teacher guide

Mechanical waves 2: Wave properties

Components

	NAME	TYPE	AUDIENCE
	Wave properties teacher guide	This provides teachers with suggestions on how to use the learning object in this resource.	teachers
	Wave properties explorer learning object	Students interact with a variety of waves to understand their properties.	teachers students
	Waves worksheet	This worksheet contains questions that involve concepts of wave type, amplitude, frequency and interference.	students

Purpose

To **Explain** characteristics and properties of mechanical waves.

Outcomes

Students:

- describe movement of particles in transverse and longitudinal waves;
- explain the meaning of amplitude, wavelength, frequency, speed and period of mechanical waves;
- describe relationships between speed, wavelength and frequency, and between frequency and period of waves; and
- explain interference caused by interacting waves.

Activity summary

ACTIVITY	POSSIBLE STRATEGY
Students explore the interactive program, *Wave properties explorer*, guided by the worksheet, *Waves*.	individually or pairs
Discussion of worksheet questions and additional questions such as: • Is a 'Mexican' wave really a wave? • In what ways has a wave been represented? (visual, descriptive, graphical)	teacher-led whole group

Technical requirements

The learning object requires Adobe Flash Player version 8 or later (this is a free download from www.adobe.com). It can be placed on a web or file-server and run either locally or remotely in a web browser.

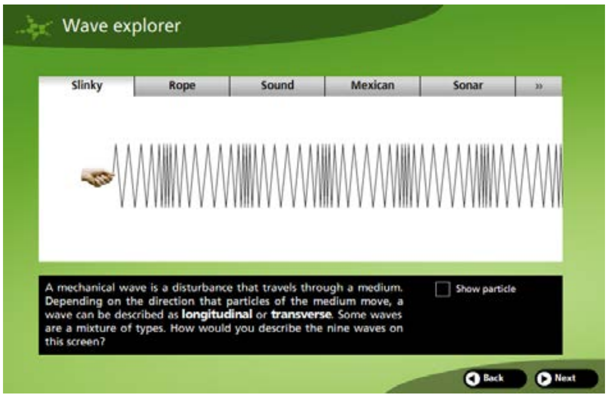
The teacher guide and worksheet require Adobe Reader (version 5 or later), which is a free download from www.adobe.com. The worksheet is also provided in Microsoft Word format.

The learning object *Wave properties explorer* shows examples of wave motion. It provides a tool to investigate fundamental properties of mechanical waves including amplitude, wavelength, frequency and speed.

Wave properties explorer

A mechanical wave consists of a progressive disturbance, started by an input of energy, that transfers energy from point to point through a medium, without net movement of the medium itself.

Mechanical waves can be transverse or longitudinal. Longitudinal waves cause the medium to vibrate in the same direction that the wave travels. Transverse waves cause the medium to vibrate at a 90° angle to the direction in which the wave travels.



Wave explorer screen

The first simulation screen displays animations of nine different mechanical waves. It provides an opportunity to explore differences between longitudinal and transverse waves. Use tabs above the animation to cycle through various animations. There is an option to display a selected 'particle' in order to focus on the nature of its movement in each example.

Slinky

A slinky wave is a longitudinal wave – the medium in which the wave travels (the slinky spring itself) vibrates back and forth in the direction of the wave. Although the slinky appears to be moving from left to right, selecting **Show particle** clearly shows that coils of the spring move back and forth. Longitudinal waves are characterised by alternating zones of compression (particles closer together) and rarefaction (particles further apart).

A slinky spring can also be used to make transverse waves by stretching it along a bench and moving it from side to side (instead of back and forth).

Rope wave

A rope wave is a transverse wave. The rope itself is the medium through which the wave travels, and particles of rope move back and forth at right angles to the direction the wave travels.

Sound wave

Sound waves are longitudinal as air molecules vibrate in the direction the sound wave travels. The distance they move is very small: for normal conversational speech, three metres from a speaker, air molecules move about 20 nm.

'Mexican' wave

Although it shows motion like that of a transverse wave it is not technically a wave since there is no transfer of energy.

Sonar wave

This is another longitudinal wave. Although water particles are move in different directions (some left to right and some up and down in the animation) all move in the direction a wave travels as it propagates radially from a source.

Water wave

A water wave is neither longitudinal nor transverse: it is an example of a class of wave called surface waves. These travel along the interface between two media, in this case water and air. The wave is confined to the surface of the water and has no effect beyond some depth in the water. Select **Show particle** to see that water particles move in a circular pattern (a rolling movement).

While water waves are a surface wave, a tsunami wave involves the entire water column. This helps explain the large energy difference between water waves and tsunamis.

Earthquake primary wave

An earthquake generates several different types of mechanical waves. P-waves are compression waves (longitudinal) and travel the fastest (between 1.5 and 8 km s^{-1} – the slower value when travelling through water, the higher value deep in the Earth).

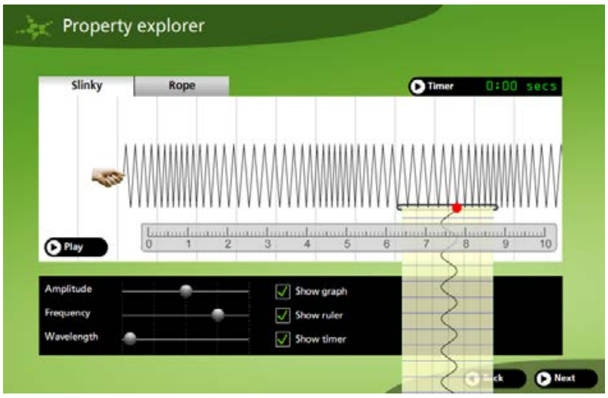
Earthquake secondary wave

S-waves are shear waves (transverse) and are slower and more destructive than P-waves. The difference in speed between both waves allows seismologists to estimate distances between an earthquake epicentre and a recording station.

