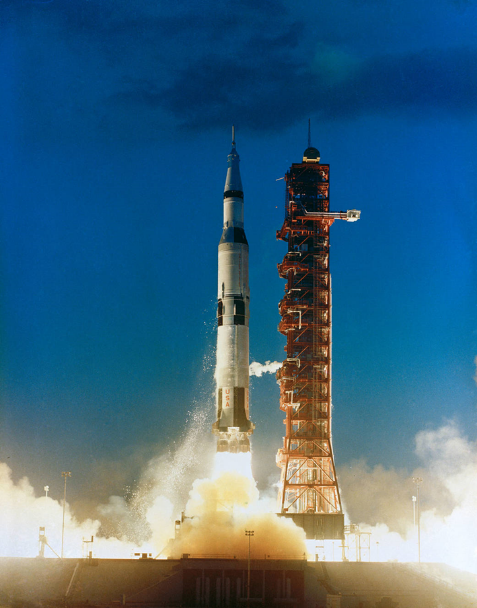
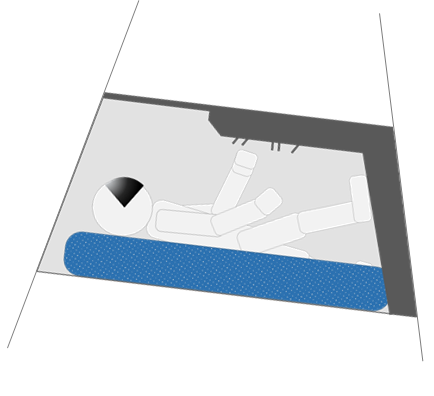
**Blast off!**



Apollo rockets have taken astronauts to the Moon six times.

The first Moon landing was on 20th July 1969.

The last Moon landing was in December 1972.

**a.** What happens to the weight of an astronaut as she blasts off?

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

|  |  |  |
| --- | --- | --- |
| **A** | Her weight gets bigger. |  |
|  |  |  |
| **B** | Her weight stays the same. |  |
|  |  |  |
| **C** | Her weight gets smaller. |  |

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

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

|  |  |  |
| --- | --- | --- |
| **A** | Her mass does not change. |  |
|  |  |  |
| **B** | The force of gravity on her does not change. |  |
|  |  |  |
| **C** | Her mass *and* the force of gravity on her do not change. |  |
|  |  |  |
| **D** | The force of gravity on her changes. |  |
|  |  |  |
| **E** | The rocket makes her speed up very quickly. |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Blast off!** |

**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 why the measured weight of an astronaut changes as they take off in a rocket. |
| Question type: | Two-tier multiple choice |
| Key words: | mass, weight, gravitational force, acceleration |

|  |  |
| --- | --- |
| **B** | **BRIDGING**  This diagnostic question probes understanding of ideas that are usually taught at age 14-16, to build a bridge to later stages of learning. |

**What does the research say?**

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.

In this question the force of the rocket on the astronaut can be calculated using Newton’s second law: force = mass x acceleration. She pushes back on the rocket with an equal sized force in the opposite direction. During take-off a bathroom scale placed between her and her seat would measure a force that is three or four times her normal weight.

**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.**  A: Her weight gets bigger.

**b.** E: The rocket makes her speed up very quickly.

**How to respond - what next?**

Some students, who are potentially very good scientists, may apply the formula weight = mass x gravitational strength to deduce that the astronaut’s weight remains constant – because her mass and the gravitational strength of the Earth do not change (answers B, C).

A more naïve view is that her weight becomes less as she moves towards space (answers C, D). Students selecting these options may be thinking that there is no gravity in space and as she approaches she weighs less and less.

Other students may realise that her weight increases (perhaps from watching films), but may link this to a changing gravitational force (answers A, D). This is analogous to stretching an elastic band, which becomes harder to stretch before it snaps. It also allows the continued application of w=mg, even though it does not apply.

If students have misunderstandings about how the measured weight of an astronaut changes as they take off in a rocket, it can help to discuss links to students’ own experiences. Accelerating quickly in a car ‘pushes you back’ in your seat. On some roller coasters there are very large accelerations which make it harder to lift up an arm or to move. Eliciting students’ own experiences of these things will allow them to share their observations which can help others to form a clearer understanding.

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

* Response activity: Moving weight

**Acknowledgments**

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Images: Peter Fairhurst (UYSEG); Apollo 4 launch: NASA - <https://www.nasa.gov/directorates/heo/scan/images/history/November1967.html>

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