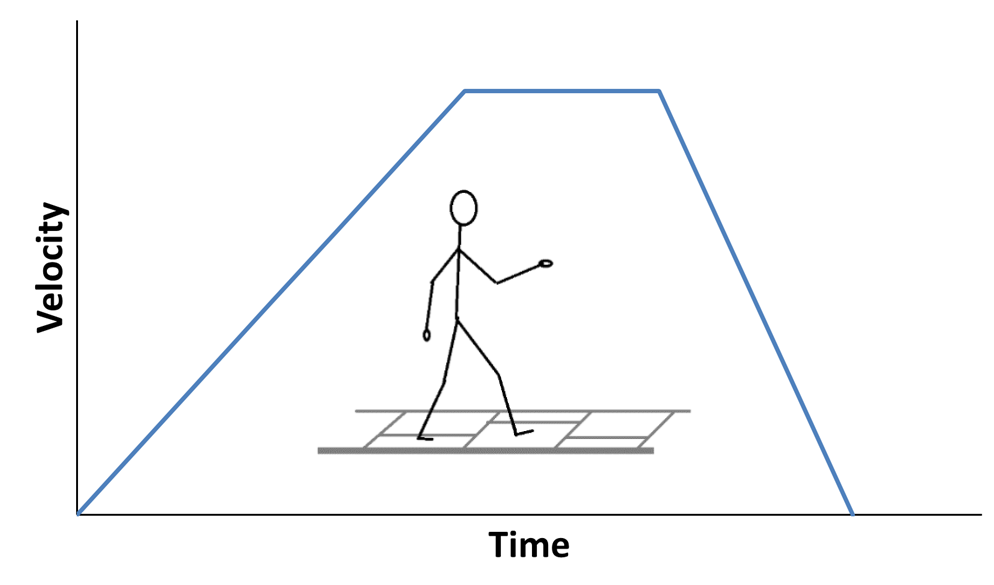
**Telling the story**

This graph shows part of Sammy’s journey to the shops.

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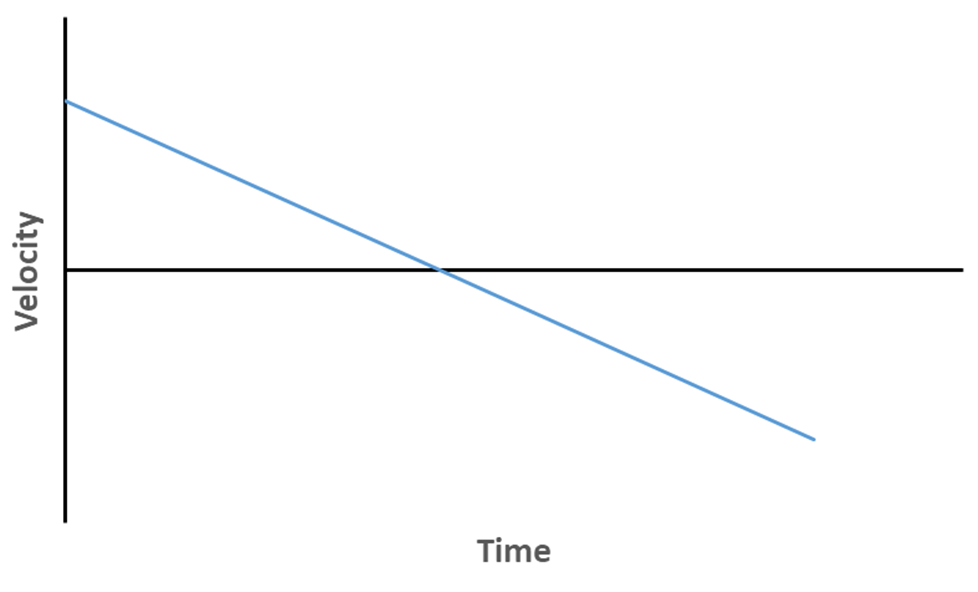
**1.** What is the best description of Sammy’s journey?

