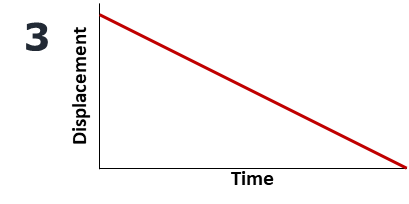
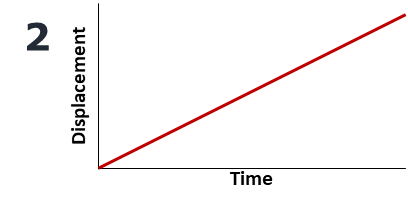
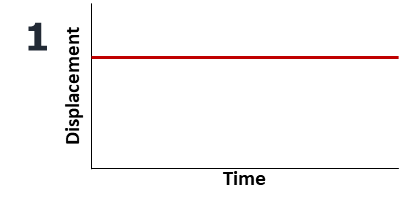
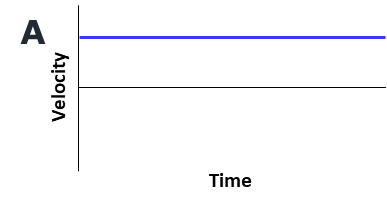
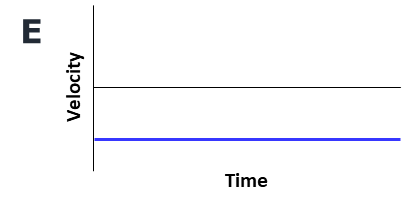
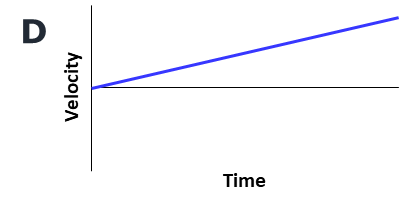
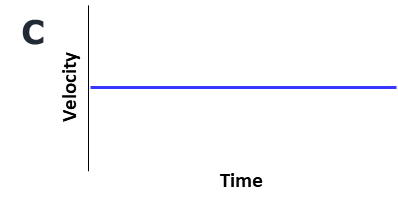
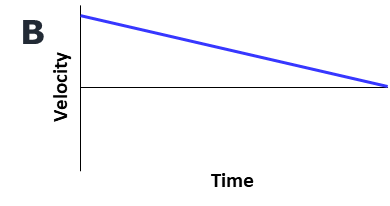
**From displacement to velocity**

The movement of an object can be shown on different types of graph.

Which velocity-time graph shows the same movement as each displacement-time graph?

*Rule a line from each displacement-time graph to the correct velocity-time graph.*



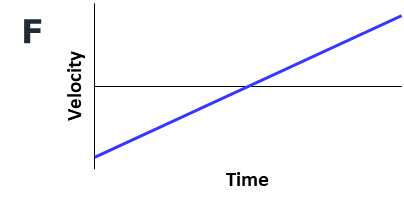
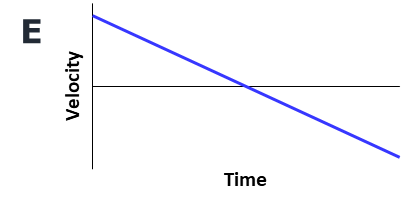
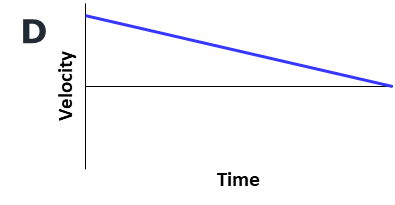
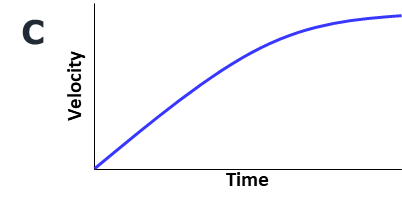
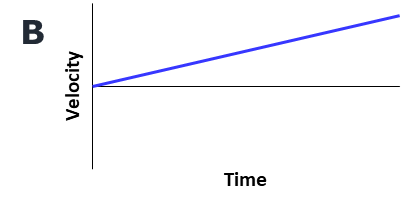
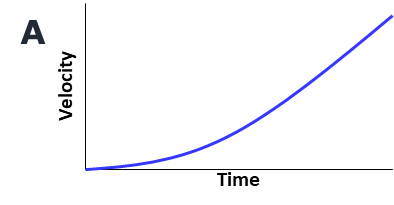
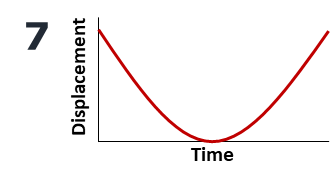
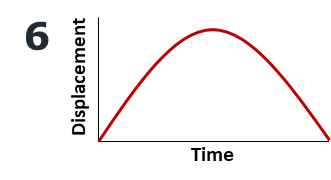
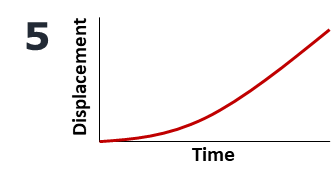
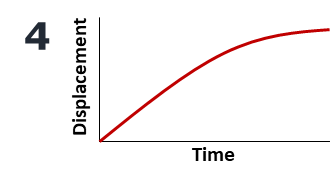
**Velocity-time graphs**

