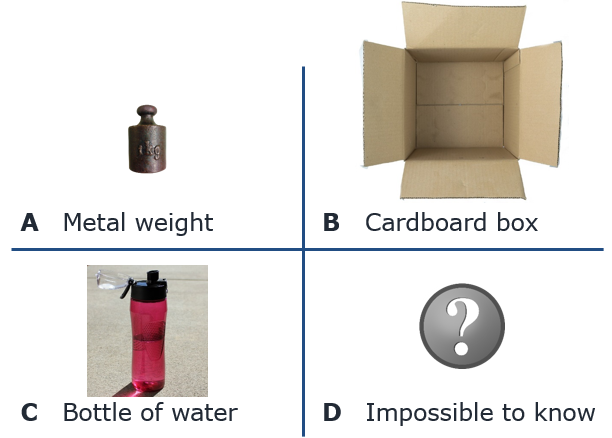
**The biggest mass**

On Earth Italian astronaut Samantha Cristoforetti has mass.

In space she has the same mass.

**a.** Which of these do you think has the biggest mass?

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



**b.** What is the best reason for your answer?

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

|  |  |  |
| --- | --- | --- |
| **A** | It is the biggest. |  |
|  |  |  |
| **B** | It is made of the heaviest material. |  |
|  |  |  |
| **C** | It is made of the most material. |  |
|  |  |  |
| **D** | It is the one that needs most force to lift it. |  |

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

|  |
| --- |
| **Diagnostic question** |
| **The biggest mass** |

**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 mass as a measure of the amount of matter in an object or substance. |
| Question type: | Two-tier multiple choice |
| Key words: | mass, material, matter |

**What does the research say?**

From an early age children develop a notion of the heaviness of an object by feeling how much it appears to ‘press down’. ‘Felt weight’ is typically conceived as a characteristic property of an object. The object’s mass is often associated with ‘massive’ because the words are similar. Ideas about mass can then be conflated with size or volume and some students will judge mass based on the size of an object (Mullet and Gervais, 1990; Driver et al., 1994; Galili and Bar, 1997; Stein, Galili and Schur, 2015).

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).

**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. D: it is impossible to tell from these pictures

b. C: it is made of the most material

**How to respond - what next?**

In ***part a****,* the objects were selected to all have approximately the same mass and different volumes, so that if students have the right understanding of mass they will recognise that it is impossible to judge which has most mass without measurement.

***Part b*** investigates the common misunderstandings: answer A identifies students who interpret mass to mean massive (as in size); answer B identifies students who link mass to the intrinsic properties of the material, in this case density; answer D is correct, but is not the best definition of mass because the force needed to lift an object can change depending both on the force of gravity acting on it and on how it is moving.

If students have misunderstandings about mass as a measure of the amount of matter in an object or substance, it can help to discuss how the ‘stuff’ that an astronaut is made from does not change when they go into space, where they are weightless. Asking students to work in pairs or small groups to write their own definitions of mass (and weight) encourages social construction of new ideas through dialogue, and asking students to individually summarise these definitions helps to consolidate learning.

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

* Response activity: Mass cans

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Samantha Cristoforetti: NASA; 1kg mass: <https://pixabay.com/photos/weight-horizontal-weigh-old-kg-2541653/>; cardboard box: <https://pixabay.com/photos/box-open-top-package-packaging-550405/>; bottle of water: <https://pixabay.com/photos/water-bottle-hydration-water-bottle-962934/>; question mark: <https://pixabay.com/vectors/question-mark-icon-symbol-question-909830/>.

**References**

Driver, R., et al. (1994). *Making Sense of Secondary Science: Research into Children's Ideas,* London, UK: Routledge.

Galili, I. and Bar, V. (1997). Children's operational knowledge about weight. *International Journal of Science Education,* 19(3)**,** 317-340.

Mullet, E. and Gervais, H. (1990). Distinction between the concepts of weight and mass in high school students. *International Journal of Science Education,* 12(2)**,** 217-226.

National Academy of Sciences (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas,* Washington, D.C.: National Academies Press.

Stein, H., Galili, I. and Schur, Y. (2015). Teaching a new conceptual fromework of weight and gravitation in middle school. *Journal of Research in Science Teaching,* 52(9)**,** 1234-1268.