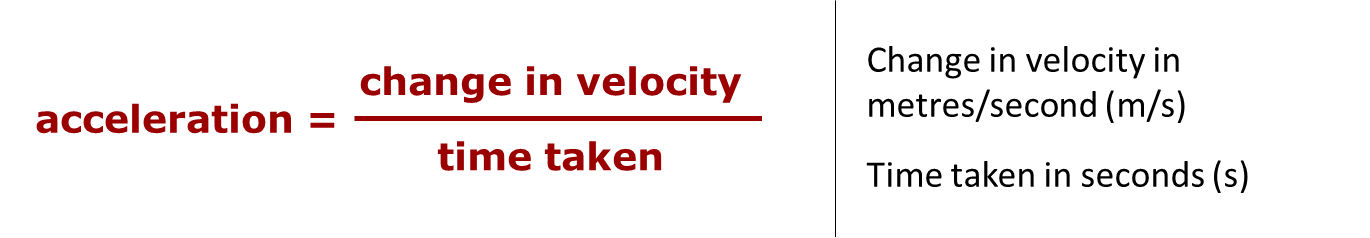
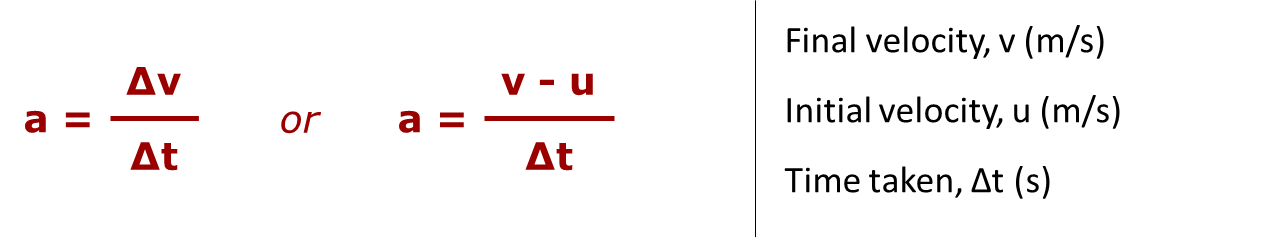
**Thinking about acceleration**

Acceleration is calculated as the change in velocity divided by the time taken for the change:

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****

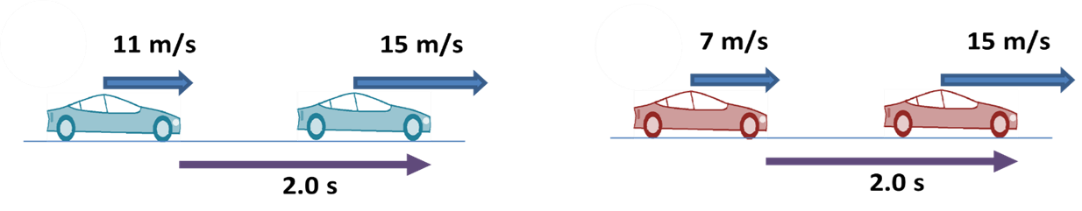
The units of acceleration can be worked out from this equation.

They are metres per second (for the velocity)per second (m/s/s).

This is usually shortened to m/s2.

Acceleration is measured in **metres per second squared**.

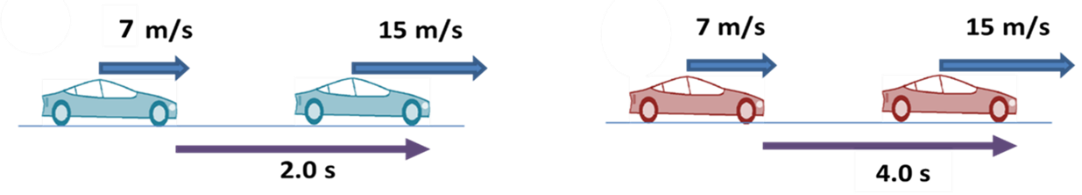
**1.** How does the acceleration of the red car compare to the acceleration of the blue car?



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

|  |  |  |
| --- | --- | --- |
| **A** | The acceleration of the red car is two times bigger. |  |
|  |  |  |
| **B** | The acceleration of the red car is the same size. |  |
|  |  |  |
| **C** | The acceleration of the red car is two times smaller. |  |

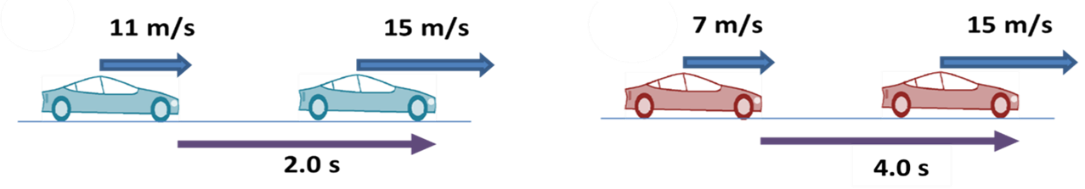
**2.** How does the acceleration of the red car compare to the acceleration of the blue car?



