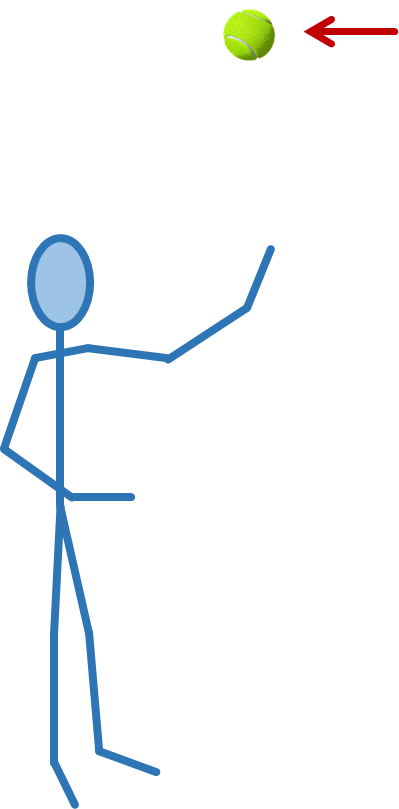
**Stopping in mid-air**

Albert throws a ball straight up in the air.

At the **top** of its flight it stops for a short moment.

What do you think about each statement?

For each statement, tick (✓) **one** column to show what you think*.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| These statements are about the forces acting on the ball at the **top** of its flight. | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | No forces are acting on the ball. |  |  |  |  |
| **B** | The upward force on the ball balances the force of gravity on the ball. |  |  |  |  |
| **C** | There is no gravity acting on the ball. |  |  |  |  |
| **D** | Only the force of gravity is acting on the ball. |  |  |  |  |

*Physics > Big idea PFM: Forces and motion > Topic PFM6: Forces make things change > Key concept PFM6.2: Force, mass and acceleration*

|  |
| --- |
| **Diagnostic question** |
| **Stopping in mid-air** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | The acceleration of an object is proportional to the resultant force acting on it and inversely proportional to its mass. An object accelerates in the direction of the resultant force acting on it. |
| Observable learning outcome: | Use the equation F = m x a to determine and explain the motion of falling objects. |
| Question type: | Confidence grid |
| Key words: | Force, mass, acceleration |

**What does the research say?**

When thinking about forces and motion, students treat motion in a horizontal plane and motion in a vertical plane differently (Lemmer, 2013). Some students do not see weight as a force, believing that gravity is the natural tendency of things to fall. Students may believe that when objects rise and fall in a gravitational field, upward and downward motions need to be explained differently (Twigger et al., 1994).

**Ways to use this question**

Students should complete the confidence grid 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.

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**

Statement D is correct. Statements A, B and C are wrong.

**How to respond - what next?**

The force acting on the ball is downwards and equal to the force of gravity. This force acts downwards and accelerates the ball in this direction.

A, B, C: the ball is momentarily stationary at the top of its flight and students often have the misunderstanding that this means that the force acting on it must be balanced. In this instance, there is no upwards force, so the logical conclusion is that no forces are acting.

B A common misunderstanding is that a force is needed to keep something moving. Some students may think that there is an upwards force moving the ball upwards that can balance the force of gravity.

C Students selecting this option are perhaps not thinking of gravity as a force, or may not have thought through the consequence of their choice, which *makes* the ball weightless.

If students have misunderstandings about using the equation F = m x a to explain the motion of falling objects, it can help to talk through the situation with the class. Very useful questions to ask are ‘what will happen to the ball next?’, ‘which way will a force need to act in order to cause that change?’ and what can cause this force.

It may be appropriate to give the opportunity to students to work in small groups to describe and explain what happens to the ball from just before it reaches the top of its flight until a short time afterwards.

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

* Response activity: Free-fall

**Acknowledgments**

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Images: Peter Fairhurst (UYSEG).

**References**

Lemmer, M. (2013). Nature, Cause and Effect of Students' Intuitive Conceptions Regarding Changes in Velocity. *International Journal of Science Education,* 35(2)**,** 239-261.

Twigger, D., et al. (1994). The conception of force and motion of students aged between 10 and 15 years: an interview study designed to guide instruction. *International Journal of Science Education,* 16(2)**,** 215-229.