**Displacement-time graphs**

*Rule a line from each of these displacement-time graph to the correct velocity-time graph.*

**Velocity-time graphs**

**Displacement-time graphs**



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

|  |
| --- |
| **Diagnostic question** |
| **From displacement to velocity** |

**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: | Identify the velocity-time graph corresponding to a given displacement-time graph, and vice versa. |
| Question type: | Linking ideas |
| Key words: | Displacement, 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).

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”.

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.

Students who struggle with this ‘iconic interpretation’ may believe that plotting different kinematic variables (displacement, velocity, acceleration) against time does not change the appearance of a graph. They can find it difficult to match distance-time graphs to corresponding speed-time graphs, or displacement-time graphs to corresponding velocity-time graphs, and vice versa (Beichner, 1994).

**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.

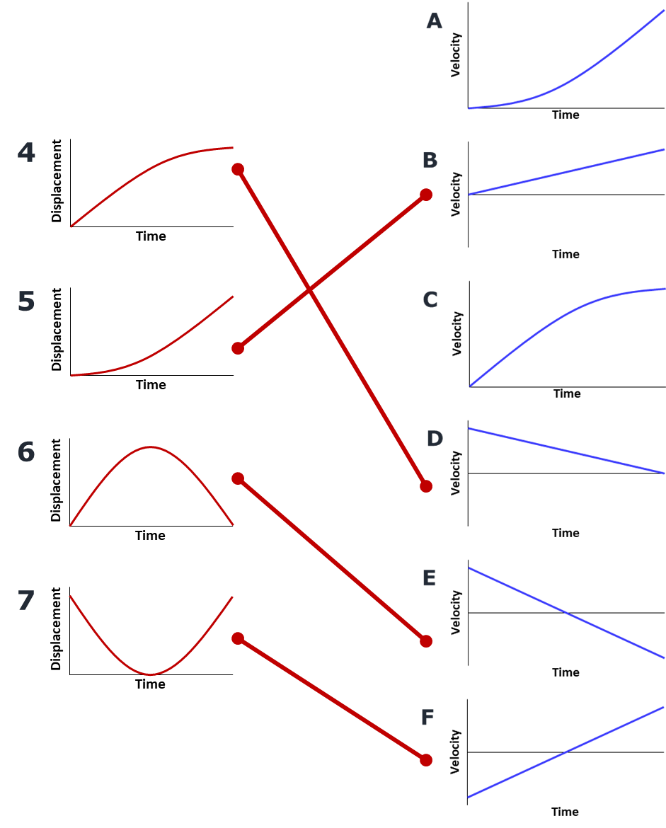
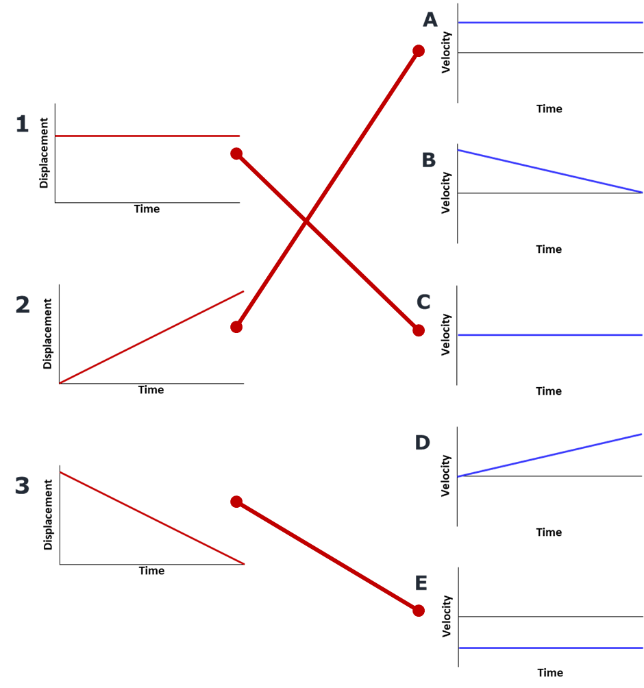
The answers to the question will show you whether students understood the concept sufficiently well to apply it correctly.

