet 3 – *Blank graphs*;
- Sheet 5 – *Inventing new situations.*

Time needed

Approximately 1 hour.

Suggested approach

Beginning the session

Give each learner a copy of Sheet 1 – *Traffic situations* and ask them to predict what will happen in each of the situations illustrated. Encourage learners to write their answers in words and to sketch a distance–time graph to show what happens, if they can.

Whole group discussion

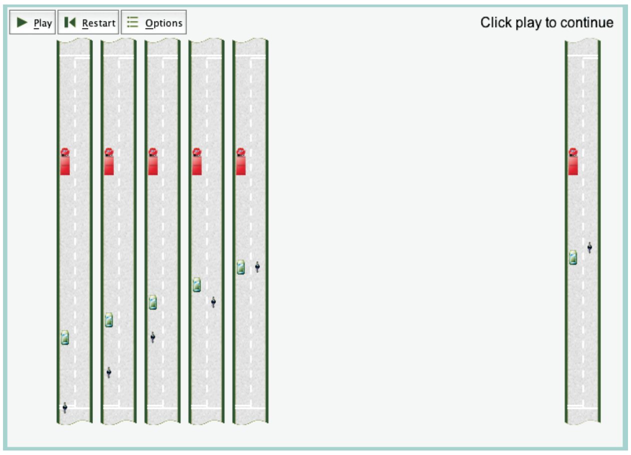
Start the computer program *Traffic* and display it on the interactive whiteboard or data projector, if one is available.

Select from the menu the example 'Velocity 7' and ensure that only the option 'Road' is checked. The computer should now show Situation 1 on Sheet 1. Explain that you now have an aerial view of the road on the screen. Ask learners to read out some of their predictions of what they think will happen to the vehicles and the order in which they think these things will happen.

Click on 'Play' and check their predictions.

Now click 'Options' and tick the buttons marked 'Photos', 'Markers' and 'Graph'. Show the first few photographs of the situation, and click 'Pause'.

On the left hand side of the screen are photographs of the situation taken at one second intervals. These are laid out side-by-side. Can you predict what the following photos will look like?



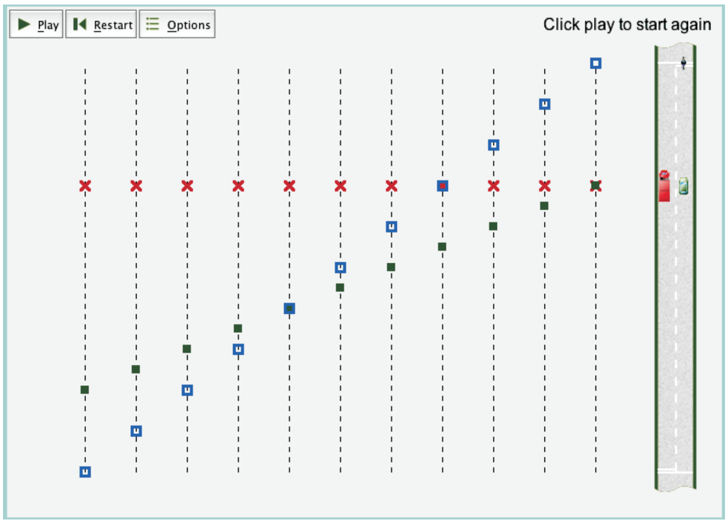
Hand out copies of Sheet 2 – *Blank photographs* and Sheet 3 – *Blank graphs* and ask learners to fill in their second-by-second predictions. Now press 'Play' and ask learners to check whether their predictions were correct.

From a set of photos, how can you tell that a vehicle is stationary? How can you tell that a vehicle is travelling quickly? How can you tell that it is travelling slowly?

What would the photos look like if we shot two photos per second and laid them out side by side? 20 photos per second?

