**Hanging ball**

A ball is hanging from a string, which is tied to the ceiling.

Some friends are talking about the forces acting on the ball.

**Niamh:** The ball is not moving. There are no forces acting on it.

**Matilda:** The string is pulling upwards on the ball and this balances the force of gravity.

**Owen:** A string cannot pull. It just stops the ball from falling.

**Luca:** The only force on the ball is the force of gravity pulling it down.

**To answer**

1. Who do you think is right about the forces on the ball?

*Explain your answer*

* 1. What mistakes do you think the others made?

*What would you say to them to help them to understand?*

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| Cards for  **Hanging ball** |  |
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*Physics > Big idea PFM: Forces and motion > Topic PFM3: More about force > Key concept PFM3.2: Hidden forces*

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| **Response activity** |
| **Hanging ball** |

**Overview**

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| Learning focus: | An object resting on the floor squashes it a little and, because at a microscopic level the floor is springy, it pushes back on the object with an equal sized force in the opposite direction to the object’s weight. |
| Observable learning outcome: | Explain how a string can support objects of different weights and hold each one at rest. |
| Activity type: | Talking heads |
| Key words: | balanced, force, gravity, weight |

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

* Diagnostic question: Ball on a rope

**What does the research say?**

Research by Terry *et al (1985)* has shown that expressing Newton’s third law in the form: “for every action (force) there is an equal and opposite reaction” is confusing for students aged 11-16. It is far clearer to describe in full: the force of object A on object B is equal in size, and opposite in direction to the force of object B pushing on object A.

When thinking about one object resting on a surface, students typically apply a concept of force that is different to the one they use for objects in motion. In a study of 1000 Norwegian upper secondary students, Sjoberg and Lie (1981) found that just 50% of the young people recognised ‘passive’ forces acting when there was no movement.

When Minstrell (1982) asked two US high school physics classes (aged 14+) about forces on an object resting on a table, most of the students understood that gravity was exerting a downwards force on the object, but only about half described the table exerting an upwards force. Students who did not identify an upwards force mostly described the table as ‘getting in the way’ (Driver et al., 1994). Typically those who recognised an upwards force from the table described the downwards force as bigger. In a further study, Montanero et al. (2002) found that only a very small minority of 11- to 16-year-olds (n=240) consistently applied the correct scientific understanding that the upwards force of a surface is the same size (and in the opposite direction) to the weight of an object that it supports.

Bridging analogies gradually take the learner through a series of easily understood ‘base analogies’, in order to lead them to an understanding of a challenging ‘target concept’, which is outside the realm of their usual experience or understanding (Bryce and MacMillan, 2005). A target question can be used to make explicit students’ alternative conceptions about the topic under consideration and an analogous case suggested by the teacher to scaffold and develop understanding. Targeted questioning and dialogue can lead students to make connections between the analogy and the target concept, and where necessary additional bridging steps (base analogies) added by the teacher, in order to reach or strengthen understanding of the target concept. (Savinainen, Scott and Viiri, 2004)

The common analogy of hanging weights from a spring to equate increased stretching with heavier weights with a corresponding increased upwards force was found by Bryce and MacMillan (2005) to be problematic. They found that many students had difficulty making connections between forces resulting from a spring being stretched and those from a surface being squashed. Bryce and MacMillan suggested this would be a useful example to discuss after students had formed a good scientific understanding, in order to consolidate their understanding in a new context.

**Ways to use this activity**

Students should complete this activity in pairs or small groups, and the focus should be on the discussions. The statements are also provided as cut-out cards for students to physically organise.

Students should work together to follow the instructions on either the worksheet or the PowerPoint. Giving each group one worksheet to complete between them is helpful for encouraging discussion, but each member should be able to report back to the class. Listening in to the conversations of each group will often give you insights into how your students are thinking.

If there is disagreement when you take feedback, a good way to progress might be 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*

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.

**Expected answers**

Matilda is correct.

Luca, Niamh and Owen do not consider an inanimate string at rest as capable of exerting a force. Owen has explained this with the idea of the string stopping the motion, which is problematic because to stop something moving you need to use a force. Replacing the string with a newton meter will show that the ball is pulling down with a force, and a hand holding the newton meter will need to exert an upwards force because if the ball is not moving, then its downward force needs to be balanced by an upward force of the same size.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG), based on EPSE (Evidence-informed Practice in Science Education) question: *F1 CC - Hanging ball*.

Images: box: Peter Fairhurst (UYSEG).

**References**

Bryce, T. and MacMillan, K. (2005). Encouraging conceptual change: the use of bridging analogies in the teaching of action-reaction forces and the 'at rest' condition in physics. *International Journal of Science Education,* 27(6)**,** 737-763.

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

Minstrell, J. (1982). Explaining the "aqt rest" condition of an object. *The Physics Teacher,* 20**,** 10-14.

Montanero, M., et al. (2002). Implicit theories of static interactions between two bodies. *Physics Education,* 37 (4)**,** 318-323.

Savinainen, A., Scott, P. and Viiri, J. (2004). Using a bridging representation and social interactions to foster conceptual change: Designing and evaluating an insturctional sequence for Newton's third law. *Science Education,* 89:2**,** 175-195.

Sjoberg, S. and Lie, S. (1981). Ideas about force and movement among Norwegian pupils and students. *Institute of Physics Report Series: Report 81-11.* University of Oslo.

Terry, C., Jones, G. and Hurford, W. (1985). Children's conceptual understanding for force and equilibrium. *Physics Education,* 20(4)**,** 162-165.