**Measuring waves speed**

The water is the medium the wave travels through.

**Does the depth of water affect the speed of a water wave?**

Speed can be calculated from measurements of distance and time.

**=**

**distance**

**time**

**speed**

How can distance, time (and the depth of water) be measured accurately?

**Safety**

Water spills can make the floor slippery and should be wiped up immediately.

**Apparatus**

* Plastic tray
* Timer
* Ruler
* Beaker (1 litre)
* Mobile phone with slow motion video capability

**Procedure**

1. Add 2 litres of water to the plastic tray and measure its depth.
2. Lift up one end of the tray a few centimetres and drop it.

*Rehearse dropping the end of the tray to make a well-defined wave every time. The wave should travel up and down the tray several times.*

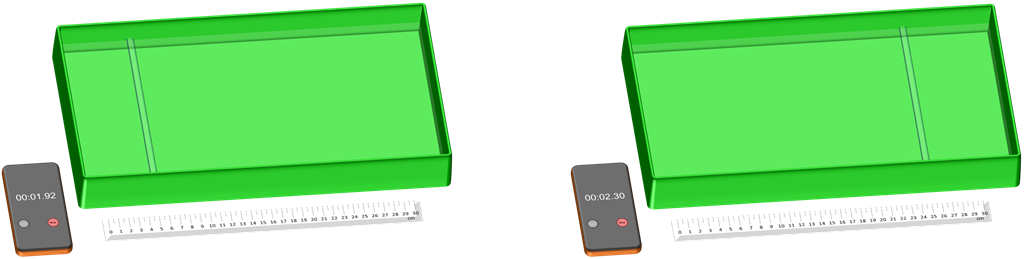


1. Measure the time for the wave to travel a distance.
2. Take three measurements of time and distance for each depth.
3. Add water to get a good range of depths.
4. Use the results to calculate the speed of the wave in each depth.

**Measurement strategies**

1. Use a timer to measure how long the wave takes to travel two (or three) lengths of the tray.
2. Make a slow-motion video of the wave moving along the ruler.

Play back and pause the video to take measurements of distance and time.



**Results**

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| --- | --- | --- | --- |
| **depth** | **distance / cm** | **time / s** | **speed / cm/s** |
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**To answer**

1. How does the depth of water affect the speed of a wave?
2. How did you improve on the method that was given? *Explain your answer.*
3. How could you improve the method further? *Explain your answer.*

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

|  |
| --- |
| **Response activity** |
| **Measuring wave speed** |

**Overview**

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| --- | --- |
| 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: | Application and practice - practical |
| Key words: | 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**

This practical activity gives students the opportunity to practise applying their understanding and to clarify their thinking through discussion. To support this, students should complete the practical in pairs or small groups.

Listening to individual groups as they work often highlights any difficulties they might have. These can often be overcome, through a whole class clarification or redirection part way through the activity.

Asking students to report their findings at end of the practical work is a useful check. After a group has fed back, it might be helpful to model an even better answer. You could do this, for example, by asking another group to add to, or clarify, the first observation. Then ask another group to sum up the important part of the observation, and so on.

*Differentiation*

Providing suitable recording sheets can help some students organise their observations so they can more easily focus on the science. If some students are working with a teaching assistant, then a list of prompt questions for the TA could help to make this activity more purposeful. Some students may benefit from being challenged to plan and organise their own record keeping.

**Equipment**

For each student/pair/group:

* Plastic tray
* Timer
* Ruler
* Beaker (1 litre)
* Mobile phone with slow motion video capability

For the class:

* Cloths or paper towels for clearing up spillages of water.

**Technician notes**

This investigation works best with trays that have flat end profiles and a depth of over five centimetres.

It will be helpful to test the height from which one end of each tray should be dropped to produce a good wave, in order to advise those carrying out the investigation.

**Health and safety**

Some water is likely to be spilled during this investigation and will need to be wiped up immediately to avoid slippery surfaces.

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**

1. The deeper the water, the faster the wave.
2. These might include:
   * strategies for improving manual timing technique which might include: not starting timing immediately, but waiting until the wave has reflected off one end of the tray; or measuring the time for the wave to cover several lengths of the tray to reduce the percentage error in the measurement
   * and strategies for measuring the depth of water accurately, perhaps using a dipstick and measuring that against a ruler.
3. These might include:
   * strategies for increasing the distance measured to reduce errors, by perhaps having a longer container
   * and strategies for creating a wave with less disturbance of the water as a whole, perhaps using a suitably shaped dipper.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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