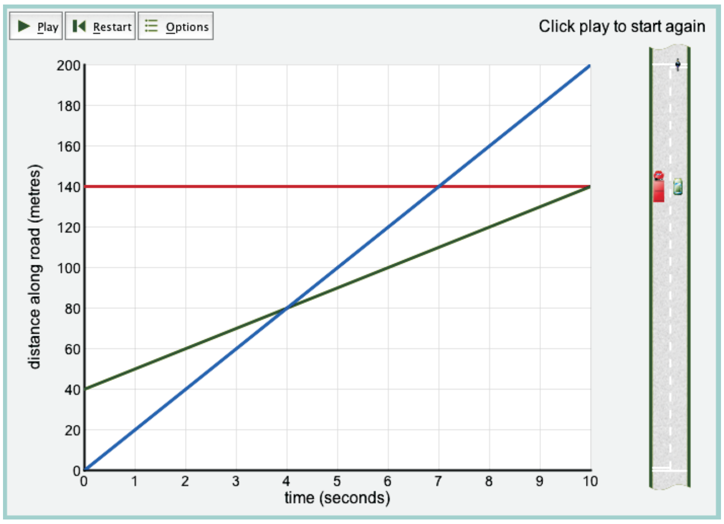
The last question may be used to draw out the continuity of the situation.

Explain that the photo predictions are a bit like a distance–time graph of the situation. In a distance–time graph, we represent the situation at each second using a vertical line, not by a picture of the road. Click on 'Play' to show this transition.



Explain that a graph must also show scales. Click on 'Play' again to show this.

Finally, the graph shows the situation at every instant of time, rather as if we were using a cine-film. Click on 'Play' again to show the distance–time graph.



How can you tell the order of overtaking from the graph alone?

Situation 2 on Sheet 1 requires interpolation. You may wish to repeat the presentation above using this situation. (On the computer, this is shown as 'Velocity 5'.) This time, give each learner a fresh copy of Sheets 2 and 3 and see if they can answer the questions using the graph paper. If they have difficulty, ask them to use the photo blanks first.

Working in groups

Interpreting distance–time graphs on the computer

Ask learners to sit in pairs at a computer and explore the remaining examples in the program. One possible approach is for learners to interpret a number of graphs, then check their interpretations using the animations.

Ask learners to choose 'Options', and switch off everything except the graph. They should then view the graph for each example and try to interpret what the vehicles are doing in that situation, as precisely as possible. That is, they should give descriptions involving distances, times and speeds. This explanation is provided for learners on Sheet 4 – I*nterpreting graphs of traffic situations.*

For example: 'Velocity 2'.

> In the first three seconds, the car travels 100 m at a constant speed of about 33 m per second. From 3 seconds to 6 seconds, the car travels 40 m at a constant speed of about 13 m per second. From 7 seconds to 10 seconds, the car is stationary. We can see that the car moves at a greater velocity for the first three seconds because the slope of the graph is steeper.

After learners have explored these examples, they should compare their descriptions with those of other learners. Ask them to make notes of any differences that emerge. As you move around the room, listen to learners' explanations and note any misconceptions that emerge for discussion in the final whole group session.

Drawing and interpreting distance–time graphs without the computer

Finally, turn off the computers and ask learners to work in pairs. Each learner should, on their own, invent a description of a traffic situation and draw the accompanying graph. Sheet 5 – *Inventing new situations* is provided for this purpose.

When a learner has done this, the graph (or description) should be hidden (by folding it back) and the description (or graph) passed to the second learner to see if they can produce the missing representation. Any mismatches should be discussed and resolved until the learners have reached agreement.

Reviewing and extending learning

Finally, hold a whole group discussion on the situation described in Sheet 6 – *The swimming race*.

Give each learner a copy of Sheet 6 and read it together slowly. If a learner thinks that a mistake has been made, ask them to describe the mistake carefully and how it should be corrected.

What learners might do next

Learners may find **A6 Interpreting distance–time graphs** a useful follow-up to this session. This takes the ideas further and brings in the measurement of acceleration and deceleration.

