**Going faster?**

The picture shows two cars at three different times.

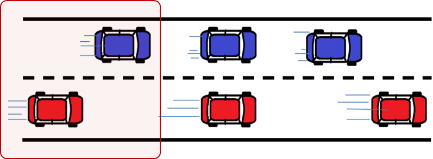
The times are equally spaced.

The red car catches up and overtakes the blue car.

Diagram

Description automatically generated

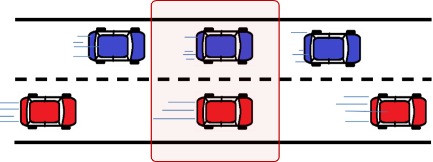
**1.** What is happening when the red car is behind the blue one?



*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** | Both cars are accelerating. |  |  |  |  |
| **B** | Neither car is accelerating. |  |  |  |  |
| **C** | The blue car has a greater acceleration than the red car. |  |  |  |  |
| **D** | The red car has a greater acceleration than the blue car. |  |  |  |  |

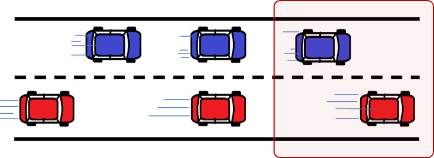
**2.** What is happening when cars are side by side?



*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** | The cars have the same velocity. |  |  |  |  |
| **B** | The cars have different velocities. |  |  |  |  |
| **C** | Both cars are accelerating. |  |  |  |  |
| **D** | Neither car is accelerating. |  |  |  |  |

**3.** What is happening when the red car is in front of the blue one?

**

*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** | Both cars are accelerating. |  |  |  |  |
| **B** | Neither car is accelerating. |  |  |  |  |
| **C** | The blue car has a greater acceleration than the red car. |  |  |  |  |
| **D** | The red car has a greater acceleration than the blue car. |  |  |  |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Going faster?** |

**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: | Recall that acceleration in one dimension describes the motion of an object that is speeding up or slowing down. |
| Question type: | Confidence grid |
| Key words: | Velocity, acceleration |

|  |  |
| --- | --- |
| **P** | **PRIOR UNDERSTANDING**  This diagnostic question probes understanding of ideas that are usually taught at age 11-14, to aid transition from earlier stages of learning. |

**What does the research say?**

Students may not differentiate clearly between distance, speed and acceleration when thinking about motion, merging different scientific concepts into a general idea of ‘motion’ (de Winter, 2021). They can find the concepts very difficult, partly because their prior ideas are established through experience, and partly because the formal scientific ideas are difficult to understand (Driver et.al., 1994).

Some students may think that when one moving object passes another they must have the same speed at that moment, even if only for a very short time (Trowbridge and McDermott, 1980; Jones, 1983). These students may be conflating their understanding of velocity and acceleration and think that when an object is moving faster, it has a greater acceleration than one which is moving more slowly, regardless of what the actual accelerations may be.

They may also think of acceleration as ‘catching up’, and fail to differentiate between velocity and change in velocity. For example, if one object catches up with a second object, it may be seen as having a greater acceleration, instead of, or as well as, having a greater velocity (Trowbridge and McDermott, 1981).

When they do consider changes in velocity, students may not account for the time interval over which the change in velocity occurs and can struggle to understand the idea of velocity at a particular instant of time.

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

2. Statement B and D are right; and statements A and C are wrong.

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

**How to respond - what next?**

These questions are about a situation in which two cars have different constant speeds. Because the faster car is behind the slower car initially, it overtakes, and at one point the cars are side by side. The pictures show that the cars move at a constant speed and neither car is accelerating.

In question 1, some students may think that the blue car initially has the greater velocity. This may be because they do not distinguish clearly between position and velocity and so think that the car in front must be going faster. Students who think that the red car has the greater acceleration may be failing to differentiate between ‘catching up’ (due to going faster) and acceleration, relating acceleration to velocity rather than to a change in velocity.

When thinking about question 2, when the cars are side by side, some students may believe the cars have the same velocity and/or the same acceleration. If so, they may be using the cars’ positions to compare velocities and/or accelerations.

If students have misunderstandings about the difference between velocity and acceleration, discuss with them what the readings of the speedometers of the cars might be as the cars travel along the motorway.

For example, ask what would happen if the speedometer on the red car read 70 mph, and that on the blue car read 60 mph? What would they about the velocities and accelerations of the two cars? It may be useful to add distance and time intervals to the diagram and ask students to calculate both the speeds and the accelerations of the cars between the first two and the last two pictures using:

and

Quantitative calculations like this do not on their own lead to understanding of the physical concepts, but coupled with qualitative thinking, like that required for these questions, they can help to develop students’ understanding of kinematical concepts.

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

* Response activity: Faster, slower

**Acknowledgments**

Developed by Simon Carson (UYSEG).

Images: Simon Carson (UYSEG)

**References**

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Jones, A. T. (1983) Investigation of students’ understanding of speed, velocity and acceleration, *Research in Science Education*, 13(1), pp. 95–104. doi: 10.1007/BF02356696.

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