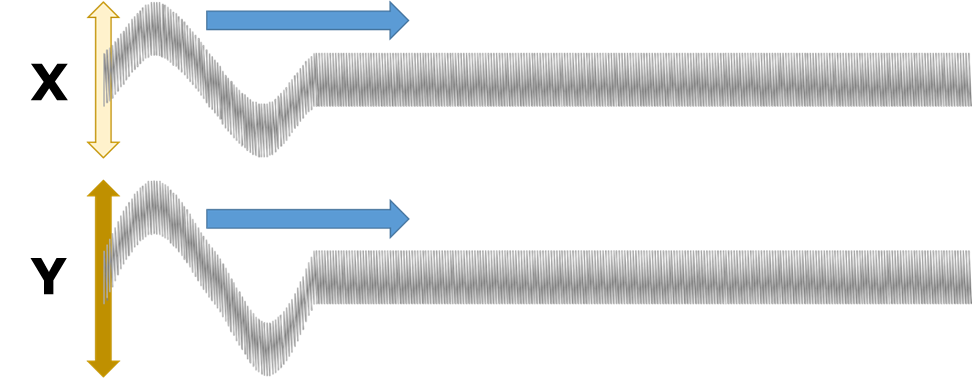
**Faster spring waves**

A wave can be made on a slinky spring by shaking it side-to-side.

Bigger waves are made by moving it a bigger distance to the side.



**1a.** Which wave moves faster along the slinky?

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

|  |  |  |
| --- | --- | --- |
| **A** | Wave **X** moves faster. |  |
|  |  |  |
| **B** | Wave **Y** moves faster. |  |
|  |  |  |
| **C** | Both waves move at the same speed. |  |

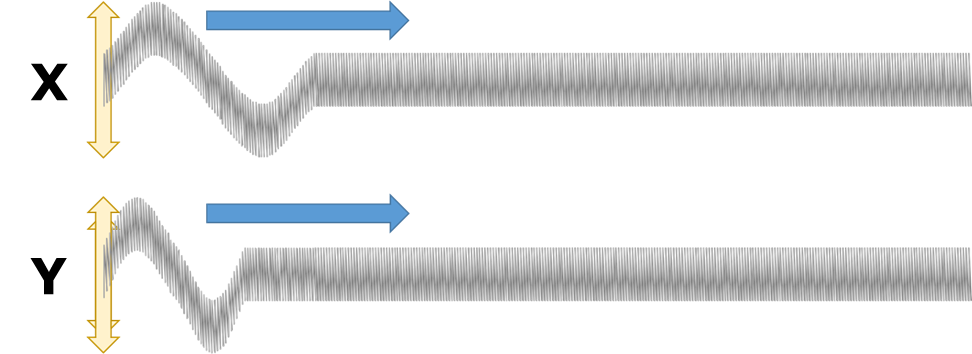
**1b.** What is the best reason for your last answer?

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

|  |  |  |
| --- | --- | --- |
| **A** | Both waves move along the same slinky. |  |
|  |  |  |
| **B** | It has more energy. |  |
|  |  |  |
| **C** | It has more force. |  |
|  |  |  |
| **D** | Less slinky needs to be moved. |  |

A wave can be made on a slinky spring by shaking it side-to-side.

Shaking it quickly makes waves with a shorter wavelength.



**2a.** Which wave moves faster along the slinky?

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

|  |  |  |
| --- | --- | --- |
| **A** | Wave **X** moves faster. |  |
|  |  |  |
| **B** | Wave **Y** moves faster. |  |
|  |  |  |
| **C** | Both waves move at the same speed. |  |

**2b.** What is the best reason for your last answer?

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

|  |  |  |
| --- | --- | --- |
| **A** | Both waves move along the same slinky. |  |
|  |  |  |
| **B** | It has more energy. |  |
|  |  |  |
| **C** | It has more force. |  |
|  |  |  |
| **D** | Less slinky needs to be moved. |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Faster spring waves** |

**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 speed of a wave can, and cannot, be changed. |
| Question type: | Two-tier multiple choice |
| Key words: | Wave, transverse wave, amplitude, wavelength, frequency |

|  |  |
| --- | --- |
| **P** | **PRIOR UNDERSTANDING**  This diagnostic question probes understanding of ideas that are usually taught at age 11-14, to aid transition from earlier stages of learning. |

**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.

In these studies (Caleon and Subramaniam, 2010; Tongchai et al., 2011; Wittmann et al., 1999), some students thought that bigger amplitudes sped up waves because the waves had more energy or more force, and others that they slowed down because it took longer for the wave to move up and down. Some thought that a smaller amplitude sped up the wave because smaller pulses slipped more easily through the wave medium.

**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**

1a. C 1b. A

2a. C 2b. A

**How to respond - what next?**

The speed of a wave through a particular wave medium is constant. It does not change if the wave has either bigger amplitude, or a shorter wavelength. A large proportion of students are likely to disagree with this.

Many students are likely to think that a wave with a bigger amplitude moves more quickly because it requires more force to set it going, and a bigger force gives a bigger acceleration. However, the force applied to give a bigger amplitude is not in the direction the wave is moving in, so it cannot affect the forward acceleration of the wave.

Many students are also likely to think that a wave with a shorter wavelength moves more quickly because it is set going with a faster vibration. Once again, the forces vibrating the slinky are not in the direction of the wave.

A few students may think that the wave with a smaller amplitude moves more quickly because it creates a smaller disturbance of the slinky. They may think there is less resistance to the wave’s forward movement.

If students have misunderstandings about what can, and cannot, affect the speed of a wave, it can help to measure the speed of real waves in order to challenge these misunderstandings.

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

* Response activity: Measuring spring waves
* Response activity: Measuring wave speed

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Caleon, I. S. and Subramaniam, R. (2010). So Students Know What They Know and What They Don't Know? Using a Four-Tier Diagnostic Test to Assess the Nature of Students' Alternative Conceptions. *Research in Science Education,* 40 (3)**,** 313-337.

Tongchai, A., et al. (2011). Consistency of students' conceptions of wave propogation: Findings from a conceptual survey in mechanical waves. *Physical Review Special Topics Physics Education Research,* 7(2)**,** 11.

Tumanggor, A. M. R., et al. (2020) Published. Using four-tier diagnostic test instruments to detect physics teacher candidates’ misconceptions: Case of mechanical wave concepts. The 5th International Seminar on Science Education, 2019 Yogyakarta, Indonesia Journal of Physics: Conference Series, Institute of Physics.

Wittmann, M. C., Steinberg, R. N. and Redish, E. F. (1999). Making Sense of How Students Make Sense of Mechanical Waves. *The Physics Teacher,* 37**,** 15-21.