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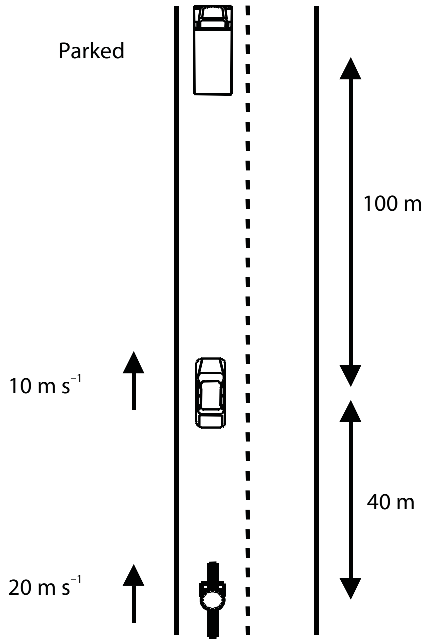
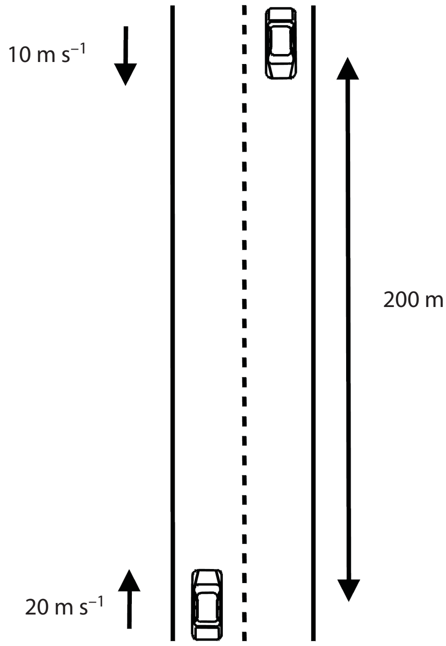
A5 Sheet 1 – *Traffic situations*





Situation 1

This picture shows an aerial view of a narrow country road.

If the vehicles continue to travel at the same steady speeds, what will happen in the next few seconds?

Describe your answers using words, sketches and/or a graph.

