**Rugby tackle**

One rugby player tackles another.

Before the tackle the players were running towards each other.

The size of momentum of each player was the same.



**a.** How will they move after the tackle?

|  |  |  |
| --- | --- | --- |
| **A** | The player with the ball will be pushed backwards. |  |
|  |  |  |
| **B** | The player who makes the tackle is pushed backwards. |  |
|  |  |  |
| **C** | Neither player is pushed backwards (they both stop). |  |
|  |  |  |
| **D** | The smaller player will be pushed backwards. |  |

**b.** What is the best reason for your last answer?

|  |  |  |
| --- | --- | --- |
| **A** | The bigger player pushes with a bigger force. |  |
|  |  |  |
| **B** | The force on both players is the same size. |  |
|  |  |  |
| **C** | The force is bigger on the player who is tackled. |  |
|  |  |  |
| **D** | It takes time to stop the player with the ball. |  |

*Physics > Big idea PFM: Forces and motion > Topic PFM6: Forces make things change > Key concept PFM6.3: Changing momentum*

|  |
| --- |
| **Diagnostic question** |
| **Rugby tackle** |

**Overview**

|  |  |
| --- | --- |
| 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: | Describe what happens to the motion of objects colliding head on. |
| Question type: | Two-tier multiple choice |
| Key words: | Momentum, mass, velocity |

**What does the research say?**

Students often do not understand Newton’s third law and how it is related to momentum change and the conservation of momentum. Students who do know that forces occur in interaction pairs may not realise that forces are equal in size and act on *different* objects. They may think wrongly that two equal and opposite forces acting on a single object make up an interaction pair.

In a study of 78 high school students in the US, Brown (1989) found many students believed a moving billiard ball would exert a greater force on a stationary ball than the stationary ball would exert on the moving ball in a collision. These students argued that the moving ball ‘had’ more force than the stationary ball. The lack of understanding of forces as interactions ‘sabotages’ students conceptual reasoning and quantitative problem solving (Brown, 1989), and their understanding of momentum and momentum conservation.

**Ways to use this question**

Students should complete the questions 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 follow-on question will give you insights into how they are thinking and highlight specific misconceptions that some may hold.

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**

**a.** C **b.** B

**How to respond - what next?**

When the tackle is made they both experience the same sized force. Their momentums must therefore change by the same amount. Because their momentums are equal in size and opposite in direction they cancel out, their final momentum is zero, and they come to an immediate stop.

*Part a*

Often students use gut feelings to determine answers to questions such as this one. This may lead students to think that the smaller player is always pushed backwards, or that the nature of a tackle determines which one of the players is pushed back.

*Part b*

A Some students might think that the bigger player always pushes with a bigger force because they appear stronger. However, at the point of contact the forces are always equal in size and opposite in direction.

C A few students might think that the player doing the tackling is exerting a bigger force because they are *doing* the tackling on the other player and are applying the force.

D Some students may think that because a collision occurs over a short amount of time that the player with the ball will continue on in the same direction for a short time, which ignores the fact that, by this logic, the other player should also continue to travel forwards too.

If students have misunderstandings about describing what happens when objects collide head on, it can help to demonstrate what happens with dynamics trolleys that are set up to stick together on impact (perhaps with Velcro attached to the front of each one, or magnets).

Careful questioning should also elicit understanding that:

* the force on each player is the same size and in the opposite direction
* the force on each player acts for the same length of time
* the motion of each player is changed by the same amount
* the momentum of each player is changed by the same amount
* there cannot be any momentum ‘left over’ for either player to continue forwards.

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

* Response activity: Crash test

**Acknowledgments**

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Image by christianesteve from Pixabay

**References**

Brown, D. E. (1989). Students' concept of force: the importance of understanding Newton's third law. *Physics Education,* 24(6)**,** 353-358.