

Chapter 11: Wave properties

Knowledge organiser

Waves in air, fluids, and solids

Waves transfer energy from one place to another without transferring matter. Waves may be **transverse** or **longitudinal**.

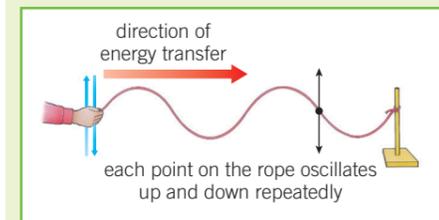
For waves in water and air, it is the wave and not the substance that moves.

- When a light object is dropped into still water, it produces ripples (waves) on the water which spread out, but neither the object nor the water moves with the ripples.
- When you speak, your voice box vibrates, making sound waves travel through the air. The air itself does not travel away from your throat, otherwise a vacuum would be created.

Transverse waves

The oscillations of a transverse wave are *perpendicular* (at right angles) to the direction in which the waves transfer energy.

Ripples on the surface of water are an example of transverse waves.

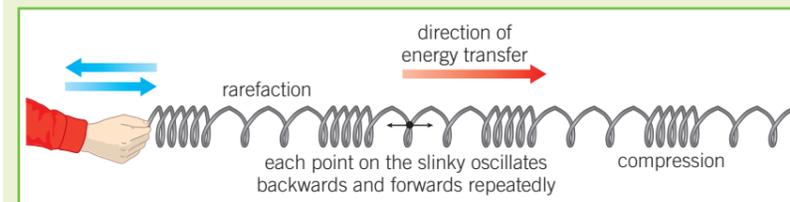


Longitudinal waves

The oscillations of a longitudinal wave are *parallel* to the direction in which the waves transfer energy.

Longitudinal waves cause particles in a substance to be squashed closer together and pulled further apart, producing areas of **compression** and **rarefaction** in the substance.

Sound waves in air are an example of longitudinal waves.



Mechanical waves require a substance (a medium) to travel through.

Examples of mechanical waves include sound waves, water waves, waves on springs and ropes, and seismic waves produced by earthquakes.

When waves travel through a substance, the particles in the substance **oscillate** (vibrate) and pass energy on to neighbouring particles.

Properties of waves

Frequency and period are related by the equation:

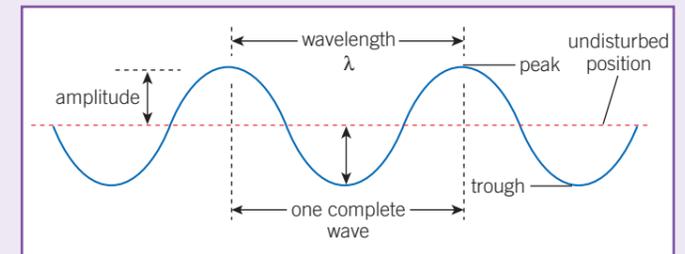
$$\text{period (s)} = \frac{1}{\text{frequency (Hz)}} \quad T = \frac{1}{f}$$

All waves obey the wave equation:

$$\text{wave speed (m/s)} = \text{frequency (Hz)} \times \text{wavelength (m)}$$



$$v = f\lambda$$



When waves travel from one medium to another, their speed and wavelength may change but the frequency always stays the same.

The speed of ripples on water can be slow enough to measure using a stopwatch and ruler, and applying the equation:



$$\text{speed (m/s)} = \frac{\text{distance (m)}}{\text{time (s)}}$$

The speed of sound in air can be measured by using a stopwatch to measure the time taken for a sound to travel a known distance, and applying the same equation.

Reflection of waves

When waves arrive at the boundary between two different substances, one or more of the following things can happen:

Absorption – the energy of the waves is transferred to the energy stores of the substance they travel into (for example, when food is heated in a microwave)

Reflection – the waves bounce back

Refraction – the waves change speed and direction as they cross the boundary

Transmission – the waves carry on moving once they've crossed the boundary, but may be refracted

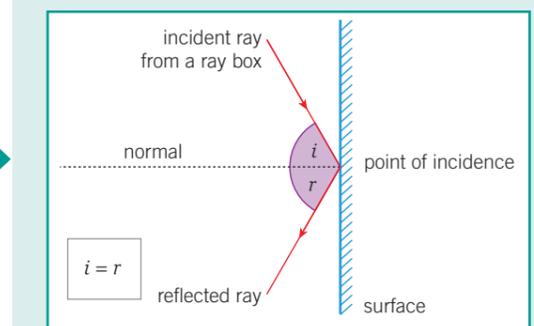
Ray diagrams can be used to show what happens when a wave is reflected at a surface.

To correctly draw a ray diagram for reflection:

- 1 use a ruler to draw all lines for the rays
- 2 draw a single arrow on the rays to show the direction the wave is travelling
- 3 draw a dotted line at right angles to the surface at the point of **incidence** (this line is normal to the surface)
- 4 label the normal, angle of incidence (i), and angle of reflection (r).

When reflection happens at a surface, the angle of incidence is always equal to the angle of reflection:

$$i = r$$



Wave motion is described by a number of properties.

Property	Description	Unit
amplitude A	maximum displacement of a point on a wave from its undisturbed position	metre (m)
frequency f	number of waves passing a fixed point per second	hertz (Hz)
period T	time taken for one complete wave to pass a fixed point	second (s)
wavelength λ	distance from one point on a wave to the equivalent point on the next wave	metre (m)
wave speed v	distance travelled by each wave per second, and the speed at which energy is transferred by the wave	metres per second (m/s)



Key terms

Make sure you can write a definition for these key terms.

absorption amplitude compression frequency incidence longitudinal mechanical wave oscillate period ray diagram reflection rarefaction transmission transverse wavelength wave speed

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Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

P11 questions

Answers

1	What is a transverse wave?	Put paper here	oscillations/vibrations are perpendicular (at right angles) to the direction of energy transfer
2	What is a longitudinal wave?	Put paper here	oscillations/vibrations are parallel to the direction of energy transfer
3	Give an example of a transverse wave.	Put paper here	electromagnetic waves
4	Give an example of a longitudinal wave.	Put paper here	sound waves
5	What is a compression?	Put paper here	area in longitudinal waves where the particles are squashed closer together
6	What is a rarefaction?	Put paper here	area in longitudinal waves where the particles are pulled further apart
7	What is the amplitude of a wave?	Put paper here	maximum displacement of a point on the wave from its undisturbed position
8	What is the wavelength of a wave?	Put paper here	distance from a point on one wave to the equivalent point on the adjacent wave
9	What is the frequency of a wave?	Put paper here	number of waves passing a fixed point per second
10	What unit is frequency measured in?	Put paper here	hertz (Hz)
11	What property of a wave always stays the same when it travels from one medium to another?	Put paper here	frequency
12	What rule do waves follow when they reflect off a surface?	Put paper here	angle of incidence = angle of reflection
13	What happens when waves are transmitted at a boundary between two substances?	Put paper here	they carry on moving at a different speed
14	What happens when waves are absorbed by a substance?	Put paper here	energy of the wave is transferred to energy stores of the substance