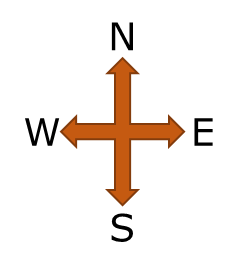
**Changing velocity**

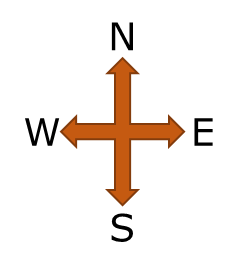
**1.** A car travels along a road and speeds up.

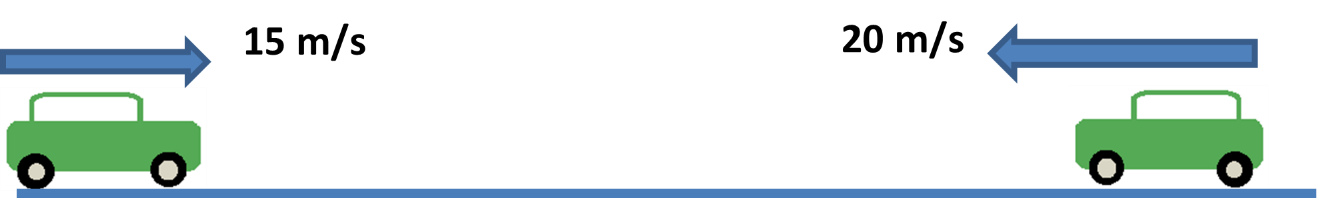


What is the change in velocity of the car?

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

|  |  |  |
| --- | --- | --- |
| **A** | The change in velocity is 5 m/s |  |
|  |  |  |
| **B** | The change in velocity is 5 m/s east |  |
|  |  |  |
| **C** | The change in velocity is 5 m/s west |  |

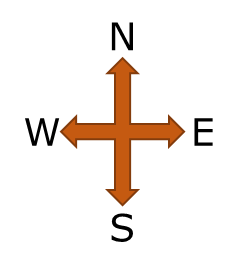
**2.** A car travels along a road, turns around and drives back.



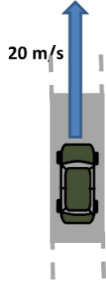
What is the change in velocity of the car?

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

|  |  |  |
| --- | --- | --- |
| **A** | The change in the velocity is 5 m/s |  |
|  |  |  |
| **B** | The change in the velocity is 5 m/s west |  |
|  |  |  |
| **C** | The change in the velocity is 35 m/s west |  |
|  |  |  |
| **D** | The change in the velocity is 35 m/s east |  |

**3.** A car travels along a road, changes direction and speeds up.

*The same car, a bit later.*



What is the magnitude of the change in velocity of the car?

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

|  |  |  |
| --- | --- | --- |
| **A** | The magnitude of the change in velocity is 5 m/s |  |
|  |  |  |
| **B** | The magnitude of the change in velocity is 25 m/s |  |
|  |  |  |
| **C** | The magnitude of the change in velocity is 35 m/s |  |

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

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

|  |  |
| --- | --- |
| **B** | **BRIDGING**  This diagnostic question probes understanding of ideas that are usually taught at age 16-19, to build a bridge to later stages of learning. |

**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. B

2. C

3. B

**How to respond - what next?**

1. The car changes to move at 5 m/s faster in the direction it was already travelling in. Its velocity has increased by 5 m/s towards the east.

Some students may confuse the direction of the increase; or reason that because there is no change of direction, the change of velocity does not have a direction.

2. The car needs to slow to a stop and then speed up towards the west. As it slows, the change of its velocity towards the east is -15 m/s, which is the same as +15 m/s towards the west. Added to the +20 m/s the car then increases its velocity west, the total change to its velocity is 35 m/s west.

Some students may think wrongly that the change of velocity is the same magnitude as the change of speed and choose option A or B. Those selecting B recognise that a change of velocity has a direction, and that the car is travelling faster when it moves west.

A few students choosing option B may understand what to do and subtract a negative velocity wrongly.

3. The difference in velocities in two-dimensions can be found graphically by subtracting the initial velocity from the final velocity.

That is 20 m/s north minus 15 m/s east. The red vector gives the difference, which shows that the car is now moving less quickly to the east, and more quickly to the north.

Options A and C are obtained by adding or subtracting the velocities, as if the car was moving in one-dimension. These students are applying rules for adding vectors in one-dimension in inappropriately to a two-dimensional change.

The correct answer is between these values and students who understand that the one-dimensional rules do not apply, are likely to choose this option because the change of motion is between the two extremes described in questions 1 and 2.

If students have misunderstandings about finding differences in velocity for 2-dimensional motion, it can help to consider the changes to velocity in each direction separately (as above) and add the vectors graphically.

This is challenging, because the change of velocity in two dimensions is often in a direction somewhat opposite to the initial motion. It may help further to show vectors that represent the change of velocity on an object, and ask student to describe how the object’s motion changes.

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)

**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.