*Put a tick (✓) in the box next to the best answer.*

|  |  |  |
| --- | --- | --- |
| **A** | Sammy walks up a hill, along the level, and then down a steeper hill. |  |
|  |  |  |
| **B** | Sammy walks at a steady speed, stops for a bit, and then returns home at a steady speed, faster than before. |  |
|  |  |  |
| **C** | Sammy gradually speeds up, walks at a steady speed, and then slows down quickly. |  |
|  |  |  |
| **D** | Sammy gradually speeds up, stops for a bit, then returns home, slowing down on the way. |  |

Sammy goes for a walk on another day.

The graph shows her journey.

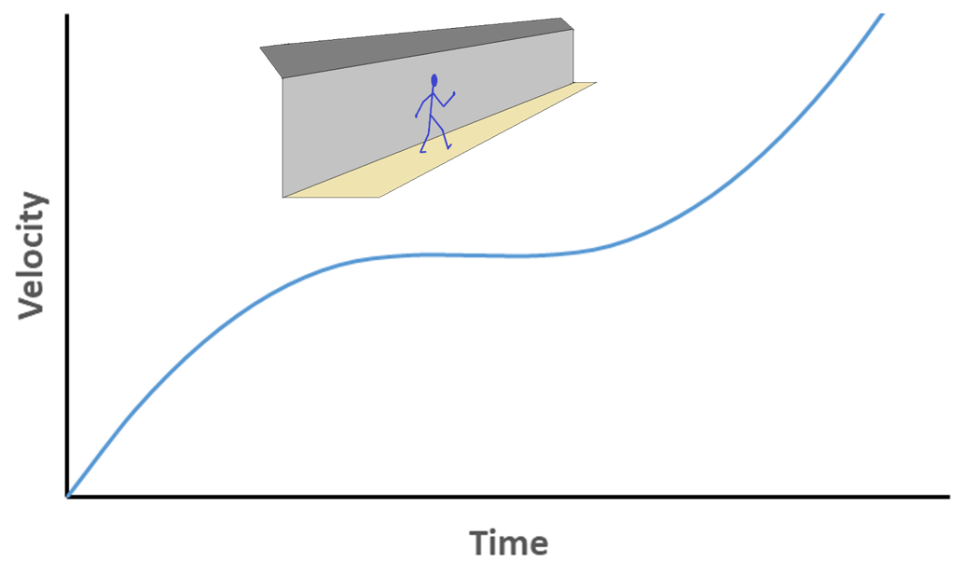


**2.** What is the best description of Sammy’s journey?

*Put a tick (✓) in the box next to the best answer.*

|  |  |  |
| --- | --- | --- |
| **A** | Sammy walks down a hill. |  |
|  |  |  |
| **B** | Sammy walks at a steady speed. |  |
|  |  |  |
| **C** | Sammy walks quickly, gradually slows down, stops and turns around.  On the way back, she speeds up again. |  |
|  |  |  |
| **D** | Sammy walks at a steady speed, then turns around and walks back at a steady speed. |  |
|  |  |  |
| **E** | Sammy walks quickly, gradually slows down and stops. She then starts walking again and speeds up as she goes. |  |

This graph shows another journey.



**3.** What is the best description of Sammy’s journey?

*Put a tick (✓) in the box next to the best answer.*

|  |  |  |
| --- | --- | --- |
| **A** | Sammy walks up a hill, along the level, and then uphill again. |  |
|  |  |  |
| **B** | Sammy gradually speeds up, stops for a bit, and then speeds up again. |  |
|  |  |  |
| **C** | Sammy gradually slows down, stops for a bit, and then speeds up again. |  |
|  |  |  |
| **D** | Sammy speeds up, walks at a steady speed, and then speeds up again. |  |

*Physics > Big idea PFM: Forces and Motion > Topic PFM4: Measuring and calculating motion > Key concept PFM4.3: Velocity-time graphs*

|  |
| --- |
| **Diagnostic question** |
| **Telling the story** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | A velocity-time graph of an object moving in one dimension can be read to find the object’s velocity at any moment of time. The gradient of the graph at a given time gives the object’s acceleration; and the area under the graph between any two times gives the change in the object’s displacement, or the distance it has travelled. |
| Observable learning outcome: | Describe the motion of an object from a velocity-time graph, and identify the velocity-time graph from a description of motion. |
| Question type: | Simple multiple choice |
| Key words: | Velocity, time, graph |

**What does the research say?**

It is common for teachers to assume students can readily extract information from graphs when this is not necessarily the case (Beichner, 1994). Misunderstandings and difficulties in interpreting graphs arise even when students have a good understanding of kinematic concepts (position, displacement, velocity and acceleration) and are evident amongst different student populations and across different academic levels (McDermott, Rosenquist and van Zee, 1987). Even when students have the necessary mathematical knowledge about how to plot and read graphs, and how to calculate gradients and areas, they may struggle with the same skills in a physics context (McDermott, Rosenquist and van Zee, 1987; Bollen et al., 2016).

