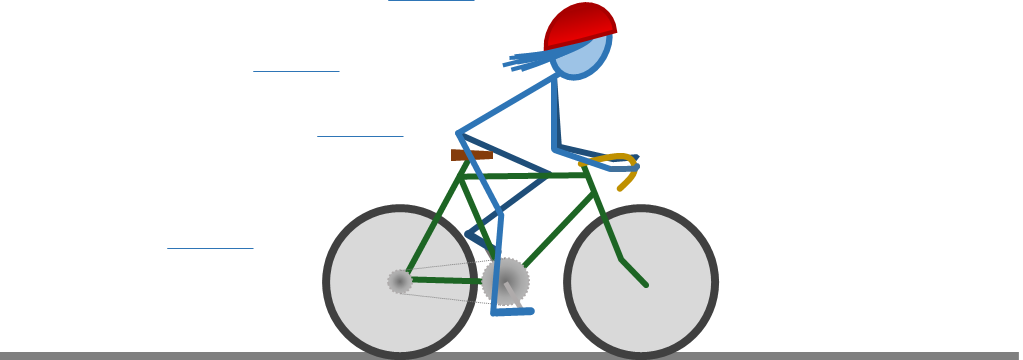
**Speed is a drag**

A cyclist experiences the force of drag.

As the cyclist speeds up, the force of drag gets bigger.



Which statements help explain the force of drag on the cyclist?

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** | A moving cyclist pushes air out of the way |  |  |  |  |
| **B** | A moving cyclist pushes forwards on the air, the air pushes backwards on the cyclist |  |  |  |  |
| **C** | As a cyclist speeds up, the air moves more and more quickly |  |  |  |  |
| **D** | As a cyclist speeds up, the air pushes on the cyclist with more and more force |  |  |  |  |

*Physics > Big idea PFM: Forces and motion > Topic PFM2: Moving by force > Key concept PFM2.4: Drag*

|  |
| --- |
| **Diagnostic question** |
| **Speed is a drag** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | The drag force on an object moving through a fluid increases with its speed and can be reduced by making the object more streamlined |
| Observable learning outcome: | Explain why the drag force on an object increases with the object’s speed |
| Question type: | Confidence grid |
| Key words: | Drag, speed |

**What does the research say?**

When the speed of an object is being increased, students tend to focus on the applied force that appears to be needed to get it going, and keep it going. They often think that a moving object *has* force that keeps it moving, and which runs out when it comes to rest (Gunstone, R and Watts, 1985; Driver et al., 1994a). Osborne (1985) found that as students get older they *increasingly* hold the view that a force, pushing in the direction of motion, is needed to keep an object moving. In a study of 200 students he found 46% of 13 year olds believed this, increasing to 53% of 14 year olds and 66% of 15 year olds.

Instead of concentrating on the applied force students need to think about all the forces acting and how they combine to produce the resultant force. They need to identify when the resultant force acts, when it changes and when it ceases. This involves understanding drag and the direction it acts in in order to recognise how it contributes to the resultant force (Driver et al., 1994b).

This question investigates students’ understanding of why drag increases with speed.

**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**

**A**: a moving cyclist pushes air out of the way; **B**: a moving cyclist pushes forwards on the air, the air pushes backwards on the cyclist ; and **D**: as a cyclist speeds up, the air pushes on the cyclist with more and more force – are all correct.

**C:** as a cyclist speeds up, the air moves more and more quickly – is wrong

**How to respond - what next?**

Most students are likely to be correct with answer A based on experience, but answers B and D need scientific understanding.

At a higher speed the cyclist hits a greater number of air particles each second, and the air particles ricochet off at higher speeds. The cyclist has to push harder on their pedals to provide the extra force needed, and the particles push back harder on the cyclist with an equal sized force in the opposite direction.

Answer C is wrong, but the relative motion of the air and the cycle when cycling quickly can be the same as it is when wind is blowing. In both situations it can feel exactly the same, which may lead to misunderstanding.

If students have misunderstandings about why the drag force on an object increases with the object’s speed, it can help to discuss the experience of walking or of trying to run at different speeds through a swimming pool.

The experience of cycling or riding on a roller coaster can be used to link understanding to moving through air.

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

* Response activity: Ball pool drag

*NB It is common for students to think that particles are widely spread out in the air. Asking students to estimate the separation of air particles with their fingers can be revealing. In fact there are about 50,000 times more particles in just 1cm3 of air as there are seconds in the entire history of the universe.*

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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