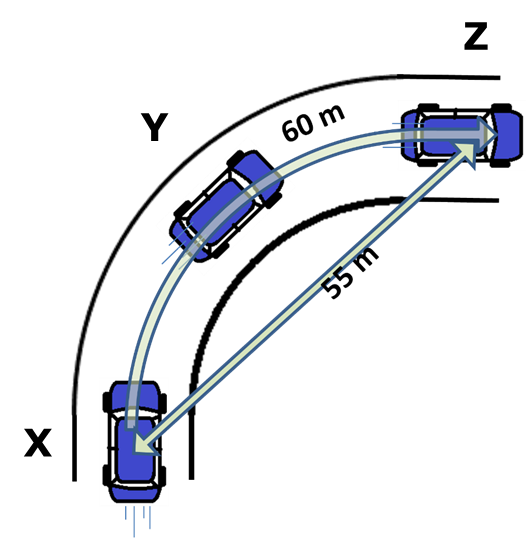
**Round the bend**

A car travels around a bend at a steady speed.



*It takes the car 5 seconds to move around the bend, from X to Z.*

**1.** What do you think about the **speed** and the **velocity** of the car?

*For each statement, tick (✓)* ***one*** *column to show what you think.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Statements about Sally | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| Its speed is the same at X, Y and Z. |  |  |  |  |
| Its velocity is the same at X, Y and Z. |  |  |  |  |
| Its average speed is the same as its average velocity. |  |  |  |  |

*Tick (✓)* ***one*** *box for each question.*

**2.** What is the average speed of the car around the bend?

|  |  |  |
| --- | --- | --- |
| **A** | 11 m/s |  |
|  |  |  |
| **B** | 12 m/s |  |
|  |  |  |
| **C** | 23 m/s |  |
|  |  |  |
| **D** | There is not enough information to work this out. |  |

**3.** What is the magnitude of the average velocity of the car around the bend?

|  |  |  |
| --- | --- | --- |
| **A** | 11 m/s |  |
|  |  |  |
| **B** | 12 m/s |  |
|  |  |  |
| **C** | 23 m/s |  |
|  |  |  |
| **D** | There is not enough information to work this out. |  |

**4.** Which of these arrows shows the direction of the average velocity?

|  |  |  |
| --- | --- | --- |
| **A** |  |  |
|  |  |  |
| **B** |  |  |
|  |  |  |
| **C** |  |  |
|  |  |  |
| **D** |  |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Round the bend** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Velocity and acceleration are vector quantities. Velocity measures how much the displacement changes in a given time, and acceleration measures how much velocity changes in a given time. |
| Observable learning outcome: | Identify the difference between speed, instantaneous velocity and average velocity for two-dimensional motion. |
| Question type: | Confidence grid and simple multiple choice |
| Key words: | speed, velocity, magnitude, direction |

**What does the research say?**

Research shows that when thinking about motion, students often do not differentiate clearly between speed and velocity (Halloun and Hestenes, 1985; de Winter and Hardman, 2021); and that it is quite common for students to be able to solve problems by substituting numbers into equations, whilst retaining some conceptual misunderstandings (Kim and Pak, 2002).

At ages 14-16, students are taught that:

and that velocity is speed in a certain direction. This teaching may strengthen ideas that speed and velocity are largely equivalent by suggesting that, to find the velocity, speed must first be calculated and a direction then added. By describing velocity as speed in a certain direction, students may come to think that the magnitude of the velocity is always equal to the speed, and this is usually not true when the average speed or average velocity is calculated.

A better definition of velocity is:

This emphasises the vector nature of velocity from the outset by relating it to displacement, which is also a vector.

Instantaneous velocity be thought of as average velocity calculated for an extremely short time interval. (Mathematically, it is the limit of the average velocity for smaller and smaller time intervals.)

The use of language is important. Teachers need to always talk about velocity with a direction, and insist that when velocity is calculated, its direction is always stated. Not doing this can reinforce the idea that direction is of secondary importance.

**Ways to use this question**

Students should complete the questions 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 differences between speed and velocity, and can correctly identify the magnitude and direction of the average velocity.

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. Statement A is right; and statements B and C are wrong.

2. B

3. A

4. C

**How to respond - what next?**

1. B: Some students may confuse velocity and speed; and a few may take the direction for velocity to be ‘along the road’.

C: The magnitude of the velocity is not the same as the magnitude of the speed, because the distance travelled is different to the displacement of Z from X. Some students may confuse distance and displacement, or not understand that displacement is not the same as distance.

N.B. Velocity is a vector and must always have a direction, so it can never actually be the same as a speed – which is not a vector.

2. Students who use displacement and not distance to calculate speed are likely to choose option A, and those who use the sum of the distance and displacement are likely to opt for C.

3. Students who use distance and not displacement to calculate velocity are likely to choose option B, and those who use the sum of the distance and displacement are likely to opt for C.

4. Options A and B correspond to the instantaneous velocity at the start or end of the journey respectively. Option B is the most likely wrong answer.

Some students who are unsure of the difference between speed and velocity may opt for D.

If students have misunderstandings about the differences between speed and velocity in two-dimensions, the following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

* Response activity: Velocity and speed in two dimensions.

**Acknowledgments**

Developed by Simon Carson (UYSEG)

Images: Simon Carson (UYSEG)

**References**

de Winter, J. and Hardman, M. (2020) *Teaching secondary physics.*

Halloun, I. A. and Hestenes, D. (1985) Common sense concepts about motion, *American Journal of Physics*, 53(11), pp. 1056–1065. doi: 10.1119/1.14031.

Kim, E. and Pak, S.-J. (2002) Students do not overcome conceptual difficulties after solving 1000 traditional problems, *American Journal of Physics*, 70(7), pp. 759–765. doi: 10.1119/1.1484151.