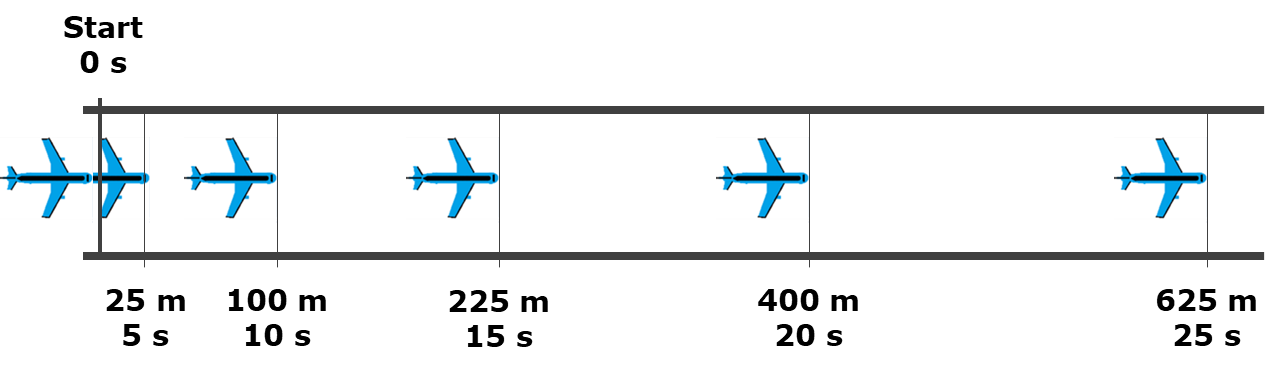
**Average velocity and instantaneous velocity**

A plane is taking off.

The picture shows where it is on the runway every 5 seconds.



1. What is the plane’s average velocity during the first 10 seconds?

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

|  |  |  |
| --- | --- | --- |
| **A** | 5 m/s to the right |  |
|  |  |  |
| **B** | 10 m/s to the right |  |
|  |  |  |
| **C** | 20 m/s to the right |  |

2. What is the plane’s **instantaneous** velocity after the first 10 seconds?

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

|  |  |  |
| --- | --- | --- |
| **A** | 5 m/s to the right |  |
|  |  |  |
| **B** | 10 m/s to the right |  |
|  |  |  |
| **C** | 20 m/s to the right |  |

**3.** What is the plane’s average velocity between 10 s and 20 s?

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

|  |  |  |
| --- | --- | --- |
| **A** | 20 m/s to the right |  |
|  |  |  |
| **B** | 30 m/s to the right |  |
|  |  |  |
| **C** | 1. /s to the right |  |

**4.** What is the plane’s **instantaneous** velocity after the first 20 seconds?

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

|  |  |  |
| --- | --- | --- |
| **A** | 20 m/s to the right |  |
|  |  |  |
| **B** | 30 m/s to the right |  |
|  |  |  |
| **C** | 40 m/s to the right |  |

*Physics > Big idea PFM: Forces and Motion > Topic PFM4: Measuring and calculating motion > Key concept PFM4.1: Velocity*

|  |
| --- |
| **Diagnostic question** |
| **Average velocity and instantaneous velocity** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Velocity and displacement are vector quantities. Velocity measures by how much displacement changes in a given time interval. |
| Observable learning outcome: | Calculate average velocity and instantaneous velocity for one-dimensional motion. |
| Question type: | Simple multiple choice |
| Key words: | Average, instantaneous, velocity |

**What does the research say?**

Students have developed their understanding of motion, both kinematics (the mathematical description of motion) and dynamics (the study of the causes of motion), through a lifetime of experience, and have built up an understanding that has been termed ‘gut dynamics’, or ‘lay dynamics’ (Driver *et al.*, 1994). These ideas are persistent and resistant to change, are systematic, and may be ‘theory-like’; they have been found among different groups of students and at different academic levels (Saltiel and Malgrange, 1980; Lemmer, 2013).

In the case of one-dimensional motion without any reversal of direction, speed and the magnitude of velocity are numerically equal. Speed is a scalar quantity and is often defined as:

This can lead to misunderstandings when students are not clear that the time referred to is the *time interval* during which the distance is travelled. This can lead to confusion when students study graphs of motion, and do not differentiate between the slope of a graph, and the division of coordinates at a point (McDermott, Rosenquist and van Zee, 1987), especially as students do not always take time into their thinking about motion appropriately (Trowbridge and McDermott, 1980; Driver *et al.*, 1994). It is better, therefore, to define speed as:

‘’ (the Greek letter delta) is the symbol used by physicists to denote a change in a quantity.

Similarly, velocity should be defined as:

The bold typeface for **s** and **v** is used to show that they are vector quantities.

The idea of an instantaneous velocity should be carefully developed and made clear that it is different to instantaneous speed.

Everyday experience is of moving at speeds or velocities for finite periods of time. Instantaneous speed or instantaneous velocity is the speed or velocity at one moment of time, when the time interval is unimaginably small. For this reason, it is better to use ‘change in time’ in the definitions of these quantities and in calculations, not just ‘time’.

**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. B (10 m/s) 2. C (20 m/s) 3. B (30 m/s) 4. C (40 m/s)

**How to respond - what next?**

1. The magnitude of the average velocity over a time interval is the magnitude of the difference in the displacement divided by the time interval.

In question 1, students selecting 5 m/s may be thinking of an average as the mid-point, and so use the numbers given at the 5 second point. Similarly, students selecting 20 m/s may be thinking of the 10 second point as the mid-point for the average, and so use the numbers given at the 20 second point.

2. In question 2, the best value for the instantaneous velocity at the 10 second point is found by using the data at times either side of the 10 second point, and as close as possible to the 10 second point, and dividing the change in the displacement by the time interval.

It is common for students to use the data at 10 s and to calculate the average velocity instead.

3. In question 3, students have to find a change in displacement and a change in time. If they choose 20 m/s, the most likely reason is that they have simply used the data given at the 20 second point rather than over the interval from 10 seconds to 20 seconds.

4. In question 4, any misconceptions are likely to match those in question 2.

If students have misunderstandings about the difference between average and instantaneous velocity, it is useful to discuss the idea of an average velocity calculated over smaller and smaller time intervals.

Thinking about what a car speedometer shows and comparing this with the variation of speed over a typical journey may help students to distinguish between instantaneous and average velocity. Asking students to work in pairs or small groups to write a definition of instantaneous velocity in their own words can help them to consolidate their learning.

The following BEST response activity could be used as a follow up to this question:

* Response activity: Calculating average velocity and instantaneous velocity

**Acknowledgments**

Developed by Simon Carson (UYSEG)

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