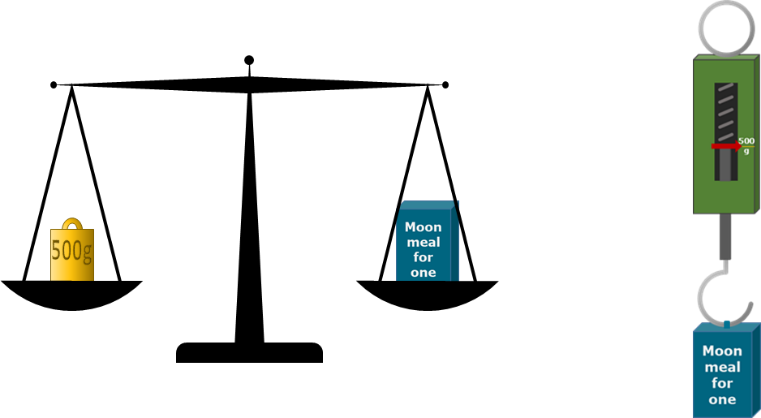
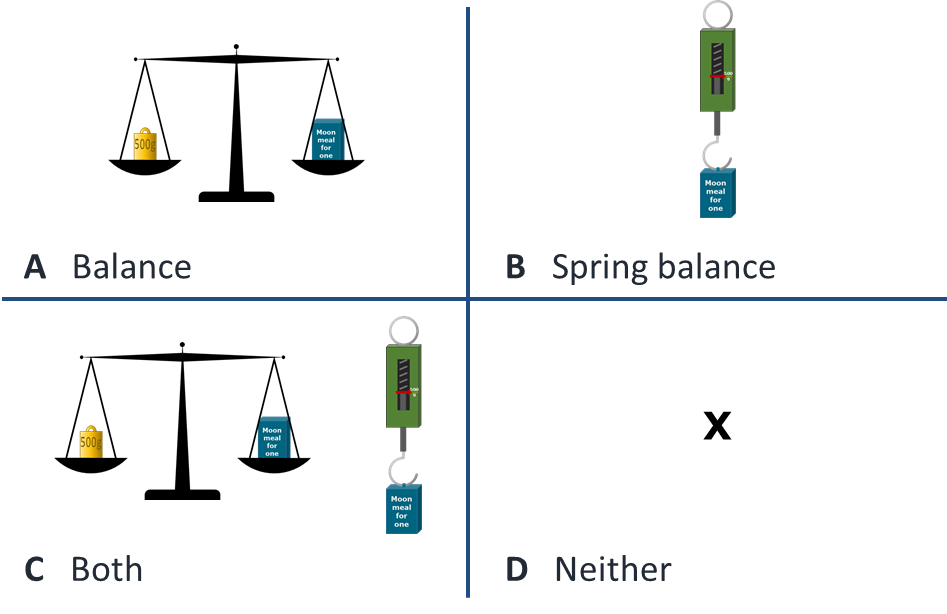
**Moon food**

An astronaut is preparing to go to the Moon.

Food for each meal is measured out carefully.



Which way of measuring food works on the Moon?



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

|  |
| --- |
| **Diagnostic question** |
| **Moon food** |

**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: | Explain the relationship between the weight and mass of an object that is caused by a gravitational force. |
| Question type: | Simple multiple choice |
| Key words: | mass |

**What does the research say?**

A mass of one kilogram is properly defined by Newton’s second law, as the mass one Newton of force will cause to accelerate at the rate of one metre per second squared. At this stage it is sufficient to define mass of an object or substance as the amount of matter it contains, and to reinforce the understanding that mass does not change unless material is added or taken away from the object.

Students often confuse the terms weight and mass, which is understandable as teachers are often advised not to distinguish between weight and mass in presecondary teaching (e.g. National Academy of Sciences, 2012).

Students aged 11-14 are typically taught that weight is a force and that a particular mass will weigh different amounts on different planets or moons because of changes in the gravitational force. This is true, but teaching that weight is caused by *just* the gravitational force (whether explicitly or implicitly) leads to misunderstandings that prevent students developing a good understanding of weightlessness, of how gravitational forces extend into space, and about other related ideas they encounter later in their studies (Gonen, 2008; Stein, Galili and Schur, 2015). For example, Sharma et al. (2004) found that half of physics undergraduates (n=200) wrongly defined weightlessness as an absence of gravity.

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.

**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**

**A** – The balance.

**How to respond - what next?**

The food has the same mass as the 500 g mass, so on the Moon they push down on either side of the balance with equal force. The force stretching the spring balance is smaller on the Moon and it will measure the mass of the food to be about 80g. The scale on the spring balance needs to be recalibrated to read mass on the Moon.

Students selecting a wrong answer are likely to be confusing mass and weight, or they have taken the 500 g mass to push down with a constant force (because mass is unchanging!).

If students have misunderstandings about how mass can be measured on the Moon, it can help to review their understanding of how weight and mass are defined, before using these definitions to apply their understanding to the new situation on the Moon, or to the situation on a planet with a larger gravitational attraction. This will give students opportunity to practise using the concepts so that they can consolidate their understanding. This often works best when they discuss their ideas in pairs or small groups, which encourage social construction of new ideas through dialogue.

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

* Response activity: Bathroom scales

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG) based on an idea by Bob Kibble (2011).

Images: Peter Fairhurst (UYSEG).

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