

Longitudinal against transverse waves: the table, the diagrams and the examples

A wave carries energy without carrying the material; the material only oscillates. Transverse: oscillation at right angles to the direction of travel (crests and troughs). Longitudinal: oscillation along the direction of travel (compressions and rarefactions). Light is transverse; sound is longitudinal.

	Transverse	Longitudinal
Oscillation	perpendicular to energy transfer	parallel to energy transfer
Parts	crests and troughs	compressions and rarefactions
Wavelength measured	crest to crest	compression to compression
Amplitude	rest line to crest (not crest to trough)	max displacement of a particle; not a height on the diagram
Needs a medium	mechanical ones yes; electromagnetic no	always
Through a vacuum	EM waves yes	no
Polarised	yes	no
Through liquids and gases	surface waves yes; S-waves no	yes
Examples	light and all EM waves, water surface, rope, guitar string, seismic S-waves	sound, ultrasound, pushed slinky, seismic P-waves

Labelling the diagrams

[] Transverse: rest line, sine curve; label crest, trough, amplitude (rest line to crest), wavelength (crest to next crest), arrow for direction of travel and a perpendicular arrow for direction of vibration

[] Longitudinal: a row of lines bunched (compression) and spread (rarefaction); wavelength from the middle of one compression to the next; BOTH arrows along the row

[] A pressure-against-distance graph of a longitudinal wave looks like a sine curve: it is a graph, not a transverse wave

The slinky, earthquakes, vacuum and polarisation

[] Flick the slinky sideways: a hump travels (transverse). Push and pull it: a bunch travels (longitudinal). A ribbon tied to one coil ends where it started

[] P-waves (longitudinal, about 6 km/s, pass through liquids) arrive before S-waves (transverse, about 3.5 km/s, blocked by liquids): the S-wave shadow proves the outer core is liquid

[] Sound is particles pushing particles, so no particles, no sound (the bell in a vacuum jar). Light is oscillating fields and crosses space at 3.0×10^8 m/s

[] Only a transverse wave has a plane of oscillation to filter, so only transverse waves can be polarised (polarised sunglasses)

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The wave equation, speeds, the mistakes, and a practice set

Quantity	Symbol, unit	Meaning
Amplitude	A, m	max displacement from rest; more amplitude, more energy
Wavelength	λ , m	distance between neighbouring identical points
Frequency	f, Hz	complete waves per second; $T = 1 / f$
Wave speed	v, m/s	$v = f \times \lambda$, for every wave

Speed of	Value
sound in air at 20 °C	343 m/s
sound in water	about 1,480 m/s
sound in steel	about 5,000 m/s
sound in soft tissue (ultrasound)	about 1,540 m/s
light and all EM waves in a vacuum	3.0×10^8 m/s
P-waves / S-waves in the crust	about 6 / 3.5 km/s

Worked

- [] 500 Hz sound, wavelength 0.686 m: $v = 500 \times 0.686 = 343$ m/s
- [] Red light, 7.0×10^{-7} m: $f = 3.0 \times 10^8 / 7.0 \times 10^{-7} = 4.3 \times 10^{14}$ Hz
- [] Water waves every 4 s, crests 6 m apart: $f = 0.25$ Hz, $v = 1.5$ m/s
- [] 2 MHz ultrasound at 1,540 m/s: $\lambda = 1,540 / 2,000,000 = 7.7 \times 10^{-4}$ m

Mistakes

- [] 'Transverse = up and down' (it is perpendicular to travel); amplitude marked crest to trough; wavelength marked crest to trough
- [] Sound faster in air than water (it is about four times faster in water); sound can be polarised; light needs a medium
- [] Frequency (Hz) confused with speed (m/s)

Practice

- State the difference between transverse and longitudinal waves with one example of each.
- On a longitudinal diagram, between which two points is one wavelength?
- $f = 50$ Hz, $\lambda = 4$ m. Speed?
- Sound at 343 m/s: wavelength of a 1,000 Hz note?
- Why does sunlight reach Earth while the Sun's sound does not?
- P-waves arrive 40 s before S-waves. Which type is which, and why the different speeds?

Answers

- Transverse oscillates at right angles to travel (light, water); longitudinal along it (sound, P-waves).
- Middle of one compression to the middle of the next.
- 200 m/s.
- 0.343 m.
- Light is an electromagnetic wave and needs no medium; sound needs particles and space is a vacuum.
- P longitudinal, S transverse; P-waves compress the rock, which resists compression more stiffly than shear, so they travel faster.