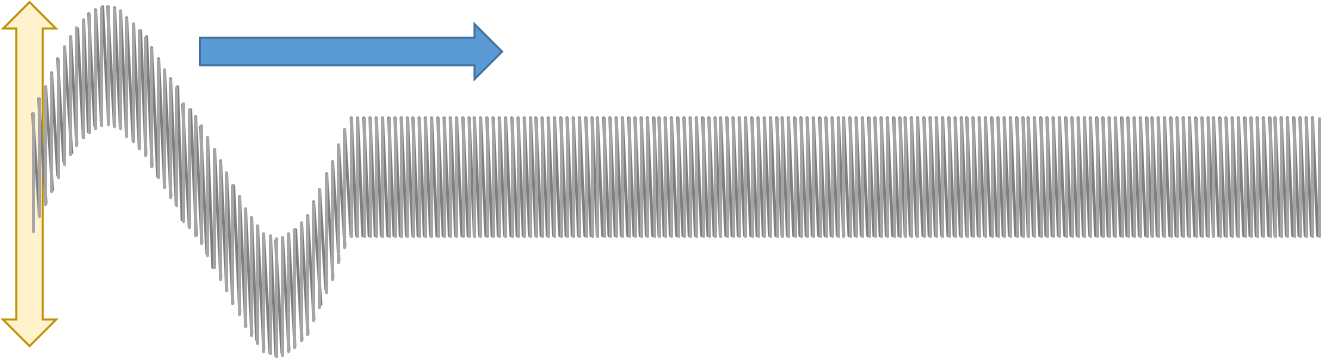
**Measuring spring waves**

Some students observe the speed of a wave pulse moving from one end of a slinky to the other end.

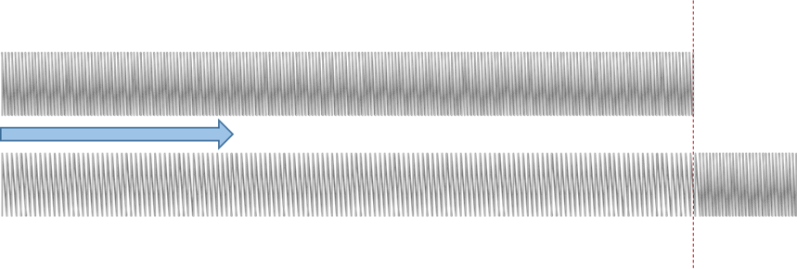


**Predict**

How will stretching the spring affect the speed of a wave along the spring?

**Explain**

Why do you think the wave will move with this speed along the stretched spring?

****

|  |
| --- |
| **Observe a wave moving along a slinky spring and then a wave moving along a stretched slinky spring.** |

**Observe**

The speed of each wave, one compared to the other.

**Explain**

Were your prediction and explanation correct?

Try to improve your first explanation to explain what happens more clearly.

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

|  |
| --- |
| **Response activity** |
| **Measuring 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: | Measure the speed of a wave using v = s/t.  Describe how the speed of a wave can, and cannot, be changed. |
| Activity type: | Predict, explain; observe, explain (PEOE) |
| Key words: | Wave medium, transverse wave, amplitude, wavelength, frequency |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic questions:

* Diagnostic question: Slow motion
* Diagnostic question: Faster spring waves
* Diagnostic question: Spring waves

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

**What does the research say?**

When talking about speed the language that we use is important as what is clear to us may be easily misunderstood by students. Constant speed may be seen as ‘moving all the time’ and steady speed may be taken as ‘not too fast’. Going faster is often seen as ‘catching up’ and when one object overtakes another they are often described as having the same speed at the point of overtaking (Driver et al., 1994b). Making sure that students have a clear qualitative understanding of speed is necessary before introducing quantitative approaches (Driver et al., 1994a).

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 activity**

Students should complete this activity in pairs or small groups, and the focus should be on the discussions. It is through the discussions that students can check their understanding and rehearse their explanations.

To begin, each group should discuss the activity and use their scientific understanding, firstly to predict *what* they think will happen, and then to explain *why* they think they are going to be right. If students in any group cannot agree, you may be able to direct them with some careful questioning.

Students now watch a demonstration.

* Show students how quickly a wave travels along a slinky stretched loosely along the top of a lab bench.
* Gather up the far end of the slinky in order to stretch the spring further, but retain the same overall length (this can be marked on the bench).
* Allow one or more students to examine and describe the differences between the stretched and ‘unstretched’ slinky spring.
* Elicit views from the class on how these differences might affect the speed of the wave.
* Show students how quickly a wave, created identically to the first, travels along the stretched slinky.

After the practical each group should be given the opportunity to change, or improve their explanation. A good way to review your students’ thinking might be through a structured class discussion. You could ask several groups for their *explanations* and put these on the whiteboard. Then ask other groups to suggest which explanation is the most accurate and the most clearly expressed, and through careful questioning work up a clear ‘class explanation’.

A useful follow up is for individual students to then write down explanations in their own words – without reference to the class explanation on the board (i.e. cover it up).

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in each group. For example, you may choose to select a student with strong prior knowledge as a scribe, and forbid them from contributing any of their own answers. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

**Equipment**

For the class:

* Slinky spring

**Health and safety**

Practical work should be carried out in accordance with local health and safety requirements, guidance from manufacturers and suppliers, and guidance available from CLEAPSS.

**Expected answers**

The wave travels more quickly along the stretched slinky.

Stretching the slinky spring increases tension between each turn of the coil, which adds to the restorative elastic forces between turns if any are moved out of position. The increased force between turns as a wave pulse passes, increases the rate at which each turn changes its side-to-side motion, and so the pulse is passed more quickly from turn to turn.

Another factor that affects the speed of a wave along a spring, but a less significant one here, is the mass of the spring. More mass per metre of length reduces the rate of change of the side-to-side motion and the speed of the wave is slower. A stretched spring has a reduced mass per metre and the wave speed is increased slightly.

**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.

Driver, R., et al. (1994a). *Making Sense of Secondary Science: Research into Children's Ideas,* London, UK: Routledge.

Driver, R., et al. (1994b). *Making Sense of Secondary Science: Support Materials for Teachers,* London: Routledge.

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.