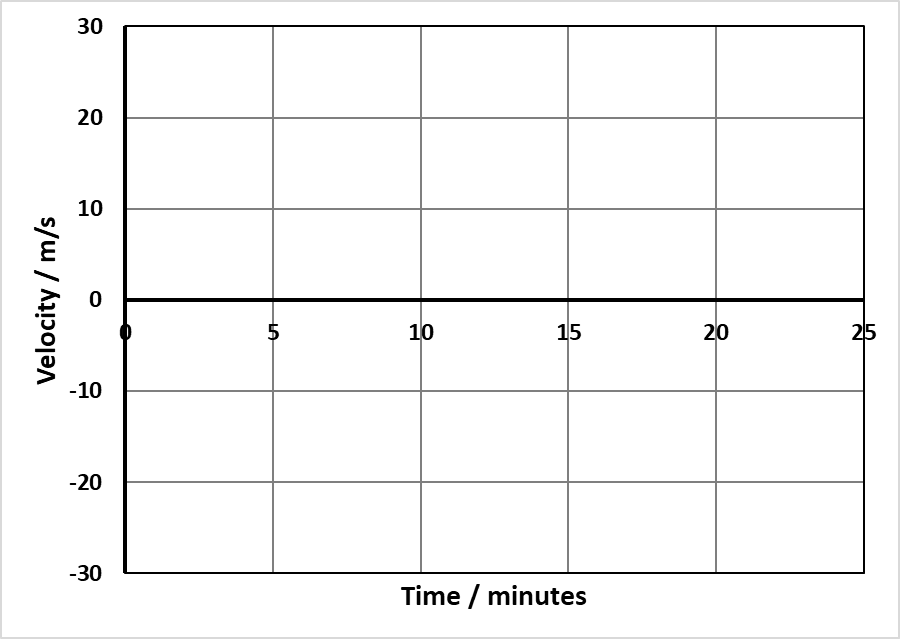
**Drawing graphs**

A car is travelling towards the right along a straight road.



**To do:** use the axes to plot a velocity-time graph of the car’s journey.



*A description of the car’s journey.*

1. For the first 5 minutes the car is moving to the right at a speed of 15 m/s.
2. It then takes one minute to speed up to 25 m/s.
3. The car then slows down and stops. It does this in 4 minutes.
4. Next, the car starts moving to the left. It takes 2 minutes for it to reach a speed of 20 m/s.
5. Over the next 3 minutes, the car continues at a steady speed.
6. The car then slows down. It takes 5 minutes for it to come to a stop.

**Use your graph to answer these questions:**

**1. a.** Use your graph to write down the velocity of the car after 17.5 minutes.

**b.** At what other time does the car have the same velocity?

**c.** In which direction is the car travelling at these times?

**2.** When is the car travelling at 10 m/s?

**3.** At what time is the car furthest from the starting point?

**4.** After 11 minutes, is the car moving towards or away from the starting point?

**5.** After 18 minutes, is the car moving away from or towards the starting point?

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

|  |
| --- |
| **Response activity** |
| **Drawing graphs** |

**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: | Read values of speed or velocity off a speed-time or velocity-time graph, and interpret the meaning of a negative velocity. |
| Activity type: | Application and practice |
| Key words: | Velocity, displacement, time, graph |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic question:

* Diagnostic question: Reading the graph

|  |  |
| --- | --- |
| **P** | **PRIOR UNDERSTANDING**  This activity explores ideas that are usually taught at age 11-14, to aid transition from earlier stages of learning. |

**What does the research say?**

The visual presentation of data in graphical form makes graphs valuable for analysing data and, perhaps more importantly, for showing relationships between data sets (Rogers, in Carson, 1999). 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”.

This activity gives students practice in plotting and reading graphs, and in interpreting the meaning of a negative velocity.

**Ways to use this activity**

This activity gives students the opportunity to practise applying their understanding and to clarify their thinking through discussion. To support this, students should plot graphs individually and then answer the question in pairs or small groups.

The focus of this activity is on plotting points and reading values from a graph, in order to interpret the information represented in the graph. For this reason scales have been provided.

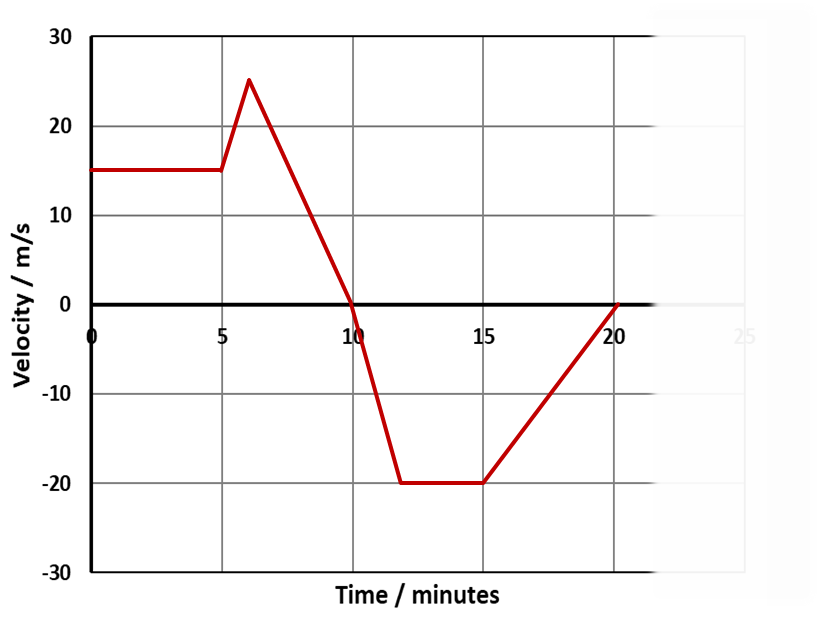
Observing students as they work often highlights any difficulties they might have. These can often be overcome, through a whole class clarification or redirection part way through the activity.

*Differentiation*

Sets of data can be adjusted to suit the mathematical skills of students. Some students may be able to select appropriate scales and confidently plot graphs without support.

If some students are working with a teaching assistant, then a list of graph plotting criteria for the TA could help to make this activity more purposeful.

**Expected answers**

****

1. a. -10 m/s b. 11 minutes c. To the left

2. 8.4 minutes (students are expected to read this from the graph, not calculate it, so answers around 8.5 minutes are reasonable)

3. 10 minutes

4. Towards

5. Towards

Students who answer question 3 incorrectly may think the car has travelled furthest after 6 minutes, mistaking the maximum value of velocity for the maximum value of displacement, or may think that the car has travelled the furthest distance after 20 minutes if they do not appreciate the significance of the negative velocity.

Students who answer questions 4 or 5 incorrectly may not understand the significance of the negative velocity. If they answer one or the other correctly, rather than both incorrectly, they may be looking at the gradient of the graph and using prior knowledge about the gradient of a displacement-time graph representing velocity.

**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.

Carson, S. (1999) *Physics in mathematical mood*. Bristol: Institute of Physics Pub.

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.

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.