Answer

Situation 2

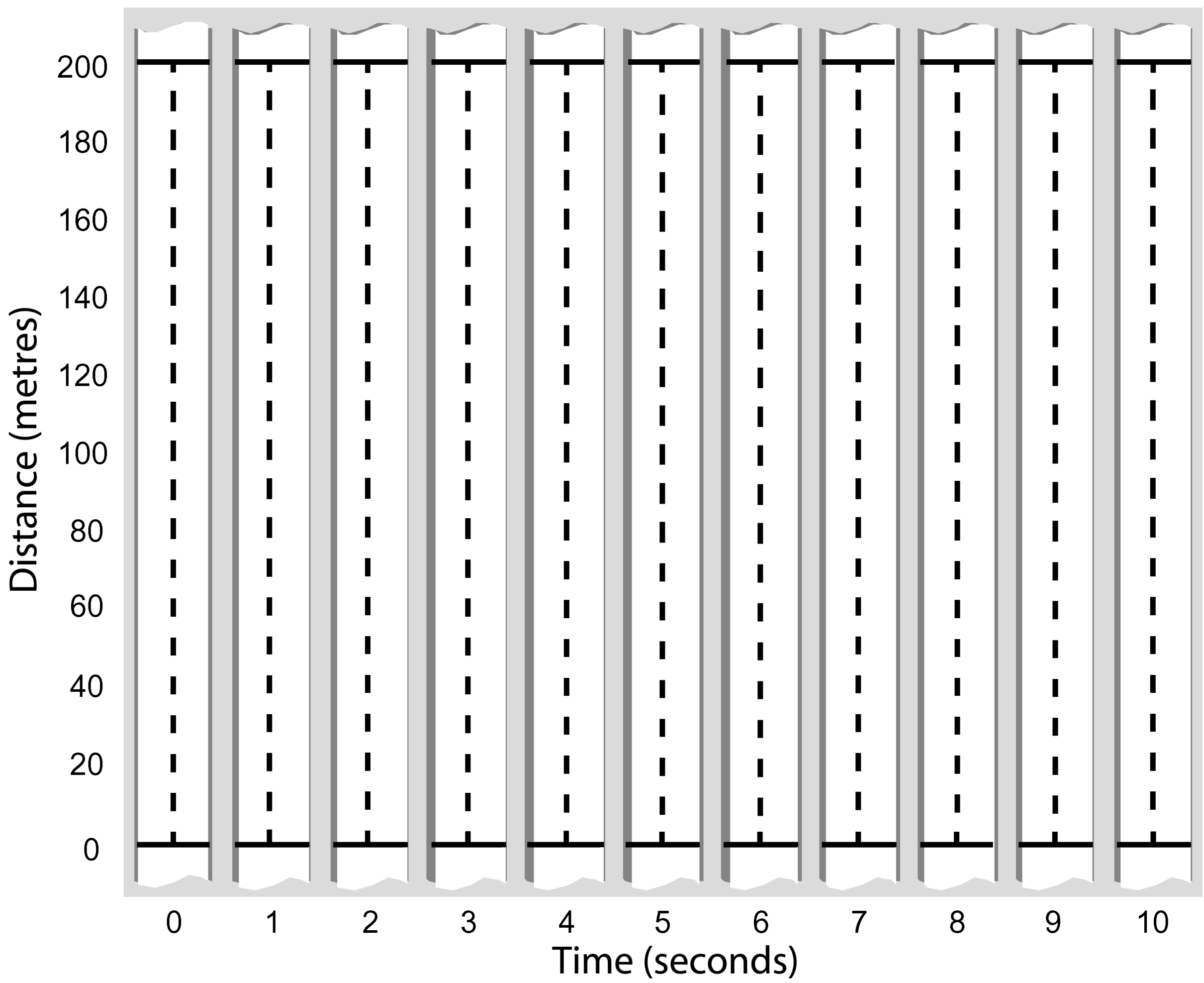
When will these two cars meet?

Where will they be along the road at this time?