Rayleigh wave (surface wave)

A Rayleigh wave is another wave generated by earthquakes that combines elements of longitudinal and transverse motion. Like water waves it is a surface wave. It propagates along the ground surface. As in water waves, particles at the surface move in a circular pattern, however the motion is retrograde (anti-clockwise in the animation) whereas motion in water waves is prograde (clockwise in the animation). Motion in a Rayleigh wave changes direction at depth, from retrograde to prograde.

Rayleigh waves are the slowest of earthquake waves, however they are amongst the most destructive. Because they propagate in two dimensions (across the surface) rather than three dimensions (through the volume of the Earth in the case of P- and S-waves) they dissipate much more slowly so they can carry a greater amount of energy further.



Property explorer screen

Students use the second screen in the animation to make a detailed investigation of three properties of mechanical waves: amplitude, frequency and wavelength.

Each can be varied for two principal wave types: a slinky spring (longitudinal wave); and a rope wave (transverse wave). The speed of the wave is constant, so varying frequency affects wavelength and vice versa according to the equation $v = f \times \lambda$ (speed = frequency multiplied by wavelength).

Controls are included to display a graph of particle motion, a moveable ruler and a timer. Using these tools, students may determine other properties such as motion period and wave speed.

Amplitude

Adjusting the **amplitude slider** changes the amount the hand generating the waves moves. Rope wave amplitude can be easily determined on screen by measuring the distance between top and bottom of wave crests. Measure the slinky wave amplitude by selecting the **Show graph** checkbox. Changing amplitude has no effect on wavelength, period, frequency or speed of a wave. Large amplitude waves carry more energy (eg a big water wave or a loud sound).

Frequency

Moving the **frequency slider** changes the rate the hand moves up and down or back and forth. Use the **Timer** to determine frequency by counting how many waves pass a fixed point in a unit of time. Frequency can be varied between 0.25 Hz and 1.25 Hz (slinky wave) and 0.5 Hz and 2.5 Hz (rope wave). Wavelength automatically adjusts as frequency is changed in order to keep speed constant.

Wavelength

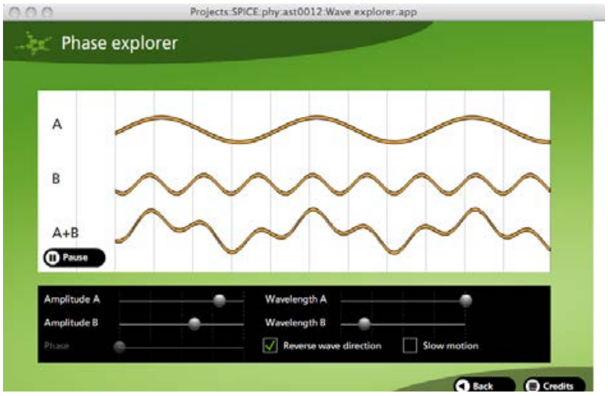
Moving the **wavelength slider** changes the wavelength. The **Ruler** can be used to determine wavelength, which varies between 8 and 1.6 units (slinky wave) and 2 and 0.4 units (rope wave). Frequency automatically varies as wavelength is adjusted in order to keep speed constant.

Speed

Speed may be calculated using the **Ruler** and **Timer**. For the slinky spring it should be 2 units s^{-1} and for the rope wave 1 unit s^{-1}.

Period

Period of the wave may be measured using the **Timer**. It's the time taken for one complete wave to pass any given reference point. The period is calculated as 1/*f* (reciprocal of the frequency).



Phase explorer screen

The third simulation screen may be used to investigate how waves combine. Two transverse waves (**A** and **B**) are shown, together with the result of adding the waves together (**A** + **B**).

Amplitude and wavelength of the two source waves may be independently varied using sliders for each. Phase difference between waves may also be adjusted so that waves are in phase or out of phase.

Select **Reverse wave direction** to reverse the direction of one wave. With this setting standing waves can be generated.

Associated SPICE resources

Mechanical waves 2: Wave properties may be used in conjunction with related SPICE resources to address the broader topic of mechanical waves.

DESCRIPTION	LEARNING PURPOSE
Mechanical waves This learning pathway shows how a number of SPICE resources may be combined to teach the topic of mechanical waves.	
Mechanical waves 1: The physics of tsunamis Video and a fact sheet compare surface waves with tsunami waves.	Engage
The sequence overview in *Mechanical waves* contains suggested **Explore** activities suitable for use at this point.	Explore
Mechanical waves 2: Wave properties This resource includes a learning object (in which students interact with a variety of waves to understand their properties), and associated student worksheets.	Explain
Mechanical waves 3: Graphing waves These student worksheets describe experiments with longitudinal waves.	Elaborate
Mechanical waves 4: Tsunami problems These student worksheets cover a range of problems concerning the physics of tsunamis and other waves.	Elaborate
The sequence overview in *Mechanical waves* contains suggested **Explore/Explain** activities suitable for use at this point.	Explore/Explain
Mechanical waves 5: The physics of whale stranding An interview with physicist Dr Ralph James illustrates how his research into microwaves led him to develop and test a theory to explain whale beaching.	Elaborate

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Web: spice.wa.edu.au
Email: spice@uwa.edu.au
Phone: (08) 6488 3917

Centre for Learning Technology (M016)
The University of Western Australia
35 Stirling Highway
Crawley WA 6009