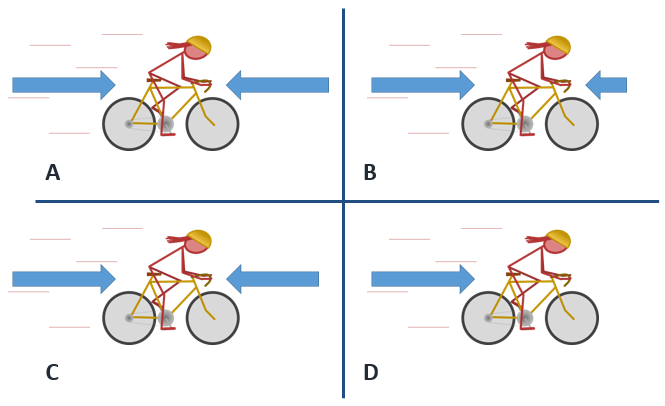
**Top speed**

A cyclist pedals as hard and as fast as they can. They reach a top speed.

**1.** The cyclist keeps up a steady top speed.

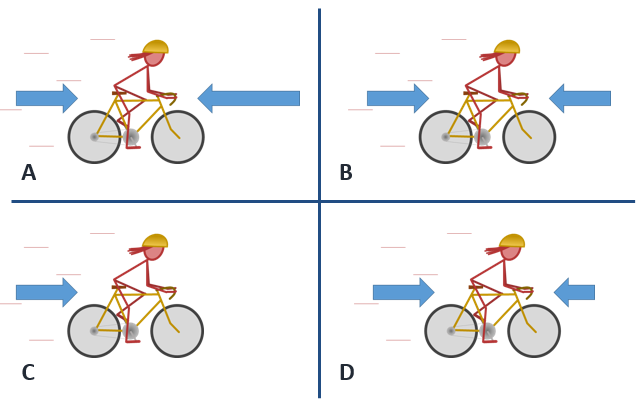
What are the forces acting on the cyclist?



The cyclist gets tired and pedals less hard. They reach a slower steady speed.

**2.** The cyclist keeps up a **slower** steady speed.

What are the forces acting on the cyclist now?



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

|  |
| --- |
| **Diagnostic question** |
| **Top speed** |

**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: | Describe the forces acting on an object when it is moving at a constant speed through a fluid |
| Question type: | Simple multiple choice |
| Key words: | Drag, resultant force, 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).

For most students the idea that a bigger resultant force produce a bigger effect is intuitive, but it is important to emphasise that resultant force does not produce speed, but a change in speed (Driver et al., 1994b). In other words: any moving object will continue to accelerate whilst a resultant force is acting on it.

This question investigates students’ understanding that a constant driving force is necessary to match counter forces (mostly drag, and a little friction) in order to maintain a steady speed.

**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.

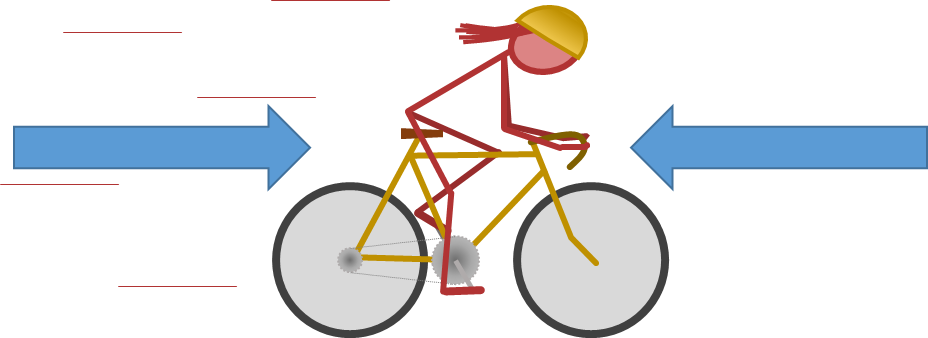
The answers to the question will show you whether students understood the concept sufficiently well to apply it correctly.

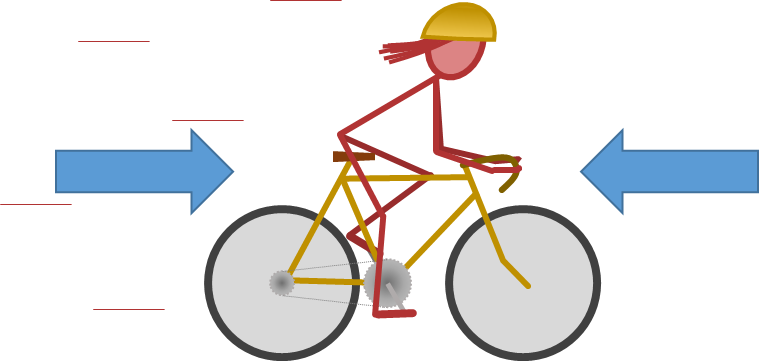
If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students 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. B 

**How to respond - what next?**

**1.** Answers B and C show students’ awareness of the counter force acting on the bicycle whilst also showing the misunderstanding that a steady *resultant* forward force is necessary to maintain a steady speed. Answer C in particular, because the counter force is only a little smaller than the driving force, shows how students may be adjusting the scientific explanation to fit their preconceptions, which is quite common.

**2.** Answer A is the situation immediately after the cyclist stops pedalling, when they are still travelling at top speed. They will be slowed down by the resultant force until the forces are again balanced – answer B. Answers C and D again indicate students who believe a forward resultant force is necessary for steady motion.

It is common for students to think that the bicycle in each of the correct answers will stop, because there is no resultant force acting.

If students have misunderstandings about the forces acting on an object when it is moving at a constant speed through a fluid, it can help to discuss the ‘story’ of the cyclist in terms of the forces acting. Talk about the force of the cyclist pushing forwards on the bike, and the force of the drag (and friction) pushing backwards on the bike. At each stage of the story ask ‘what force is left over to change the speed of the bicycle?’

Students can be challenged to describe the story of how the cyclist speeds up to a top speed, or slows down to a slower steady speed, in order to consolidate their understanding. Working in pairs or small groups can encourage social construction of understanding through dialogue.

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

* Response activity: Ball pool drag
* Response activity: Parachutes

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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