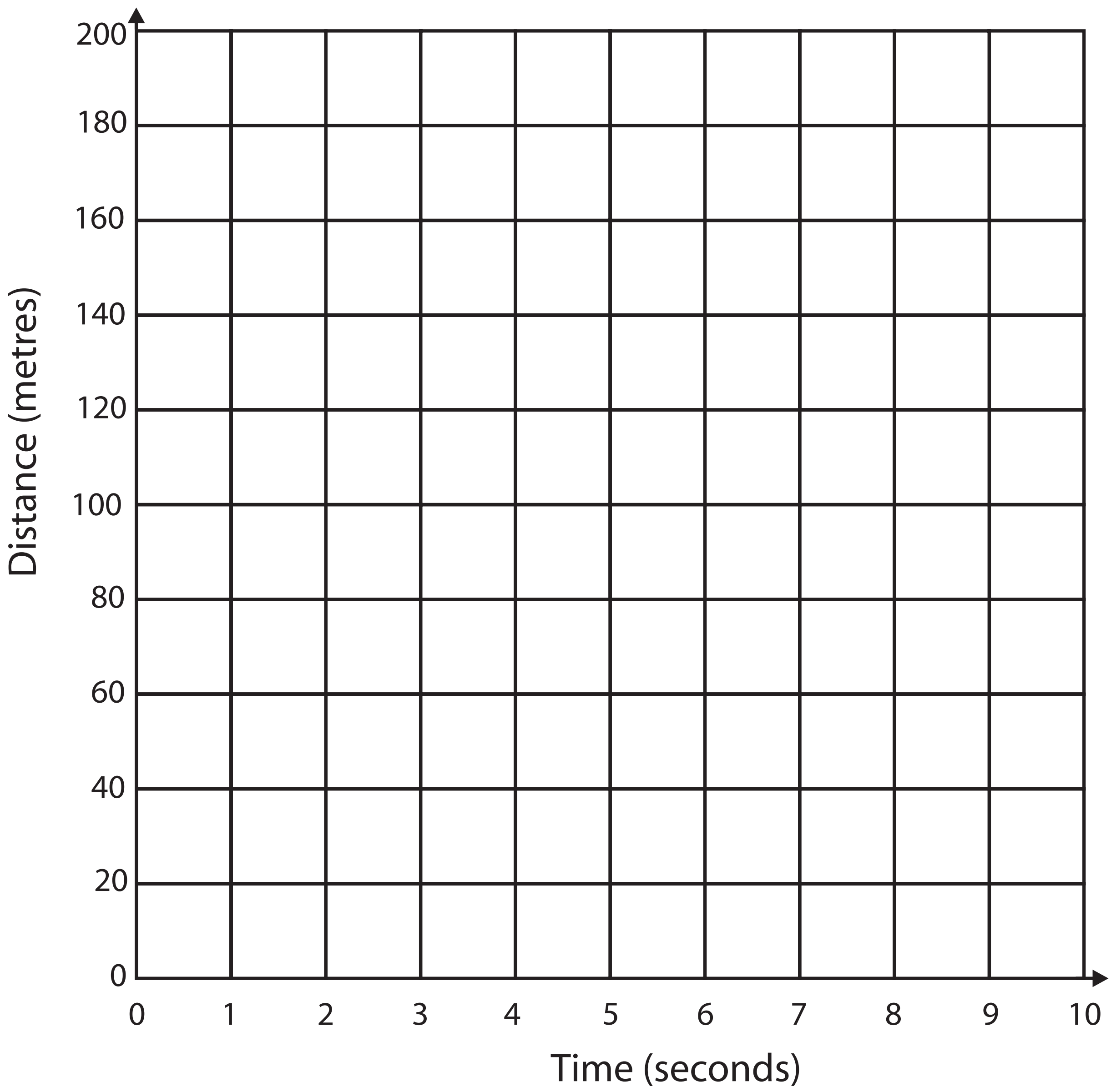
Explain how you know this.

Answer

A5 Sheet 2 – *Blank photographs*

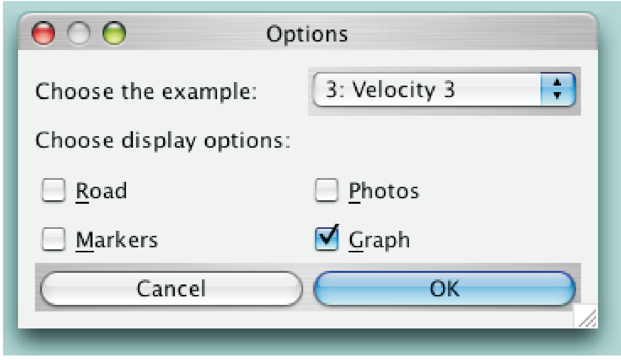


A5 Sheet 3 – *Blank graphs*



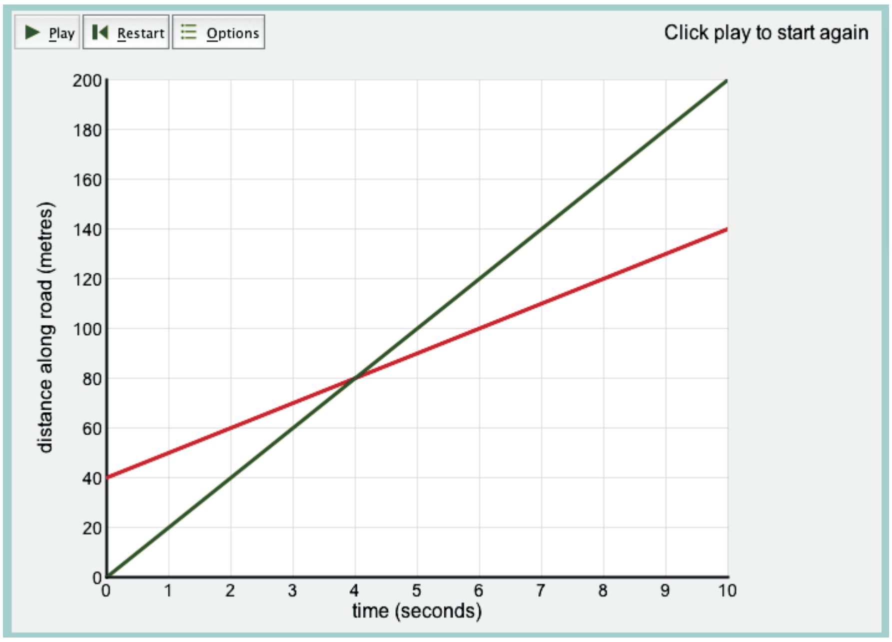
A5 Sheet 4 – *Interpreting graphs of traffic situations*

