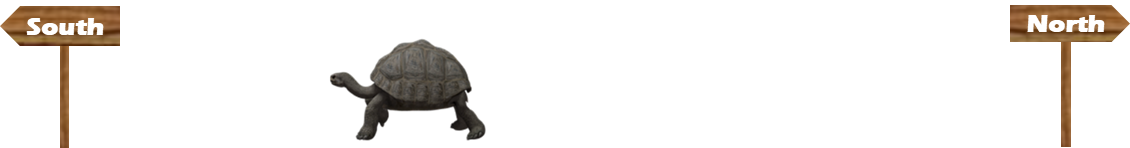
**Displacement and velocity**

A tortoise walks north at 0.1 metres per second for 20 seconds.

The tortoise then turns around and walks south at the same speed.

It walks south for 30 seconds.



A steady 0.1 m/s

For the first 20 seconds, the tortoise walks north at 0.1 metres per second.

1. After the first 20 seconds of its journey, what do you think about the **distance** and the **displacement** that the tortoise has travelled?

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | Its distance from the start is 2 metres. |  |  |  |  |
| **B** | Its displacement from the start is 2 metres. |  |  |  |  |
| **C** | Its distance from the start is 2 metres north. |  |  |  |  |
| **D** | Its displacement from the start is 2 metres north. |  |  |  |  |

The tortoise walks north for 20 seconds at 0.1 m/s.

It then walks south for 30 seconds at the same speed.

**2.** At the end of the journey, what do you think about the **displacement** of the tortoise?

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | Its displacement from the start is 5 metres. |  |  |  |  |
| **B** | Its displacement from the start is 1 metre. |  |  |  |  |
| **C** | Its displacement from the start is 1 metre south. |  |  |  |  |
| **D** | Its displacement from the start is -1 metre north. |  |  |  |  |

**3.** Over the whole journey, what do you think about the **speed** and the **velocity** of the tortoise?

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | Its average speed is 0.1 m/s |  |  |  |  |
| **B** | Its average speed is 0.02 m/s |  |  |  |  |
| **C** | Its average velocity is 0.1 m/s south |  |  |  |  |
| **D** | Its average velocity is 0.02 m/s south |  |  |  |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Displacement and 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 displacement and velocity for one-dimensional motion. |
| Question type: | Confidence grid |
| Key words: | Displacement, velocity |

**What does the research say?**

Students may not differentiate clearly between the scalar quantity, speed, and the vector quantity, velocity. It is important to establish a good understanding of displacement and velocity as vectors before studying accelerations and forces.

Students need to be clear about the vector nature of quantities such as displacement, velocity and acceleration. 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 taught 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. The first step towards understanding the vector nature of kinematical quantities in two dimensions is to understand them in one dimension.

Velocity is a vector quantity, and is sometimes defined as “speed in a given direction”. This is not a good definition. It is true that the magnitude of the instantaneous velocity is equal to the instantaneous speed, but the magnitude of the average velocity is not, in general, equal to the average speed.

Velocity is not simply speed with a direction tacked on. An accurate definition of velocity is that velocity is equal to rate of change of displacement.

Average velocity is the change in the displacement divided by the time interval over which the change occurs:

The bold typeface, for **v** and **s**, is used to denote a vector quantity.

It is worth emphasising that velocity is the rate of change of both the direction and the magnitude of the displacement, and acceleration is the rate of change of both the direction and the magnitude of the velocity (Reif and Allen, 1992).

**Ways to use this question**

Students should complete the confidence grid 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.

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 and D are correct; B and C are wrong.

2. C and D are correct; A and B are wrong.

3. A and D are correct; B and C are wrong.

**How to respond - what next?**

1. If students get the wrong answers for question 1, they are not taking direction into account properly when considering the scalar quantity, distance, and the vector quantity, displacement. Specifying displacement fully means giving both a magnitude and a direction. Option B is, of course, correct in the sense that the tortoise has moved a distance of 2 m, and it has moved north. However, distance is a scalar and so only a magnitude should be given. In discussion with students, it is worth making this technical use of language crystal clear.

2. Question 2 requires a deeper understanding of displacement as a vector. Here, unlike in question 1, the magnitude of the displacement is not equal to the distance travelled as the magnitude of displacement measures the shortest straight-line distance between the starting point and the end point.

Option D introduces a further subtlety by using a minus sign to indicate that the displacement is opposite to the direction that is given (north). Minus signs are often used to describe displacements and velocities in one direction, but the reference direction is often implicit. To help students to develop a firm grasp of the vector nature of displacement and velocity, the direction should always be stated explicitly.

3. Question 3 requires that students use their understanding of displacement tested in question 2 to calculate velocity. Note that the time interval used in the calculation is the total journey time.

Students who opt for C may do so for one of two reasons: they may think that the magnitude of the velocity is the same as the speed, because they are sometimes told that ‘velocity is speed in a certain direction’; they may also reason that the 1 metre south that the tortoise travels only takes the final 10 seconds of the journey. Reasoning either way is incorrect.

If students have misunderstandings about the vector nature of displacement or velocity, it is worth discussing real journeys, and perhaps looking at them on a map in order to differentiate between the total distance travelled, and the distance ‘as the crow flies’, and giving a compass direction.

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

* Response activity: Calculating average speed and average velocity

**Acknowledgments**

Developed by Simon Carson (UYSEG).

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**References**

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