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**

****

**How to respond - what next?**

These questions require students to think qualitatively about the meaning of displacement-time and velocity-time graphs. They have to think about the gradient of the displacement-time graph, and about the meaning of negative velocities.

In each question, velocity-time graphs having the same shape as the displacement-time graphs are provided as distractors. Students choosing these may think of the graphs as literal pictures of the corresponding motion, believing that switching between kinematical variables does not change the shape of the graphs.

Students have to think about the meaning of the gradient of the displacement-time graphs in order to identify the correct velocity-time graphs. This is easier in the first set of questions as all the graphs are linear. Identifying the first displacement-time graph as corresponding to zero velocity may prove particularly problematic.

The second set of questions is much harder than the first. Students may struggle to understand how a curved displacement-time graph can correspond to a linear velocity-time graph, and may also struggle to understand the significance of the negative axis on the velocity-time graphs, and how negative values of velocity can correspond to changing positive values of displacement.

If they do grasp the significance of negative values of velocity, they may confuse the answers to the final two questions with each other, believing that if the displacement-time graph begins by increasing, so must the velocity-time graph. This is essentially another manifestation of the graph-as-picture misconception.

If students have misunderstandings about how to translate from displacement-time graphs to the corresponding velocity-time graphs, the following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

* Response activity: Translating motion graphs

**Acknowledgments**

Developed by Simon Carson (UYSEG).

Images: Simon Carson (UYSEG)

**References**

Beichner, R. J. (1994) ‘Testing student interpretation of kinematics graphs’, *American Journal of Physics*, 62(8), pp. 750–762. doi: 10.1119/1.17449.

Bollen, L. *et al.* (2016) ‘Generalizing a categorization of students’ interpretations of linear kinematics graphs’, *Physical Review Physics Education Research*, 12(1), p. 010108. doi: 10.1103/PhysRevPhysEducRes.12.010108.

Clement, J. (1985) ‘MISCONCEPTIONS IN GRAPHING’, in *Proceedings of the Ninth Conference of the International Group for the Psychology of Mathematics Education*. *Ninth Conference of the International Group for the Psychology of Mathematics Education, Noordwijkerhout, The Netherlands, July, 1985.*, Netherlands, p. 8.

Goldberg, F. M. and Anderson, J. H. (1989) ‘Student difficulties with graphical representations of negative values of velocity’, *The Physics Teacher*, 27(4), pp. 254–260. doi: 10.1119/1.2342748.

Leinhardt, G., Zaslavsky, O. and Stein, M. K. (1990) ‘Functions, Graphs, and Graphing: Tasks, Learning, and Teaching’, *Review of Educational Research*, 60(1), p. 64.

McDermott, L. C., Rosenquist, M. L. and van Zee, E. H. (1987) ‘Student difficulties in connecting graphs and physics: Examples from kinematics’, *American Journal of Physics*, 55(6), pp. 503–513. doi: 10.1119/1.15104.