Choose 'Options' and switch off everything apart from the 'Graph' option.



Now choose each situation in turn. Write a short story saying what you think is happening to the vehicle(s) in that situation. Include details such as speeds.

For practice, complete the details in this example 'Velocity 3'.



The green car is travelling along at a steady speed of ...... metres per second. The driver of the green car sees a red car 40 metres in front of her. The red car is travelling more slowly at ...... metres per second. After ...... seconds, the green car overtakes the red car.

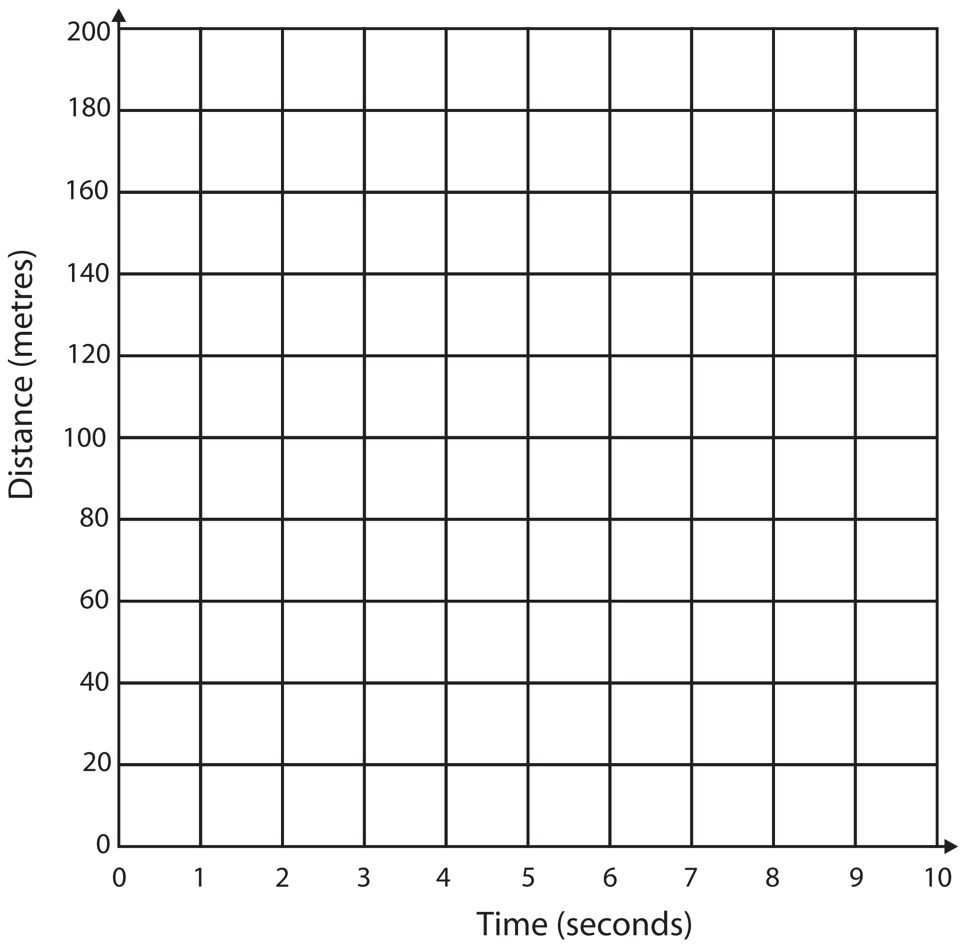
Now check your story by selecting 'Options' in 'Velocity 3' and selecting 'Road' and 'Graph'. Click 'Play' to see the motion and graph develop together.

