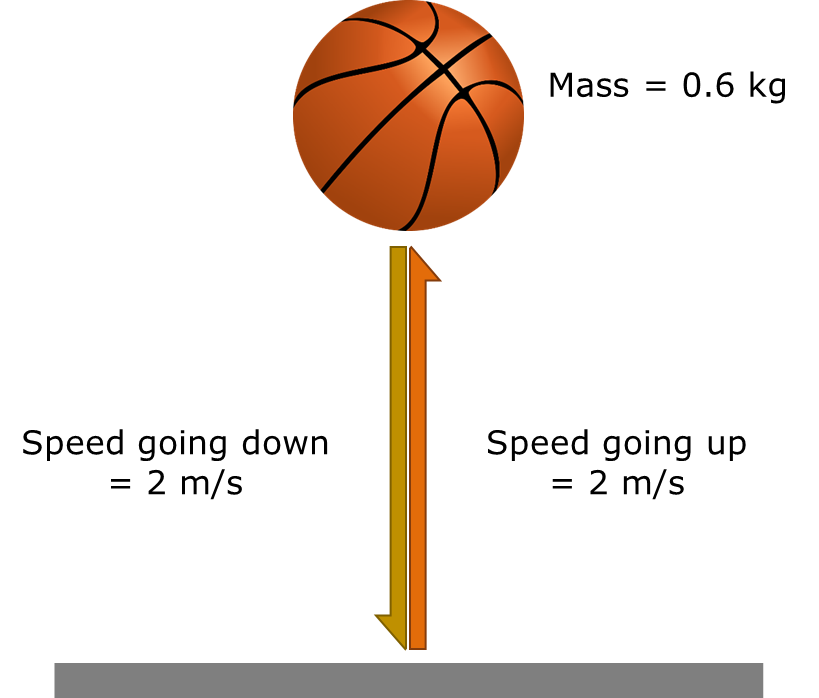
**Bouncing**

A basketball bounces on the ground.



When the ball bounces, how does its momentum change?

*Put a tick (✓) in the box next to the best answer.*

|  |  |  |
| --- | --- | --- |
| **A** | It doesn’t change. |  |
|  |  |  |
| **B** | It changes 1.2 kg m/s downwards. |  |
|  |  |  |
| **C** | It changes 1.2 kg m/s upwards. |  |
|  |  |  |
| **D** | It changes 2.4 kg m/s downwards. |  |
|  |  |  |
| **E** | It changes 2.4 kg m/s upwards. |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Bouncing** |

**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: | Determine changes in momentum, Δp. |
| Question type: | Simple multiple choice |
| Key words: | Momentum, force, (impulse), (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**

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 answer**

E Its momentum changes 2.4 kg m/s upwards.

**How to respond - what next?**

Momentum is a vector, so its direction matters. The change in momentum of the ball is the momentum it has after it has bounced minus the momentum it had before it bounced.

* Its momentum after it bounces, p = 0.6 kg x 2 m/s; p = 1.2 kg m/s upwards.
* Before it bounces its momentum is 1.2 kg m/s downwards, which can also be written as -1.2 kg m/s.
* Change of momentum ∆p = 1.2 kg m/s - (-1.2 kg m/s); ∆p = 2.4 kg m/s.
* In this calculation, the ‘positive’ direction of momentum has been chosen to be upwards, so the ‘positive’ change calculated is in the upwards direction (indicated by it being positive).

*The change in momentum in this example, can also be reasoned to be in an upwards direction because the force of the floor on the ball, that caused its momentum to change, pushes upwards on the ball.*

A Some students may choose option A if they only consider the size (magnitude) of the ball’s momentum.

B, C Students choosing option C have probably calculated the momentum of the ball after it bounces. They may understand that the change is in an upwards direction, or simply have noted that the ball is now travelling upwards. Those choosing option B (or C) may have done the same calculation and have guessed at the direction.

D Some students may have calculated the change of momentum as the starting momentum minus the finishing momentum. This is quite a common mistake when calculating changes.

If students have misunderstandings about determining changes in momentum, Δp, it can help to provide a range of calculations of changes in momentum for them to try. For each answer, they could be given the opportunity work in small groups to explain their reasoning for each of their answers. Calculations should involve choosing a positive direction for momentum, and include opportunites for describing the direction of forces causing changes in momentum.

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

* Response activity: Wall game

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Images: Simon Carson (UYSEG), with basketball by OpenClipart-Vectors from Pixabay.

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