**Which weighs more?**

A large bag of feathers hangs on force meter.

A small bag of metal balls hangs next to the feathers.

Both force meters are the same.



What do you think about metal and the feathers?

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** | The same force is needed to lift both. |  |  |  |  |
| **B** | The metal is harder to lift than the feathers. |  |  |  |  |
| **C** | There is more gravity pulling on the feathers. |  |  |  |  |
| **D** | The feathers weigh the same as the metal. |  |  |  |  |

*Physics > Big idea PFM: Forces and motion > Topic PFM3: More about force > Key concept PFM3.1: Mass and weight*

|  |
| --- |
| **Diagnostic question** |
| **Which weighs more** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Mass is a measure of the amount of matter an object or substance is comprised of and weight is the force needed to support the object or substance. |
| Observable learning outcome: | Describe weight as the force needed to support an object or substance. |
| Question type: | Confidence grid |
| Key words: | force, gravity, weight |

**What does the research say?**

Galili and Bar (1997) detected two common ways in which students aged 5-11 think about weight. Some misunderstood that “weight is a pressing force that some objects have (stones, sticks, etc.) and some do not (air, dust, etc.)”; others misunderstood that “weight is the amount of matter” that an object contains. The latter misunderstanding is understandable as teachers are often advised not to distinguish between weight and mass in presecondary teaching (e.g. National Academy of Sciences, 2012).

Driver et al. (1994) note several studies that show students do not generally think of weight as a force of gravity (Stead and Osborne, 1980; Ruggiero et al., 1985; Watts, 1982) instead this is a concept that is introduced through teaching. Watts (1982) found secondary students do not use the concept of gravity consistently, applying gravity differently to different objects and not always in the same way at all times to a particular object. When weight is defined as equal to mass multiplied by gravitational field strength and students understand that mass is unchanging, then it becomes necessary for them to apply a non-scientific and flexible approach in order to make sense of situations such as the weightlessness of an astronaut in Earth orbit.

To avoid teaching students about weight in a way that leads to misunderstandings, it is important to distinguish between weight caused by a gravitational force and weight caused by relative motion (Galili, 1995; Tural, Akdeniz and Alev, 2010). At an introductory stage it is sufficient to teach that the weight of a mass is equal to force needed to support the mass (Galili and Kaplan, 1996; Stein, Galili and Schur, 2015).

A widespread view of gravity amongst 11-to-17-year-olds, is that it is a ‘holding’ force rather than a pulling force. This thinking is bound up with the idea that gravity is linked to the atmosphere, and with air pressing down to stop things floating away (Stead and Osborne, 1980; Driver et al., 1994). This can lead to the misunderstanding that there must be air for there to be gravity. This has implications for thinking about gravity acting in space, on other planets and on the Moon.

**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**

Statements A and D are correct.

Statements B and C are wrong.

**How to respond - what next?**

Statements A and D can be combined to give a working definition of weight. Weight can also be described as the force that an object or a substance exerts on the ground, or more generally the force needed to support the object or substance.

Statement B may be thought correct if students consider weight to be an intrinsic property of the object, which is quite common in pre-secondary age children. Statement C can indicate students who think of gravity as a ‘holding force’ that is bound up with the idea that gravity is linked to the atmosphere, and with air pressing down to stop things floating away. This misunderstanding is widespread amongst students aged 11-17.

If students have misunderstandings about weight being the force that supports an object or substance, it can help to give students hands-on experience weighing objects made from different substances. One strategy is to give students a range of objects that are made from different materials to organise in order of weight by judging how heavy they feel. Measuring the force needed to lift each one should confirm that heavier objects need more force to lift. It is also useful to include items that students may think are weightless, such as feathers or a balloon filled with air. It may be necessary to demonstrate the weight of each of these on a sensitive balance.

Having established that weight is the force needed to support an object or substance, the following BEST ‘response activity’ could be used to consolidate understanding:

* Response activity: Weight

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG); feathers: <https://pixabay.com/vectors/pen-feathers-bird-animal-beautiful-1674848/> and <https://pixabay.com/vectors/pen-feathers-bird-animal-beautiful-1674846/>.

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