**The difference matters**

Two cyclists are travelling a the road.



A picture containing shape

Description automatically generated

**1.** What is the magnitude of the difference between the velocities of the two cyclists?

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

|  |  |  |
| --- | --- | --- |
| **A** | 2 m/s |  |
|  |  |  |
| **D** | 14 m/s |  |

Shape

Description automatically generated with medium confidence

**2.** What is the magnitude of the difference between the velocities of the two cyclists now?

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

|  |  |  |
| --- | --- | --- |
| **A** | 2 m/s |  |
|  |  |  |
| **D** | 14 m/s |  |

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

|  |
| --- |
| **Diagnostic question** |
| **The difference matters** |

**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 differences in velocity for 1-dimensional and 2-dimensional motion. |
| Question type: | Simple multiple choice |
| Key words: | Velocity, difference |

**What does the research say?**

Students may not differentiate clearly between the scalar quantity, speed, and the vector quantity, velocity. To be able to describe motion accurately, and to carry out calculations correctly, they need to be clear about the vector nature of quantities such as displacement, velocity and acceleration.

Research shows that despite being taught about vectors at school, very many students on undergraduate introductory physics courses in the USA have no *useful* knowledge of vectors (Aguirre, 1988; Knight, 1995).

Students’ misunderstandings of vector ideas may be compounded by the different approaches taken in school mathematics and physics teaching: although students may be able to add and subtract column vectors in mathematics, graphical addition and subtraction of vectors of the sort more likely to be encountered in physics proved more problematic (Tairab *et al.*, 2020). It is important, therefore, to establish a good understanding of displacement and velocity as vectors before studying accelerations and forces.

**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. A 2. D

**How to respond - what next?**

In question 1, both velocities have the same direction and so have the same sign with respect to this direction. The magnitude of the difference between the velocities is the simple difference between the speeds (8 m/s - 6 m/s = 2 m/s).

In question 2, the velocities are in opposite directions, so if the first cyclist has a velocity of +8 m/s, the second one will have a velocity of -6 m/s. The magnitude of the difference between these velocities is 8 m/s - (-6m/s) = 8 m/s + 6 m/s = 14 m/s.

Most students should answer question 1 correctly.

Those that do not have a clear understanding that velocities in opposite directions have opposite signs, are likely to answer question 2 wrongly. Q2 could also be answered wrongly by students who are working out the difference in *speed*, or by those who took away the negative number wrongly.

If students have misunderstandings about how to calculate the difference of two velocities, it can help to work out how far apart they would be after one second, moving at a constant velocity, if they started in the same place. The bigger the difference in their velocities, the further apart they should be.

The following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

* Response activity: Bumps and orbits

**Acknowledgments**

Developed by Simon Carson (UYSEG).

Images: Simon Carson (UYSEG), photograph by Manfred Richter from Pixabay.

**References**

Aguirre, J. M. (1988) Student preconceptions about vector kinematics, *The Physics Teacher*, 26(4), pp. 212–216. doi: 10.1119/1.2342490.

Knight, R. D. (1995) The vector knowledge of beginning physics students, p. 6.

Tairab, H. *et al.* (2020) Examining Grade 11 science students’ difficulties in learning about vector operations, *Physics Education*, 55(5), p. 055029. doi: 10.1088/1361-6552/aba107.