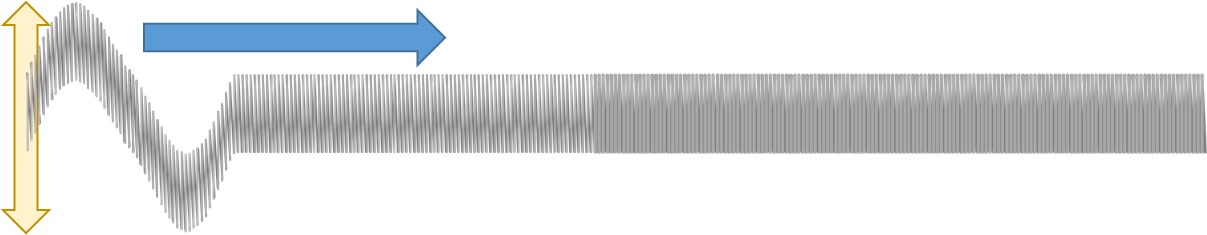
**Slow wave**

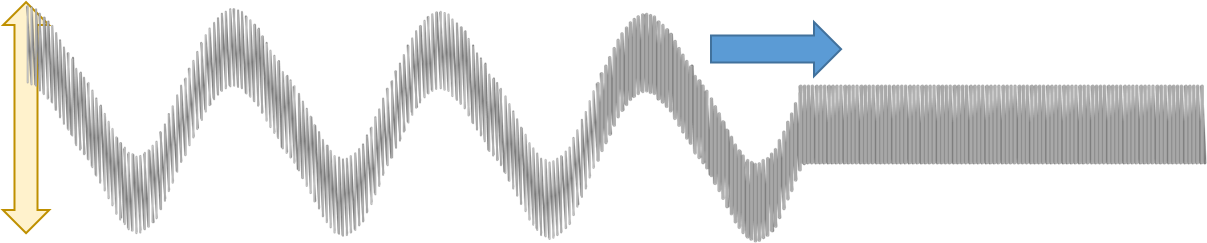
Two slinky springs are joined together.

The second one is made of thicker metal. This makes it heavier.

A wave is made that moves along the springs.



It moves at a slower speed along the second spring.



*Drawings not to scale.*

What happens to the properties of the wave when it slows down?

For each statement, tick (✓) **one** column to show what you think*.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | Its wavelength stays the same. |  |  |  |  |
| **B** | Its frequency stays the same. |  |  |  |  |
| **C** | Its frequency = speed of the wave, divided by the number of waves passing a point in one second. |  |  |  |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Slow wave** |

**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: | Calculate the frequency or wavelength of a wave using v = f x λ. |
| Question type: | Confidence grid |
| Key words: | Frequency, wavelength, wave medium |

**What does the research say?**

Caleon and Subramaniam (2010) 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.

Students often treat the equation v = f x λ as a mathematical formulation without (necessarily) reference to the physics. For this reason, Caleon and Subramaniam suggest that an understanding that wave speed is determined solely by the properties of the medium, namely its elastic and inertial properties, is developed and consolidated before introducing v = f x λ. This is a focus of the BEST topic: PSL4 Waves.

To help consolidate understanding that the speed of a wave is independent of frequency and wavelength, Caleon and Subramaniam (2010) suggest developing a qualitative understanding of the equation v = f x λ first, before using it to calculate quantitative values. This approach supports students in understanding the physical meaning of each term and the relationships between them. It also helps move the analysis of a problem beyond a ‘brittle rote procedure’ and can promote insights that may simplify some more challenging problems (Redish and Kuo, 2015).

Rearranging formulae is something that students can often find challenging (Boohan, 2016). The difficulty in students being able to use maths in physics may be that they can’t do the maths, but it could also be to do with students struggling with the way symbols in equations are used to make meaning differently in maths and physics (Redish and Kuo, 2015).

**Ways to use this question**

Students should complete the confidence grid 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.

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**

Statement B is right; and statements A and C are wrong.

**How to respond - what next?**

The key to this question is understanding that speed is determined solely by the wave medium and that in the equation v = f x λ, v is a constant (for each particular wave medium). The challenge here, for students, is in working through the physical processes of cause and effect, in order to understand how a changing speed affects the wavelength and frequency of a wave.

As can be seen in the pictures, the second spring is physically connected to the first one and so both must be vibrating at exactly the same rate. However, because the wave in the second spring is travelling more slowly than in the first, the wave front in the second spring will not have travelled so far before the start of each successive vibration. This means that the wavelength of the wave in the second spring is shorter than it is in the first.

A Although it is stated on the drawings of the springs that they are not to scale, a number of students may decide statement A is correct, because this is what the picture depicts, without thinking through the physics involved.

B It is common for students to wrongly think that the speed of a wave depends on the frequency of the wave and so it is likely that a number will think that statement B is wrong.

C Students who decide the third statement is correct are unlikely to have thought through the physics of what they are reading. The statement is designed to *sound* plausible, but requires careful reflection. The ‘number of waves passing a point in one second’ is a definition of the frequency of a wave.

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

To develop and to consolidate understanding, it can help to ask students to work in pairs or small groups to define each term in the equation v = f x λ and to explain what causes each to have the value that it does. Answers should reveal that speed, v, is determined by the wave medium; frequency, f, by the rate of vibration that creates the wave; and wavelength, λ, by a combination of the wave speed and frequency of vibration.

It can be revealing to ask students to compare each of the following statements and comment about which one more accurately describes the physics of a wave:

* ‘wave speed is equal to wavelength multiplied by frequency’ and
* ‘wave speed is found by multiplying wavelength by frequency.’

Students could also be challenged to formulate their own statements about v = f x λ that more fully describe the physics of a wave – perhaps along the lines of: ‘the unchanging speed of a wave in a particular wave medium can be found by multiplying the measured wavelength of a wave in that medium by the measured frequency of the same wave.’

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

* Response activity: Measuring wave frequency

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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