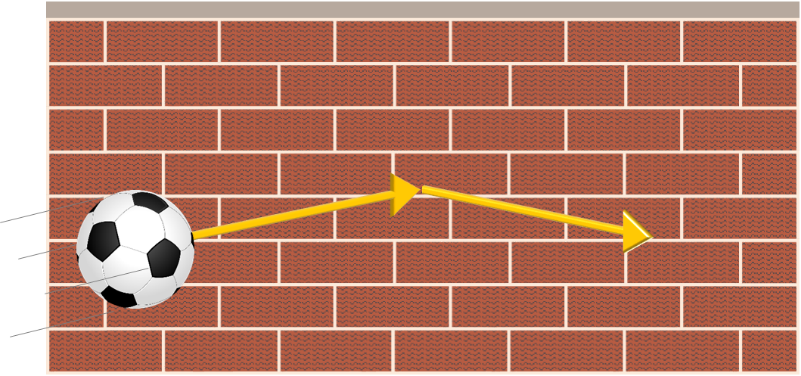
**Wall game**

Lucy kicks a football off a wall.

It bounces off at an angle, but its speed does not change.



Some students are discussing what happens to the momentum of the football when it bounces.

**Olivia:** the ball’s momentum changes in the direction the wall pushes on it.

**Noah:** its direction changes, so its momentum must change as well.

**Lydia:** its momentum doesn’t change because its mass and speed stay the same.

**Mirha:** momentum is a vector.

**Paul:** momentum towards the wall equals momentum away from the wall.

**To answer**

1. Who is right about the momentum of the ball?

* *Explain your answer*

2. Who is wrong about the momentum of the ball?

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

|  |  |
| --- | --- |
| Cards for  **Wall game** | **Lydia:** its momentum doesn’t change because its mass and speed stay the same. |
| **Mirha:** momentum is a vector. | **Noah:** its direction changes, so its momentum must change as well. |
| **Olivia:** the ball’s momentum changes in the direction the wall pushes on it. | **Paul:** momentum towards the wall equals momentum away from the wall. |

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| Cards for  **Wall game** | **Lydia:** its momentum doesn’t change because its mass and speed stay the same. |
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*Physics > Big idea PFM: Forces and motion > Topic PFM6: Forces make things change > Key concept PFM6.3: Changing momentum*

|  |
| --- |
| **Response activity** |
| **Wall game** |

**Overview**

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| --- | --- |
| Learning focus: | In a collision (or any closed system), momentum is conserved and the size of the forces are equal to the rate of change of momentum. |
| Observable learning outcome: | Determine changes in momentum, Δp. |
| Question type: | Talking heads |
| Key words: | Momentum, mass, speed, velocity, vector |

**What does the research say?**

Whilst most students readily accept that both mass and velocity have a direct impact on the damage that a moving object can cause when it collides with other objects, it is common for them to confuse ideas about momentum with ones about energy in a kinetic store (Bryce and MacMillan, 2009). These authors argue that thinking about the conservation of momentum without describing the external forces involved masks the universal applicability of this conservation law. Related to this is the difficulty students often have in defining what is meant by an ‘isolated system’, which may lead some to believe that the momentum of each object in a collision is separately conserved. Bryce and MacMillan (2009) also point out that in most textbooks the scenarios used for momentum calculations are usually friction free, which may leave students wondering about real world applications where objects perceptibly slow down.

Students also find it difficult to separate the concepts of energy in a kinetic store and momentum with respect to their scalar and vector nature, respectively (Singh and Rosengrant, 2003; Bryce and MacMillan, 2009). Students struggle to reason correctly about vector quantities even after studying vectors (Knight, 2004; Flores, Kanim and Kautz, 2004).

Students find questions involving impulse and change in momentum more difficult than the ‘special case’ questions where momentum is conserved (Lawson and McDermott, 1987; Pride, Vokos and McDermott, 1998; Singh and Rosengrant, 2003). In a study of over a thousand undergraduates in the US, only about 5% of students were correctly able to answer a question about momentum change caused by an impulse, regardless of the amount of instruction about the impulse-momentum theorem (Pride et al., 1998).

**Ways to use this question**

This task is intended for discussion in pairs or small groups. It can be done as a pencil and paper exercise or projected onto a screen.

Students should read the statements and follow the instructions on either the worksheet or the PowerPoint. Listening in to the conversations of each group will often give you insights into how your students are thinking. Each member of a group should be able to report back to the class.

Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of the science.

*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 the 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.

NB in any class, small group discussions typically improve over time and a persistence with this strategy is often very successful in the medium to long term.

**Expected answers**

1. Mirha, Noah and Olivia are right about the momentum of the ball.

Momentum is a vector because it is measured in a particular direction. This means that when its direction changes, its value must change as well. In this example, the push of the wall on the ball changes the direction of the ball by pushing it directly away from the wall.

2. Lydia and Paul are wrong about the momentum of the ball.

Lydia is right that the balls mass and speed stay the same, but its direction and therefore its velocity do not. Momentum equals mass times velocity.

Paul is partially right. The size of the momentum towards the wall is equal to the size of the momentum away from the wall, but these are in opposite directions. That means there is a difference in momentum between each situation.

**Acknowledgments**

Developed by Simon Carson (UYSEG) and Peter Fairhurst (UYSEG).

Images: Simon Carson (UYSEG).

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