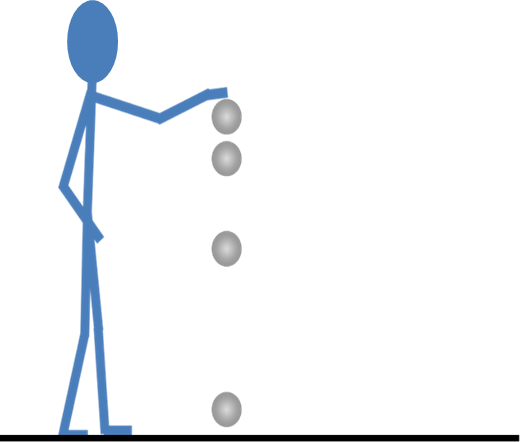
**Down, up, down**

Isaac drops a ball.

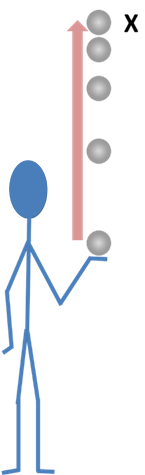
The ball is shown at equal intervals of time.



**1.** What happens to the ball as it falls?

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | Its velocity keeps increasing until it hits the floor. |  |  |  |  |
| **B** | Its acceleration increases at first, then stays the same. |  |  |  |  |
| **C** | Its acceleration is always the same as it falls. |  |  |  |  |
| **D** | Its acceleration increases as it falls. |  |  |  |  |

****

Isaac throws a ball up.

The ball is shown at equal intervals of time.

Its maximum height is at X

**2.** What happens to the ball as it rises?

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | The ball is not accelerating. |  |  |  |  |
| **B** | The ball is accelerating in an upwards direction. |  |  |  |  |
| **C** | The ball is accelerating in a downwards direction. |  |  |  |  |
| **D** | At its maximum height its acceleration is zero. |  |  |  |  |

*Physics > Big idea PFM: Forces and Motion > Topic PFM4:Measuring and calculating motion > Key concept PFM4.2: Acceleration*

|  |
| --- |
| **Diagnostic question** |
| **Down, up, down** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Acceleration, like displacement and velocity, is a vector quantity. Acceleration measures by how much velocity changes in a given time interval. |
| Observable learning outcome: | Recognise that in one dimension, the directions of the velocity and the acceleration may be different. |
| Question type: | Confidence grid |
| Key words: | Velocity, acceleration |

**What does the research say?**

Students may not differentiate clearly between speed, velocity and acceleration when thinking about motion, merging different scientific concepts into a general idea of ‘motion’, not always realising the important differences between them (de Winter, 2021). Although these terms are connected, the differences matter, and teachers should use terms carefully, taking care to be precise in their use of language.

Students may split objects into groups: those at rest; and those that are moving. Changes in the motion, such as the acceleration from a state of rest to a state of motion, are less frequently focused on, and changes in speed once an object is moving may be observed less frequently. The term acceleration is not commonly used by school age pupils prior to its introduction in science lessons, and everyday terms such as ‘going faster’ are used in ambiguous ways. Sometimes ‘going faster’ is used referring to the magnitude of the speed of an object and at other times referring to the speed increasing with time. (Driver *et al.*, 1994)

In everyday language, ‘acceleration’ may be taken to mean ‘speeding up’, rather than describing the rate of change of velocity, which can lead to misunderstanding (Reif and Allen, 1992). Referring to change in *velocity*, rather than a change in *speed*, is more accurate and can help students to understand that acceleration can refer to speeding up, slowing down, and changing direction.

When thinking about the directions of velocity and acceleration, students tend to think that these must be in the same direction, and that if velocity is zero, even if only instantaneously, then so must be acceleration (Rosenblatt and Heckler, 2011). Acceleration may be perceived by students to be increasing if the speed is increasing (Jones, 1983).

**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**

1. A and C are right; B and D are wrong.

2. C is right; A, B and D are wrong.

**How to respond - what next?**

In both questions, the ball is accelerated by the force of gravity and it is constant (ignoring air resistance). As the ball falls, its velocity increases at a steady rate; and when the ball is thrown upwards, its velocity decreases at the same steady rate.

Q1 Students who think that statement B is correct recognise that the ball must accelerate from rest to a state of motion, but then do not understand that the ball continues to accelerate. This is quite a common misunderstanding amongst younger students. They are differentiating between a state of rest and of motion, but not between different states of motion.

Students who think that statement D is correct are likely to be confusing acceleration with velocity, rather than understanding it as a *change* in velocity.

Q2 Students who think the ball is not accelerating may think that acceleration only refers to speeding up, using a limited everyday definition of acceleration.

Students who choose option B may realise the ball is accelerating but do not understand that the directions of acceleration and velocity do not need to be the same.

Students who choose option D may believe that if the velocity of an object is zero, even if only instantaneously, then the acceleration must be zero. They are likely to be confusing acceleration with velocity, rather than understanding it as a *change* in velocity.

If students have misunderstandings about the vector nature of velocity, change in velocity, and acceleration, it may help to watch real objects fall frame-by-frame on video playback. This enables them to see the increase in the distance moved between frames.

They can use data from a video to calculate the speed of the falling ball, and to show that the increase in speed is same size after equal increases in the number of frames, or after equal increases of time.

The same activity can be repeated for an object thrown upwards, and used to discuss the idea that a decrease in speed can be described as a negative increase and to discuss ideas about the directions of the three important vectors here: velocity, change in velocity, and acceleration.

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

* Response activity: Which way now?

**Acknowledgments**

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