A5 Sheet 5 – *Inventing new situations*

Description

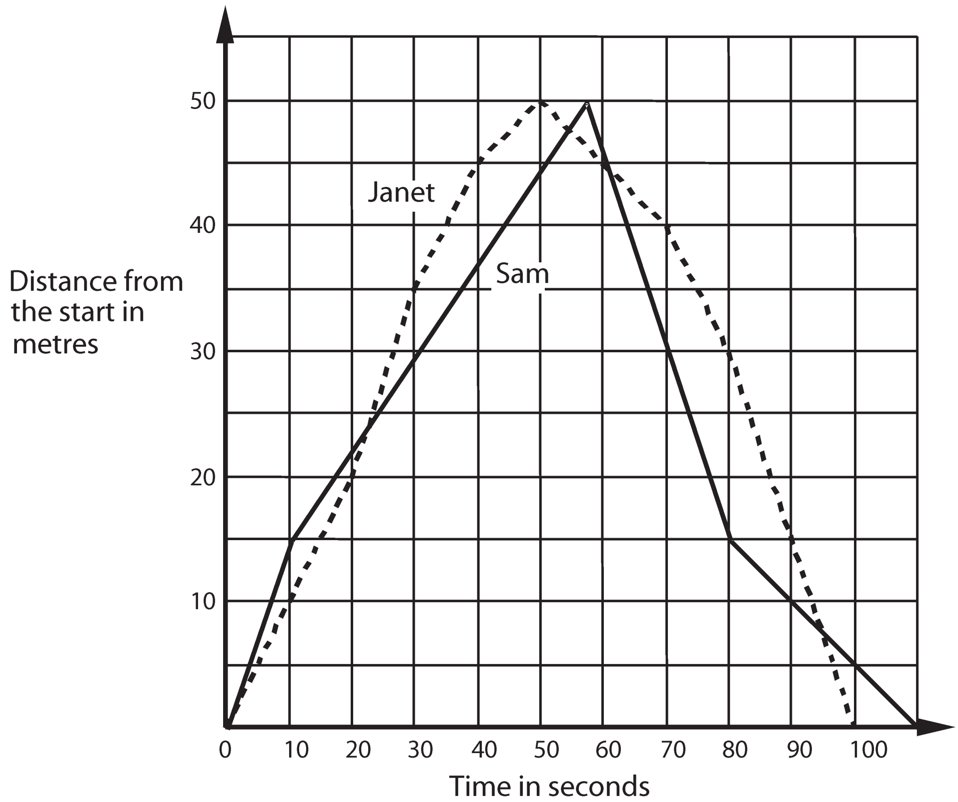
. . . .

Graph



A5 Sheet 6 – *The swimming race*

The following graph describes a swimming race.



In an exam, a learner was asked to write a commentary to go with this graph. Check her answer and see how many mistakes you can find.

The race commentary:

> Sam goes quickly into the lead. He is swimming at 15 metres per second. Janet is swimming at only 10 metres per second. After 22 seconds, Janet overtakes Sam. Janet swims more quickly than Sam from 25 seconds until she turns at 50 seconds. Sam overtakes Janet after 55 seconds, but she catches up again, 5 seconds later. Janet is in the lead until right near the end. Sam swims at a steady 30 metres per second after the turn, until 80 seconds, while Janet is gradually slowing down. Sam wins by 10 seconds.

Now try to write a better commentary.