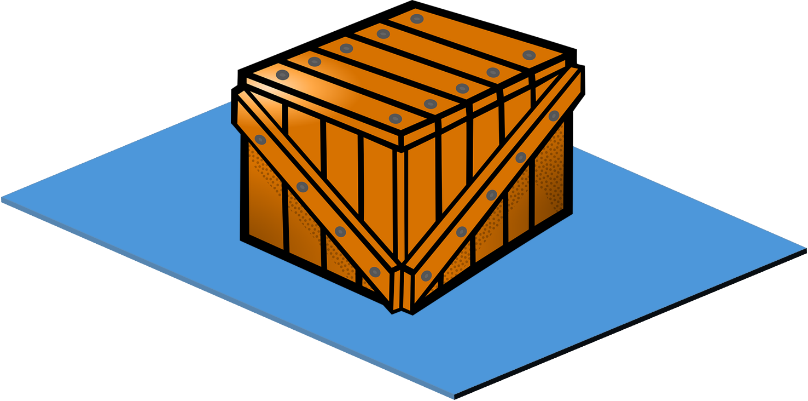
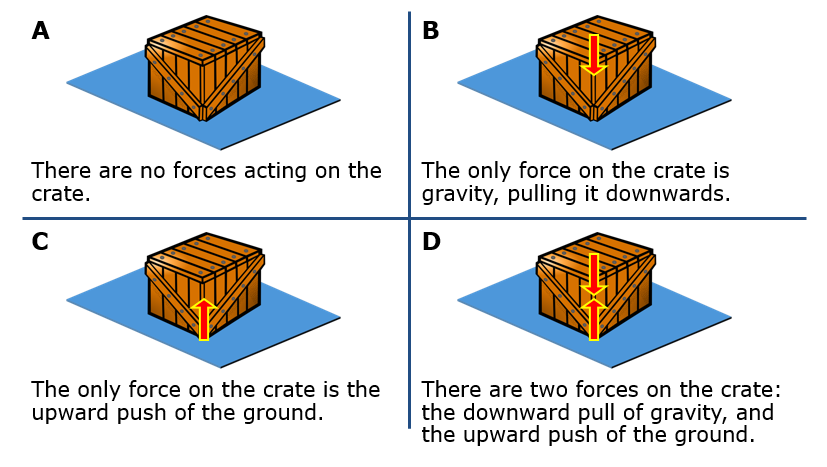
**Heavy crate**

A heavy crate is sitting on the ground.



Which picture shows the forces acting on the crate?

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



*Physics > Big idea PFM: Forces and motion > Topic PFM3: More about force > Key concept PFM3.2: Hidden forces*

|  |
| --- |
| **Diagnostic question** |
| **Heavy crate** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | An object resting on the floor squashes it a little and, because at a microscopic level the floor is springy, it pushes back on the object with an equal sized force in the opposite direction to the object’s weight. |
| Observable learning outcome: | Explain how objects of different weights can all be supported by the same floor. |
| Question type: | Simple multiple choice |
| Key words: | balanced, force, weight |

**What does the research say?**

Research by Terry *et al (1985)* has shown that expressing Newton’s third law in the form: “for every action (force) there is an equal and opposite reaction” is confusing for students aged 11-16. It is far clearer to describe in full: the force of object A on object B is equal in size, and opposite in direction to the force of object B pushing on object A.

When thinking about one object resting on a surface, students typically apply a concept of force that is different to the one they use for objects in motion. In a study of 1000 Norwegian upper secondary students, Sjoberg and Lie (1981) found that just 50% of the young people recognised ‘passive’ forces acting when there was no movement.

When Minstrell (1982) asked two US high school physics classes (aged 14+) about forces on an object resting on a table, most of the students understood that gravity was exerting a downwards force on the object, but only about half described the table exerting an upwards force. Students who did not identify an upwards force mostly described the table as ‘getting in the way’ (Driver et al., 1994). Typically those who recognised an upwards force from the table described the downwards force as bigger. In a further study, Montanero et al. (2002) found that only a very small minority of 11- to 16-year-olds (n=240) consistently applied the correct scientific understanding that the upwards force of a surface is the same size (and in the opposite direction) to the weight of an object that it supports.

Bridging analogies gradually take the learner through a series of easily understood ‘base analogies’, in order to lead them to an understanding of a challenging ‘target concept’, which is outside the realm of their usual experience or understanding (Bryce and MacMillan, 2005). A target question can be used to make explicit students’ alternative conceptions about the topic under consideration and an analogous case suggested by the teacher to scaffold and develop understanding. Targeted questioning and dialogue can lead students to make connections between the analogy and the target concept, and where necessary additional bridging steps (base analogies) added by the teacher, in order to reach or strengthen understanding of the target concept. (Savinainen, Scott and Viiri, 2004)

This question investigates students’ understanding of the target concept that is the learning focus of the key concept.

**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**

D There are two forces on the crate: the downward pull of gravity, and the upward push of the ground.

**How to respond - what next?**

Most students will recognise that gravity pulls the crate down, but in studies (without bridging towards this concept) only about 50% of students recognise an upwards force from the floor (Sjoberg and Lie, 1981).

Some students may think that the floor does not push up because it is not moving, or because it has not been visibly squashed or distorted.

A few students may say there are no forces on the crate if they do not believe there is an upward force, and they understand that the forces on the crate need to be balanced.

Some students may consider that gravity stops pulling on an object once it has ‘fallen’ to the ground. These students may select answer C.

If students have misunderstandings about the forces acting on the crate, it may be necessary to go (back) through the diagnostic questions and response activities from earlier in the learning progression for the key concept. Using examples from these activities can help lead them to an understanding of the challenging ‘target concept’: that an object resting on the floor squashes it a little and, because at a microscopic level the floor is springy, it pushes back on the object with an equal sized force in the opposite direction to the object’s weight.

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

* Response activity: Squashing a mattress
* Response activity: Box on a table

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG), from question F01-064 in the EPSE (Evidence based Practice in Science Education) question bank.

Images: crate: <https://pixabay.com/vectors/box-crate-packing-packing-case-1295328/>, Peter Fairhurst (UYSEG).

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