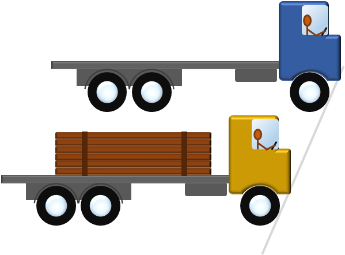
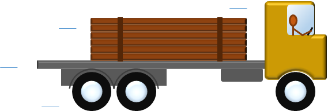
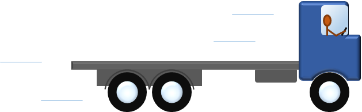
**Loaded lorry**

Two identical lorries accelerate from a standing start.

One lorry is carrying a load.

They both start at the same time.



After 3 seconds, the blue lorry is travelling faster.

What can you say about the resultant force on each lorry?

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

|  |  |  |
| --- | --- | --- |
| **A** | The resultant force on each lorry is the same. |  |
|  |  |  |
| **B** | The resultant force on the blue lorry is bigger. |  |
|  |  |  |
| **C** | The resultant force on the yellow lorry is bigger. |  |

*(Ignore the effect of air resistance)*

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

|  |
| --- |
| **Diagnostic question** |
| **Loaded lorry** |

**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 effect of a resultant force on objects of different mass. |
| Question type: | Simple multiple choice |
| Key words: | Resultant force, mass, 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 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 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 answer**

A: The resultant force on each lorry is the same.

**How to respond - what next?**

Each lorry is identical apart from the load and, ignoring air resistance, the resultant force on each is the same. The blue lorry accelerates at a faster rate because it has less mass and is easier to speed up or slow down. It has less inertia than the red lorry.

B It is relatively common for students to think that a bigger (resultant) force is needed to keep an object moving at a higher speed.

C Everyday experience suggests that heavier objects need more force to make them move.

If students have misunderstandings about describing the effect of a resultant force on objects of different mass, it can help to remind students that force make things *change*: speed, shape or direction. With careful questioning, it should then be possible to elicit understanding that:

* It is harder to speed up or slow down an object with a bigger mass
* If the same force were used to push a heavier shopping trolley (something everyone will probably have experience of doing) it speeds up more slowly than one that is less heavy.

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

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

**Acknowledgments**

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Images: Peter Fairhurst (UYSEG).

**References**

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