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

|  |  |  |
| --- | --- | --- |
| **A** | The acceleration of the red car is two times bigger. |  |
|  |  |  |
| **B** | The acceleration of the red car is the same size. |  |
|  |  |  |
| **C** | The acceleration of the red car is two times smaller. |  |

**3.** How does the acceleration of the red car compare to the acceleration of the blue car?

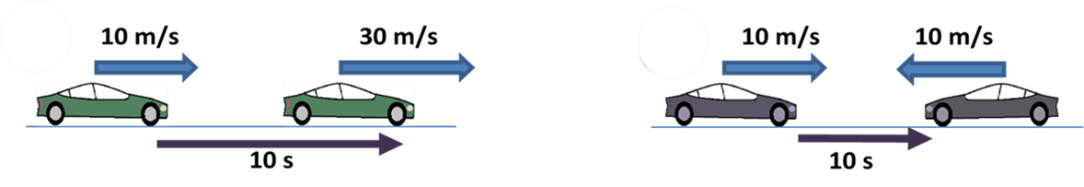


*Put a tick (✓) in the box next to the best answer.*

|  |  |  |
| --- | --- | --- |
| **A** | The acceleration of the red car is two times bigger. |  |
|  |  |  |
| **B** | The acceleration of the red car is four times bigger. |  |
|  |  |  |
| **C** | The acceleration of the red car is the same size. |  |
|  |  |  |
| **D** | The acceleration of the red car is two times smaller. |  |

**4.** How does the acceleration of the grey car compare to the acceleration of the green car?

The acceleration of each car is in a different direction. When answering this question, think only about the magnitude (the size) of each acceleration.



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

|  |  |  |
| --- | --- | --- |
| **A** | The acceleration of the the grey car is two times bigger. |  |
|  |  |  |
| **B** | The acceleration of the the grey car is the same size. |  |
|  |  |  |
| **C** | The acceleration of the the grey car is two times smaller. |  |
|  |  |  |
| **D** | The acceleration of the the grey car is zero. |  |

*Physics > Big idea PFM: Forces and Motion > Topic PFM4:Measuring and calculating motion > Key concept PFM4.2: Acceleration*

|  |
| --- |
| **Diagnostic question** |
| **Thinking about acceleration** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Acceleration, like displacement and velocity, is a vector quantity. Acceleration measures by how much velocity changes in a given time interval. |
| Observable learning outcome: | Calculate acceleration in one dimension from the equation |
| Question type: | Simple multiple choice |
| Key words: | Acceleration, velocity, time |

**What does the research say?**

Whilst carrying out calculations is an important part of students’ learning, success in using equations is not the same thing as developing conceptual understanding (Kim and Pak, 2002) and misconceptions may remain.

To expert physicists, symbols stand for physical quantities, and the results of the mathematical manipulations must be interpreted in terms of their meaning for a given physical system. Experts draw on their experience and (often tacit) knowledge of physical systems in order to make meaning from the mathematics (Carson, 1999; Redish and Kuo, 2015).

To students, the manipulation of the symbols and the substitution of numbers into formulae may be ends in themselves, devoid of physical meaning. Even after having been taught mechanics, students may lack the ability to reason about the vectors that represent kinematical quantities and forces (Flores, Kanim and Kautz, 2004). This is why students need to be supported in thinking qualitatively, as well as quantitatively.

Students do not always differentiate between velocity and change in velocity when thinking about acceleration. They may compare the accelerations of objects on the basis of final velocities, and may fail to consider their initial velocities. When they do consider changes in velocity, they may not take into account the time interval or the distance over which the change in velocity occurs (Trowbridge and McDermott, 1981).

Understanding the vector nature of quantities such as displacement, velocity, change in velocity and acceleration is important for students’ further learning and needs to be made clear at this stage. 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).

**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. C, 3. C, 4. B.

**How to respond - what next?**

Questions 1 and 2 change one of the two variables in the definition of the acceleration, question 3 changes both and in question 4 the accelerations being compared are in opposite directions.

Q1 Checks that students understand that increasing the change in velocity increases the acceleration.

Option B is likely to be chosen by students who are wrongly using just the final velocity to determine acceleration.

Q2 Checks that students understand that increasing the time interval over which the velocity changes decreases the acceleration, and that they are taking time into account in their thinking.

Option B is likely to be chosen by those who think wrongly that acceleration is a measure of the change in velocity, rather than the rate of the change.

Q3 Checks that students can reason about a simultaneous change in the velocity and in the time interval in a way that means that the two effects cancel out.

Option B, a change in the acceleration by a factor 4, checks for the misunderstanding that the two changes reinforce one another rather than cancel out.

Q4 The direction of the velocity changes so that the magnitude of the change in velocity, as well as the time interval over which this occurs, is the same in both pictures. This question checks that students take the direction of the velocity into account when thinking about the change, and do not simply think about a change in speed.

If students have misunderstandings about the relationship between the change in velocity, the time interval and the acceleration, or about how to calculate the change in velocity when the direction changes, the following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

* Response activity: Calculating acceleration

**Acknowledgments**

Developed by Simon Carson (UYSEG)

Images: Simon Carson (UYSEG)

**References**

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Trowbridge, D. E. and McDermott, L. C. (1981) Investigation of student understanding of the concept of acceleration in one dimension, *American Journal of Physics*, 49(3), pp. 242–253. doi: 10.1119/1.12525.