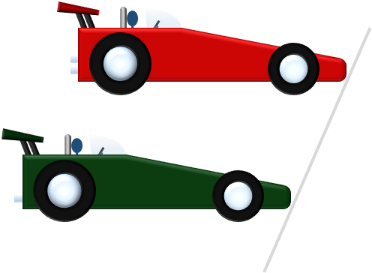
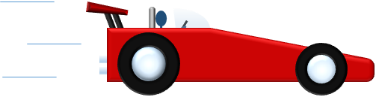
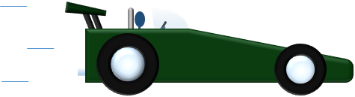
**Drag race II**

Two cars have the same shape and mass, but different engines.

The red car is pushed with a force two times bigger than the green car.

Starting at the same time, both cars accelerate from rest.





The red car is pushed with twice the force as the green car.

What do you think about each statement?

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 red car has twice the top speed. |  |  |  |  |
| **B** | At first, the red car accelerates at twice the rate. |  |  |  |  |
| **C** | After 1 s, the red car has about twice the speed. |  |  |  |  |
| **D** | As the red car speeds up, its acceleration goes down. |  |  |  |  |

*Physics > Big idea PFM: Forces and motion > Topic PFM6: Forces make things change > Key concept PFM6.2: Force, mass and acceleration*

|  |
| --- |
| **Diagnostic question** |
| **Drag race II** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | The acceleration of an object is proportional to the resultant force acting on it and inversely proportional to its mass. An object accelerates in the direction of the resultant force acting on it. |
| Observable learning outcome: | Describe the relationship between the resultant force on an object and its acceleration. |
| Question type: | Confidence grid |
| Key words: | Resultant force, acceleration |

**What does the research say?**

Students struggle to understand forces and motion, and use a system of ‘gut dynamics’ based on everyday experience in their reasoning. Understanding motion in Newtonian terms is a major task for students, and students of all ages, including physics undergraduates, fail to understand Newtonian concepts of motion (Driver et al., 1994).

Students have intuitive theories about forces and motion that resemble mediaeval ‘impetus’ theory (McCloskey, 1983). They may not see force as an interaction between two objects but rather as something that resides in a single object. They may use the terms ‘energy’ and ‘force’ in an undifferentiated way (Twigger et al., 1994) and may use ideas about force in a way that resembles what a physicist means by momentum (Watts and Zylbersztajn, 1981). They may believe that a force is required to maintain motion at a constant velocity, and that a greater force is required to maintain motion at a greater velocity, so that force is seen as being proportional to velocity rather than to acceleration as in the Newtonian view.

**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**

Statements B, C and D are right; and statement A is wrong.

**How to respond - what next?**

Each car is essentially identical apart from the force pushing it forwards. At first, the red car accelerates at twice the rate because air resistance is negligible and it has twice the resultant force pushing it forward. After one second, air resistance is still small, so it will have about twice the speed because during the first second its resultant force is about twice as big.

As the red car (and the green car) speed up, its acceleration goes down. This is because air resistance increases and the resultant force pushing it forwards goes falls.

A It is relatively common for students to have the misunderstanding that a bigger (resultant) force is needed to keep an object moving at a higher speed. And that twice the force moves an object at twice the speed.

D Often students confuse speed and acceleration, or use the terms interchangeably. This can lead to the misunderstanding that a higher speed means a *higher* acceleration.

If students have misunderstandings about describing the relationship between the resultant force on an object and its acceleration, it can help to remind students that force make things *change*: speed, shape or direction and that the bigger the force, the faster the change of speed.

To develop consolidate a better understanding, perhaps give students the opportunity to work in small groups to describe and explain what happens to the speed and acceleration of the cars – from the start up until they reach their top speed.

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

* Response activity: Trolley pull
* Response activity: Dropping forces

**Acknowledgments**

Developed by Simon Carson (UYSEG) and Peter Fairhurst (UYSEG).

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**References**

Driver, R., et al. (1994). *Making Sense of Secondary Science: Research into Children's Ideas,* London, UK: Routledge.

McCloskey, M. (1983). Intuitive Physics. *Scientific American,* 248(4).

Twigger, D., et al. (1994). The conception of force and motion of students aged between 10 and 15 years: an interview study designed to guide instruction. *International Journal of Science Education,* 16(2)**,** 215-229.

Watts, D. M. and Zylbersztajn, A. (1981). A survey of some children's ideas about force. *Physics Education,* 16(6)**,** 360-365.