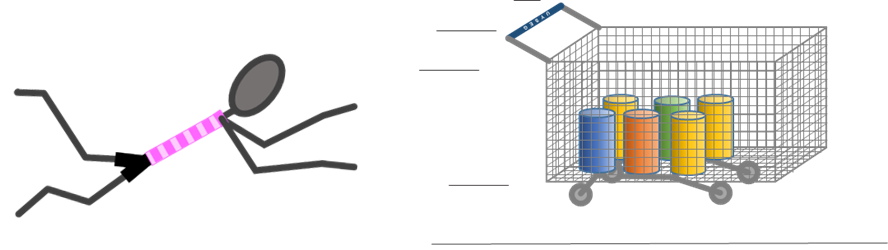
**Shopping trolley disaster!**

Isobel is running through a car park with a full shopping trolley.

She pushes it at a constant speed.



She trips and leaves go of the shopping trolley!

**a.** What happens to the trolley now?

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

|  |  |  |
| --- | --- | --- |
| **A** | It immediately comes to a stop |  |
|  |  |  |
| **B** | It moves at a steady speed for a while and then slows to a stop |  |
|  |  |  |
| **C** | It immediately starts slowing down to a stop |  |
|  |  |  |
| **D** | It continues at a constant speed |  |
|  |  |  |
| **E** | Its speed increases for a while and then starts slowing to a stop |  |

**b.** What is the best reason to explain what happens?

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

|  |  |  |
| --- | --- | --- |
| **A** | The forwards force is used up |  |
|  |  |  |
| **B** | There is no forwards force |  |
|  |  |  |
| **C** | There is a backwards force |  |

*Physics > Big idea PFM: Forces and motion > Topic PFM2: Moving by force > Key concept PFM2.3: Changing motion*

|  |
| --- |
| **Diagnostic question** |
| **Shopping trolley disaster!** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | A resultant force on an object can cause it to speed up or slow down, depending on the direction of the force. |
| Observable learning outcome: | Explain how friction and other resistive forces can act to continually reduce the speed an un-propelled object. |
| Question type: | Two-tier multiple choice |
| Key words: | Speed, acceleration, force, friction |

**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 it acts, when it changes and when it ceases. This involves understanding friction and the direction it acts in in order to recognise how it contributes to the resultant force (Driver et al., 1994b).

In a study (Hast and Howe, 2013), children observed a ball falling in free fall, accelerating down a ramp and rolling along a flat surface. In each case they were asked to predict whether the ball was speeding up, slowing down or travelling at a steady speed through the second half of each motion. For the accelerating balls the thirty-six 11-year-olds involved in the study made correct predictions only a little more often than they would have done by chance. They were significantly worse at predicting that the ball rolling along a horizontal surface was slowing down throughout the whole of the motion

This question investigates students’ understanding of how objects slow down continually whilst a resultant force acts in the opposite direction to motion.

**Ways to use this question**

Students should complete the questions 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 follow on question will give you insights into how they are thinking and highlight specific misconceptions that some may hold.

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. C: it immediately starts slowing down to a stop

b. C: there is a backwards force

**How to respond - what next?**

In this question the friction acting against the motion of the trolley is caused mainly by rubbing in the bearings of the wheels; drag forces are small in comparison.

The shopping trolley slows down because a steady resultant force acts in the opposite direction to its motion and it loses the same amount of speed each second. At first it has a higher speed and travels a significant distance in one second. As it slows to a stop it is travelling much slower and will move only a short distance in the final second of its motion. This can give the impression that the trolley continues to travel at a steady speed for a short time and then slow down fairly quickly.

In **part a**, this impression can lead a significant number of students to choose answer B. Some may choose answer E for similar reasons and because when throwing a ball students often have the misunderstanding that the ball is sped up *after* leaving the hand.

Answer A, to part a, is a logical conclusion from the misunderstanding that a force, pushing in the direction of motion, is needed to keep an object moving. Experience tells most students this is wrong. Answer D may be given by students who are trying to apply the rule that a force is needed to change speed and who have overlooked the *hidden* force of friction.

In **part b** it is a common misunderstanding (A) to think that force is used up. When this follows answer C for part a, the wrong reason has led to the right answer. Answer B is a correct statement, but does not explain the answer to part a.

If students have misunderstandings about how friction and other resistive forces can act to continually reduce the speed an un-propelled object, it can help to give students the opportunity to describe and justify what they think will happen, before observing a practical demonstration in order to confirm what really does happen. Working in pairs or small groups can encourage social construction of understanding through dialogue. A further opportunity for each student to correct or improve their explanation will allow them to consolidate their learning.

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

* Response activity: Counter force

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG), based on question F3-10 from EPSE (Evidence-based Practice in Science Education)

Images: Peter Fairhurst (UYSEG).

**References**

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