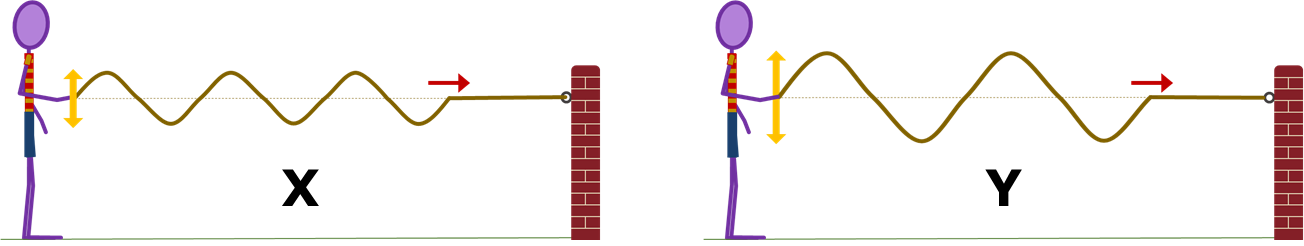
**Two shakes**

Tishana shakes the end of a rope to produce a wave.

She shakes the same rope differently to make another wave.



Which of these two waves has the highest frequency?

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

|  |  |  |
| --- | --- | --- |
| **A** | They both have the same frequency. |  |
|  |  |  |
| **B** | Wave X has the highest frequency. |  |
|  |  |  |
| **C** | Wave Y has the highest frequency. |  |
|  |  |  |
| **D** | It is impossible to tell from the information given. |  |

*Physics > Big idea PSL: Sound, light and waves > Topic PSL5: Measuring waves > Key concept PSL5.2: Speed of waves*

|  |
| --- |
| **Diagnostic question** |
| **Slow motion** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | The speed of a wave is determined by the wave medium in which it moves and can be calculated by multiplying its frequency and wavelength. |
| Observable learning outcome: | Describe how the frequency of a wave moving through a particular medium is related to its wavelength. |
| Question type: | Simple multiple choice |
| Key words: | Frequency, amplitude, wavelength |

**What does the research say?**

The speed of a mechanical wave depends on the properties of the medium it is passing through and is independent of the wave’s frequency or the size of disturbance (amplitude). In a study of (n=598) students aged 15 to 16, Caleon and Subramaniam (2010) found that over 70% held the common misunderstanding that wave speed depends on frequency. Studies by Tongchai et al (2011) of (n=324) senior high school students, Wittmann, Steinberg and Redish (1999) of (n=92) students enrolled onto a university physics course and Tumanggor et al (2020) of trainee physics teachers (n=35) all found similar results.

Caleon and Subramaniam (2010) also found that it is common for students (72% in their study) to consider the terms in the equation for the speed of a wave, v = f x λ, to be three interdependent variables. This is wrong, as the speed, v, of the wave is fixed by the wave medium and is independent of frequency, f, and wavelength, λ. In other words, changes to frequency and wavelength do not affect the speed of a wave.

**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**

B

**How to respond - what next?**

Both waves travel along the rope (the same medium as each other) at the same speed. As both waves have travelled the same distance in the pictures, they must have been created in the same amount of time. There are more wavelengths shown on wave X, showing the rope must have been shaken more rapidly, at a higher frequency, to create it.

C The most common misunderstanding students are likely to have is that shaking the rope more quickly will increase the speed of the wave. This may lead them to think that the wave with the higher frequency is Y, because it is more ‘stretched out’.

D Another misunderstanding that some students have is that increasing the amplitude of a wave speeds it up (or slows it down). Students with this misunderstanding, as well as those who think that frequency alters the speed of a wave, are likely to conclude that there is not enough information from which to determine the frequency of the wave.

A If students think wrongly that amplitude increases the speed of a wave, they may instead deduce that this will spread the wave out as shown, and that both waves have the same frequency.

If students have misunderstandings about how the frequency of a wave moving through a particular medium is related to its wavelength, it is essential to check first that they understand that *all* waves moving through that medium travel at the same speed. Diagnostic questions from earlier in the learning progression for this key concept could be used to do this.

Using the fact that waves of different frequencies travel at the same speed through a common medium, a simple activity can be used to demonstrated the relationship between frequency and wavelength:

One student repeatedly draws a line from side-to-side on a piece of paper whilst a second student pulls the paper along at a steady speed. This should produce a wave pattern. The same process can be repeated with the first student drawing the line at different frequencies, with the second student always pulling the paper at the same speed. The wave patterns produced can be compared.

Careful questioning should elicit understanding that doubling the frequency will halve the wavelength, and vice-versa. Tripling the frequency…, and so on.

To consolidate understanding, students could be asked to explain how different wavelengths of wave are produced.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

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