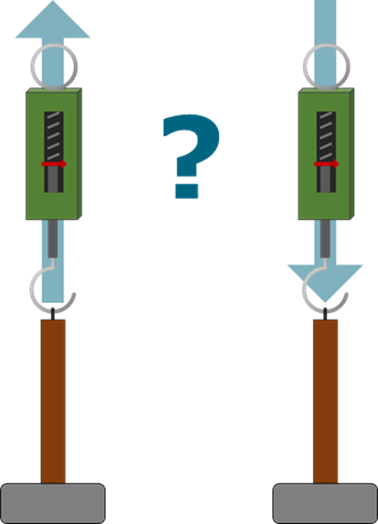
**Moving weight**

A force meter can be used to measure the weight of an object.

Weight is measured in Newton.

**Predict**

What happens to the weight of an object when the force meter is:

* pulled upwards very quickly?
* moved downwards very quickly?

**Explain**

Explain why you think this will happen.

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| **Carry out the investigation** |

**Observe**

Describe how the pointer moves.

(You won’t be able to take exact measurements)

**Explain**

Were your prediction and explanation correct?

Try to improve your first explanation to explain what happens more fully.

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

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| **Response activity** |
| **Moving weight** |

**Overview**

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| --- | --- |
| 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.  Explain why an astronaut orbiting the Earth is weightless. |
| Activity type: | Predict, explain; observe, explain (PEOE) |
| Key words: | mass, weight, gravitational force |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic questions:

* Diagnostic question: Blast off!
* Diagnostic question: A very tall tower
* Diagnostic question: Falling weight

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

**What does the research say?**

In most text books (Galili and Kaplan, 1996; Tural, Akdeniz and Alev, 2010; Stein, Galili and Schur, 2015) and in many syllabuses and curricula (Department for Education, 2013; Department for Education, 2014) weight is defined as the gravitational force acting on a mass. The equation weight = mass x gravitational field strength (w = mg) clearly shows that an object with more mass feels heavier and has more weight. This is logically correct because ‘bigger mass’ describes an object which contains more matter which requires more force to lift.

There is however a problem with this definition in that it also suggests that an astronaut will be weightless only when there is zero gravity; and this is not the case. On the International Space Station (ISS) astronauts clearly experience weightlessness, yet the ISS orbits so close to the surface of Earth (about 400 km) that the gravitational force on it and on the astronauts inside is still 89% of what it is on the Earth’s surface.

Defining weight as the gravitational force on an object does not work in all situations and reinforces the misunderstanding that there is no gravity in space (Stein et al., 2015). An alternative definition of weight that is often used by teachers is: weight is the force needed to pick up an object; or alternatively weight is the force which an object pushes down on a surface. This definition works well to explain what is happening to the astronaut in the ISS. The ISS and the astronaut are orbiting at the same speed and are following the same path, so as the astronaut falls - the ‘floor’ of the space station falls away from her at exactly the same speed. The experience of the astronaut is explained, but the equation w=mg does not work.

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.

Stead and Osborne (1980) found in a study of 11- to 14-year-olds that it is common for eleven-year-olds to think that gravity only relates to the Earth. At age thirteen (n=258) 44% do not think there is gravity on the Moon, and they commonly think that not all planets have gravity. 81% of 13-year-olds and 75% of 14-year-olds in the study did not think that there is gravity in space (Stead and Osborne, 1980; Driver et al., 1994). Similarly, Galili (1995) found that the majority of students aged 14-15 (n=34) understood weightlessness to depend solely on an object’s location (a place with little or no gravity).

This activity investigates what happens to measured weight when the measuring system is accelerated.

**Ways to use this activity**

Students should complete this activity in pairs or small groups, and the focus should be on the discussions. It is through the discussions that students can check their understanding and rehearse their explanations.

To begin, each group should discuss the activity and use their scientific understanding, firstly to predict *what* they think will happen, and then to explain *why* they think they are going to be right. If students in any group cannot agree, you may be able to direct them with some careful questioning.

Students now carry out the practical, or watch a demonstration. You will need to decide whether it is better for each group to carry out the practical and risk some unexpected observations, or to demonstrate the activity so that everyone *observes* the same thing.

After the practical each group should be given the opportunity to change, or improve their explanation. A good way to review your students’ thinking might be through a structured class discussion. You could ask several groups for their *explanations* and put these on the whiteboard. Then ask other groups to suggest which explanation is the most accurate and the most clearly expressed, and through careful questioning work up a clear ‘class explanation’.

A useful follow up is for individual students to then write down explanations in their own words – without reference to the class explanation on the board (i.e. cover it up).

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in the each group. For example, you may choose to select a student with strong prior knowledge as a scribe, and forbid them from contributing any of their own answers. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

**Equipment**

For each student/pair/group:

* Force meter
* A hanging mass (see health and safety)

**Technician notes**

Hanging masses need to be single masses and not several unsecured masses on a mass hanger.

The weight of each mass should be about ½ to ⅔ the maximum reading on the force meter.

Smaller masses and more sensitive force meters are preferable to minimise risk.

**Health and safety**

Students will be lifting and lowering masses quickly, which are hanging on a force meter. Thought needs to be given to ensure the masses used cannot easily slip off the force meters.

Smaller masses and more sensitive force meters are preferable to minimise risk.

Carrying out the investigation in a clear space away from a desk is necessary.

Practical work should be carried out in accordance with local health and safety requirements, guidance from manufacturers and suppliers, and guidance available from CLEAPSS.

**Expected answers**

In both situations the part to focus on is the start of the motion when acceleration of the mass and the force meter is greatest.

*Lifting the force meter quickly.*

The weight increases at the start of the lift, then reduces as the force meter is lifted at a more steady speed. At the top of the lift the weight is seen to reduce to its starting value.

*Lowering the force meter quickly.*

The weight decreases at the start of the drop, then increases as the force meter is lowered at a more steady speed. At the bottom of the drop the weight is seen to increase to its starting value.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

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