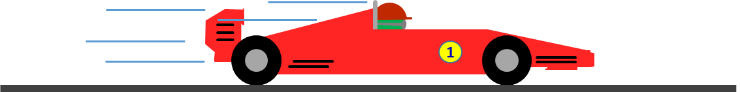
**Going in the right direction**

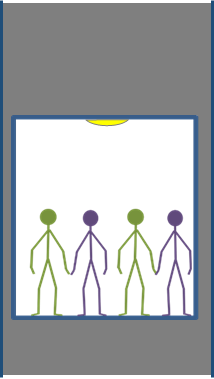
**1.** Which statement ***best*** describes the **acceleration** of the racing car?



A racing car travelling fast along a track.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **A** | | | The racing car is accelerating to the right. | |  |
|  | | |  | |  |
| **B** | | | The racing car is accelerating to the left. | |  |
|  | | |  | |  |
| **C** | | | The racing car is not accelerating. | |  |
|  | | |  | |  |
| **D** | | | The racing car might not be accelerating, or it might be accelerating to the right. | |  |
|  |  |  | |
| **E** | | | The racing car might not be accelerating, or it might be accelerating to the right or to the left. | |  |

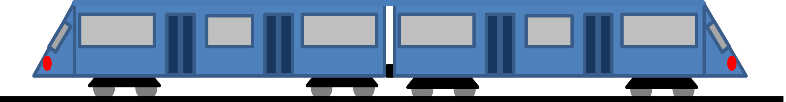
**2.** Which statement ***best*** describes the motion of the lift?

**

The lift is accelerating upwards.

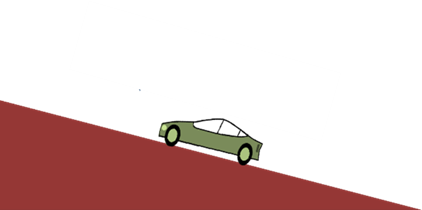
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **A** | | | The lift is moving upwards. | |  |
|  | | |  | |  |
| **B** | | | The lift is moving downwards. | |  |
|  | | |  | |  |
| **C** | | | The lift is not moving. | |  |
|  | | |  | |  |
| **D** | | | The lift might not be moving, or it might be moving upwards. | |  |
|  |  |  | |
| **E** | | | The lift might not be moving, or it might be moving upwards or downwards. | |  |

**3.** Which statement ***best*** describes the **acceleration** of the train?



The train is in the station. It is not moving.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **A** | | | The train is accelerating to the right. | |  |
|  | | |  | |  |
| **B** | | | The train is accelerating to the left. | |  |
|  | | |  | |  |
| **C** | | | The train is not accelerating. | |  |
|  |  |  | |
| **D** | | | The train might not be accelerating, or it might be accelerating to the right or to the left. | |  |



4. Which statement ***best*** describes the motion of the car?

The car is accelerating up a hill.

*.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **A** | | | The car is moving up the hill. | |  |
|  | | |  | |  |
| **B** | | | the car is moving down the hill. | |  |
|  | | |  | |  |
| **C** | | | The car is not moving. | |  |
|  | | |  | |  |
| **D** | | | The car might not be moving, or it might be moving up the hill. | |  |
|  |  |  | |
| **E** | | | The car might not be moving, or it might be moving up or down the hill. | |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Going in the right direction** |

**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, velocity and acceleration may be in different directions. |
| Question type: | Simple multiple choice |
| Key words: | Acceleration |

**What does the research say?**

Students need to be clear about the vector nature of quantities such as displacement, velocity, change in velocity and acceleration. This understanding becomes increasingly important as students develop their understanding of physics, but despite being taught about vectors at school, very many students on undergraduate introductory physics courses in the USA have no *useful* knowledge of vectors (Aguirre, 1988; Knight, 1995).

In their study of 650 undergraduate students enrolled on physics courses, Rosenblatt and Heckler (Rosenblatt and Heckler, 2011) found that when thinking about the directions of velocity and acceleration in one dimension, students tended to use one of two models when reasoning incorrectly. The first model is the belief that the two vectors need not be aligned, and may point in opposite directions, but one cannot be zero if the other is non-zero (‘‘cannot-be-zero’’ model). The second model is the belief that if one vector is non-zero, the other might be zero but could not point in the opposite direction (‘‘cannot-be opposite’’ model).

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. When given information about acceleration, students are less likely to reason correctly about the velocity of an object than when asked to reason about acceleration, given information about velocity. There is an asymmetry in their thinking about the relationship between these quantities (Rosenblatt and Heckler, 2011).

**Ways to use this question**

Students should complete the question 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 answers to the question will show you whether students understood the concept sufficiently well to apply it correctly.

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. E 2. E 3. D 4. E

**How to respond - what next?**

Questions 1 and 3 give students information about the velocity of an object, and ask them to reason about the acceleration. In both cases, the direction of the acceleration is independent of the direction of the velocity. The racing car could be speeding up (accelerating towards to the right), slowing down (accelerating towards the left), or travelling at constant speed (zero acceleration). Likewise, the train could be about to start or have just stopped and be momentarily at rest whilst changing direction, with an acceleration in either direction, or it may remain at rest if it has zero acceleration.

Q1 The most likely wrong answer in question 1 is that students do not think the acceleration can be to the left (the “cannot be opposite” model).

Q3 The most likely error is that students believe that if the velocity is zero, the acceleration must also be zero.

Questions 2 and 4 give information about the acceleration of an object, and ask students to reason about the direction of the velocity. In both questions, it is impossible to infer anything about the direction of the motion given the direction of the acceleration.

Q2 The most likely wrong answer is that the lift must be moving upwards in the same direction as acceleration.

Q4 The most likely error is that the car must be moving up the hill in the same direction as acceleration.

If students have misunderstandings about the independence of the directions of the velocity and the acceleration, it can help to remind students that a resultant force acting on an object will cause it to change its speed in the direction of the resultant force; and to discuss with them how this links to the definition of acceleration as the rate of change of velocity.

Careful questioning should elicit understanding that an object moving in a straight line can experience a resultant force in the opposite direction to its motion; that this force can reduce the its speed; and that the object may still be moving in its original direction, which is opposite to the direction of the resultant force and to the direction of its change of speed (acceleration).

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

* Response activity: Which way now?

**Acknowledgments**

Developed by Simon Carson (UYSEG), with some ideas from Rosenblatt and Heckler (2011)

Images: Simon Carson (UYSEG)

**References**

Aguirre, J. M. (1988) Student preconceptions about vector kinematics, *The Physics Teacher*, 26(4), pp. 212–216. doi: 10.1119/1.2342490.

Knight, R. D. (1995) The vector knowledge of beginning physics students, p. 6.

Rosenblatt, R. and Heckler, A. F. (2011) Systematic study of student understanding of the relationships between the directions of force, velocity, and acceleration in one-dimension, *Physical Review Special Topics - Physics Education Research*, 7(2), p. 020112. doi: 10.1103/PhysRevSTPER.7.020112.