A common error that some students make is to see a graph as a literal picture of a physical situation and, rather than viewing a graph as a mathematical representation of a motion, they may see it as a sort of ‘photograph’ that duplicates the motion (Clement, 1985; Leinhardt, Zaslavsky and Stein, 1990; Beichner, 1994; Bollen et al., 2016). This can make it hard for them to describe qualitatively a motion represented by a graph, or to draw the shape of a graph from a description of a motion.

When asked to think about graphical representations of velocity, students often think only about speed (Goldberg and Anderson, 1989). They may be aware that velocity is a vector quantity, with both a magnitude and a direction, but see these as completely separate properties that are not combined in a graphical representation. For these reasons, they may struggle to read velocity-time graphs, especially those that include both positive and negative values of velocity. Some students may believe that a negative quantity on a velocity-time graph implies a speed that is less than zero, which makes no sense, rather than interpreting the negative sign as meaning “in the opposite direction”.

It has been found in large studies that students who demonstrate a good command of kinematical concepts, and who have a good grasp of how to plot and to read graphs and of how to calculate gradients from their study of mathematics, often misinterpret what the gradient of a velocity-time graph represents (McDermott, Rosenquist and van Zee, 1987; Bollen et al., 2016).

**Ways to use this question**

Students should complete the question individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation.

The answers to the question will show you whether students understood the concept sufficiently well to apply it correctly.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations, it may be more appropriate for a teaching assistant to read for one or two students.

**Expected answers**

1. C 2. C 3. D

**How to respond - what next?**

These questions require students to think qualitatively about the meaning of velocity-time graphs, including thinking about the meaning of a negative velocity, and the meaning of the slope of the graph.

In question 1, option A may be chosen by students who see the graph as a literal picture of the journey.

Option B would be a correct interpretation if the graph were a distance-time graph, and the inability to convert from one graph type to another is common amongst students who see graphs as pictures and do not expect there to be differences between distance-time and velocity-time graphs.

Students choosing option D may understand some aspects of a velocity-time graph, namely increasing and decreasing speed, but see horizontal sections of the graph as representing stationary objects, as if the graph were a distance-time graph.

In question 2, choosing the correct option involves both understanding the significance of the gradient of the graph, and of the sign of the velocity. The second half of the graph, where the velocity is negative, shows that Sammy is walking in the opposite direction, i.e., back home again.

Students who see graphs as literal pictures of a journey are likely to choose option A.

Students choosing option B may be confusing distance-time (or displacement-time) graphs with velocity-time graphs.

Students choosing option D may understand the significance of the minus sign as an indication of the change in direction, but see a constant slope as indicating a constant speed, as on a distance-time graph.

Students choosing option E understand the significance of the gradient, but not of the sign.

Question 3 probes students’ understanding of a changing gradient as showing that velocity is changing more or less quickly, i.e. with a greater or lesser acceleration.

Students choosing option A see the graph as a literal picture of the motion.

Those choosing B understand the significance of the gradient, but fail to appreciate the significance of the horizontal part of the graph, interpreting it as they would on a distance-time graph.

Option C describes the motion that would be represented if this were a distance-time graph.

If students have misunderstandings about how to interpret these qualitative velocity-time graphs, they may: see the graph as a literal picture; fail to appreciate the difference between distance-time (or displacement-time) and velocity-time graphs; or fail to understand the significance of the minus sign when reading velocity from the graph.

The following BEST ‘response activity’ could be used to develop these aspects of understanding in follow-up to this diagnostic question:

* Response activity: Drawing the story

**Acknowledgments**

Developed by Simon Carson (UYSEG).

Images: Simon Carson (UYSEG)

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