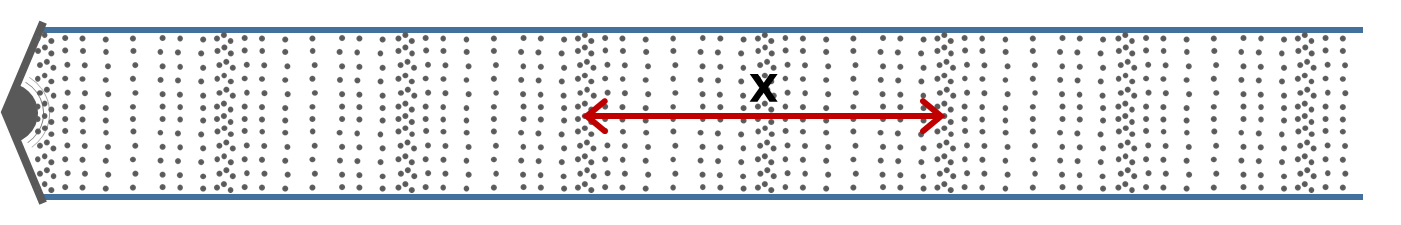
**Longitudinal measurements**

Particles in air move very, very quickly in all directions.

They are bouncing off each other all the time.

A loud speaker adds an extra movement.

The extra movement forms a sound wave.



*N.B. In the air, there are many millions of times more*

*particles than those shown in this diagram.*

What is the amplitude and wavelength of this wave?

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** | Amplitude is equal to the distance X. |  |  |  |  |
| **B** | Wavelength is equal to the distance the loudspeaker moves in and out. |  |  |  |  |
| **C** | Wavelength is equal to the distance X. |  |  |  |  |

***The symbol for wavelength is the Greek letter lambda: λ***

*Physics > Big idea PSL: Sound, light and waves > Topic PSL5: Measuring waves > Key concept PSL5.1: Visualising waves*

|  |
| --- |
| **Diagnostic question** |
| **Longitudinal measurements** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | The motion of particles in a wave can be represented by a displacement-distance or a displacement-time graph, from which the wave’s amplitude and wavelength or time period can be found. |
| Observable learning outcome: | Identify wavelength and amplitude on pictures of longitudinal waves. |
| Question type: | Confidence grid |
| Key words: | Wavelength, amplitude, longitudinal wave |

**What does the research say?**

About two thirds of students age 15 and 16 in Caleon and Subramaniam’s study (2010) struggled to identify the wavelength of a longitudinal wave from a picture or description of its particles. They did not have any significant misunderstandings, but were unsure of how particle positions in a longitudinal wave related to wavelength. This may be because they are trying to make direct connections with the wavelength shown in the wave picture of a transverse wave. Tumanggor et al. (2019) found that about half of trainee physics teachers (n=35) had a similar uncertainty.

**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 C is right and statements A and B are wrong.

**How to respond - what next?**

Air particles move in random directions at a mean speed of several hundred metres per second and experience many collisions each second. The movement of particles caused by a sound wave adds to this motion. The extra vibration of each air particle caused by the soundwave is typically much smaller than the wavelength of the sound.

A Amplitude is the maximum displacement of each particle from its ‘undisturbed’ position and is typically a much shorter distance than X.

B The loudspeaker repeatedly pushes air particles forwards, and as it moves backwards the void it leaves is quickly filled. The loudspeaker adds the extra forward and backward movement to the air particles.

Some students may think that particles pushed forward by the loudspeaker move forward and are squashed into the next wave front (compression). In fact, there is a long chain of collisions between the particles hit by the speaker and those in the first compression. The distance the loudspeaker moves in and out is more closely related to the amplitude. For a particular frequency, the greater the distance the loudspeaker moves, the greater the force it exerts on air particles.

A few students may think that air particles move forward with the wave.

C The distance X is equal to the wavelength.

The extra backward and forward motion of the air particles in a sound wave cause a repeating pattern of compressions and rarefactions (in which particles are more spread out). In the centre of each compression or rarefaction, the air particles are in their ‘undisturbed’ positions. The particles to the left of a compression are on average displaced to the right, and those to the right of a compression are displaced to the left.

On average, the particles in two consecutive compressions, or at any pair of equivalent points between consecutive compressions, are moving in the same way. The distance each pair of equivalent points between consecutive compressions is one wavelength.

If students have difficulty identifying wavelength and amplitude on pictures of longitudinal waves, it may be necessary to first review their understanding of the motion of particles in a longitudinal wave (perhaps using resources from the BEST key concept: PSL4.2 A wave model of sound).

Developing an understanding of how the motion of particles in a longitudinal wave combine to form compressions and rarefactions is challenging. The following BEST ‘response activity’ supports the development and consolidation of this understanding and could be used in follow-up to this diagnostic question:

* Response activity: Explaining longitudinal waves

**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), pp. 313-337.

Tumanggor, A. M. R., Supahar, Kuswanto, H. and Ringo, E. S. (2019) 'Using four-tier diagnostic test instruments to detect physics teacher candidates’ misconceptions: Case of mechanical wave concepts'. *The 5th International Seminar on Science Education*, Yogyakarta, Indonesia Journal of Physics: Conference Series,  Institute of Physics.