Waves: modelling P and S waves on a slinky spring

Key stage 4/5

The scenario

In order for scientists to locate a crater on Mars using seismometers, they need to understand the properties of the two types of wave that they will observe on the accelerometer trace. This demonstration allows students to understand the basic properties of waves, and using images of the waves produced, analyse different waves.

The activity

What is a wave? Ask students to give a definition of what they think a wave is. They may physically wave, they may do a Mexican wave. They may say it's a way of transferring energy. However the key point is that a wave is a method of transferring energy without transferring matter.

By far the easiest way to demonstrate longitudinal and transverse waves is with the use of a slinky spring.

Select a volunteer from the class and ask them to hold one end of the spring. Move apart so that the spring is stretched out on the floor.

Attach a piece of coloured tape to the top of one of the coils to allow you to easily observe the movement of that single coil.

Demonstrating a longitudinal (P) wave: You are now going to demonstrate a longitudinal, or a push-pull wave. Pull a couple of the coils nearest to you towards you, compressing them. When you release them they relax, moving apart and compressing the coils ahead of them. As these relax they compress the coils ahead of them and so on. The movement of the coils is signifying the movement of the particles in a longitudinal wave.

Now repeat this, but get students to look at the piece of coloured tape. They should notice that it oscillates backwards and forwards around a point, but the coil itself does not permanently move from its position. The wave has travelled through the slinky, transferring energy, but no single coil has permanently changed its position.

Ask students to give an example of a transverse wave e.g. sound. Note that transverse waves require a medium to travel through.

Observing wavelength and amplitude

Take a picture of the wave as it progresses through the slinky. Can students work out what wavelength will be on this image?

(One wavelength is the distance between the centre of a compression to the centre of the next compression).

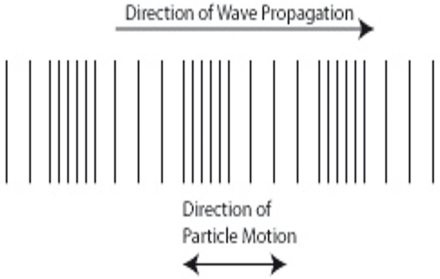
Learning objectives

- definition and properties of transverse and longitudinal waves
- what do we mean by a wave?
- definition of wavelength, amplitude and frequency

Equipment needed

- slinky spring
- piece of coloured tape
- camera
- stopwatch

Slinky springs are a useful tool to demonstrate longitudinal and transverse waves.



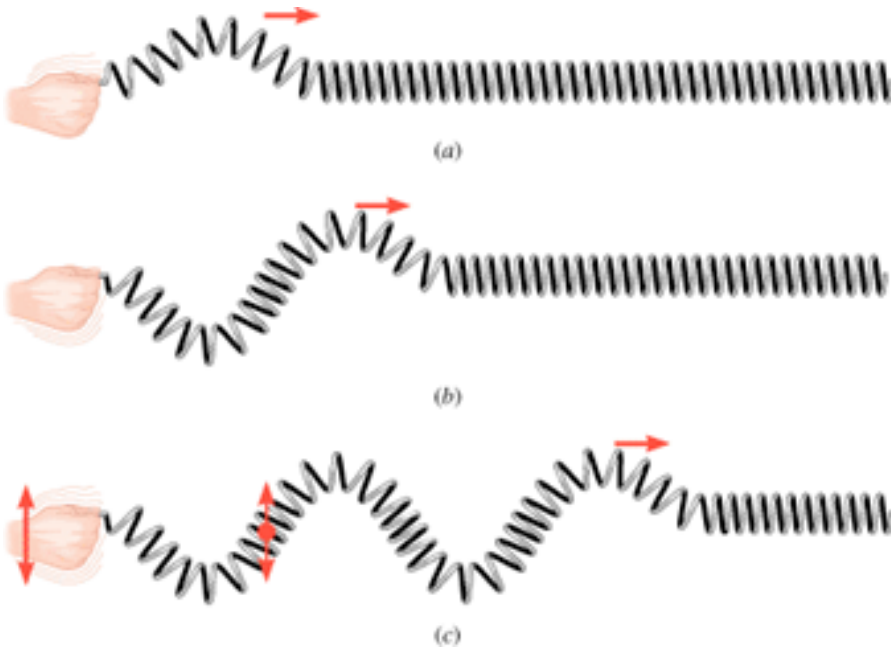
A longitudinal wave is made up of compressions, where particles are close together and rarefactions, where particles are spread out. The particles move in a direction that is parallel to the direction of wave propagation.

MarsQuake

Demonstrating transverse (S) waves: You will now use the same set up to demonstrate a transverse wave – one where the oscillation of the particles is perpendicular to the direction of propagation (advancement) of the wave. Move your hand side to side once, allowing a wave pulse to travel down the slinky. Again get students to identify what the motion of the tape is. This time is oscillates up and down, while the wave travels along the spring. Show students that if you continue oscillating, you can set up a standing wave.

In groups, students can now set up their own standing waves. Get them to increase the frequency of the wave by oscillating their hand faster. Can students work out the relationship between frequency and wavelength? At this point you can introduce them to the wave equation:

In transverse waves, the particles oscillate in a plane perpendicular to the direction of propagation of the wave. While most transverse waves require a medium to travel through, some such as electromagnetic waves (light waves) do not. In an electromagnetic wave, it is the electric and magnetic fields that are 'oscillating'.



$$v \text{ (speed of wave)} = f \text{ (frequency)} \times \lambda \text{ (wavelength)}$$

Measuring wavelength and amplitude

Take a picture of the wave as it progresses through the slinky. Can students label the wavelength and amplitude of this wave?