Transverse and longitudinal waves

4.6.1.1 · Waves · revision notes

Waves transfer energy from one place to another without transferring matter. You need to describe the difference between transverse and longitudinal waves, give examples of each, and describe evidence that it is the wave, not the water or the air, that travels. Expect 1 to 3 mark recall and 'describe' questions.

Key facts

- Waves transfer energy, not matter
- Longitudinal: oscillations parallel to the direction of energy transfer
- Longitudinal example: sound waves in air
- Sound needs a medium; it cannot travel through a vacuum
- Transverse: oscillations perpendicular to the direction of energy transfer
- Transverse examples: ripples on water, waves on a string, all electromagnetic waves
- Compression = particles close together; rarefaction = particles spread out

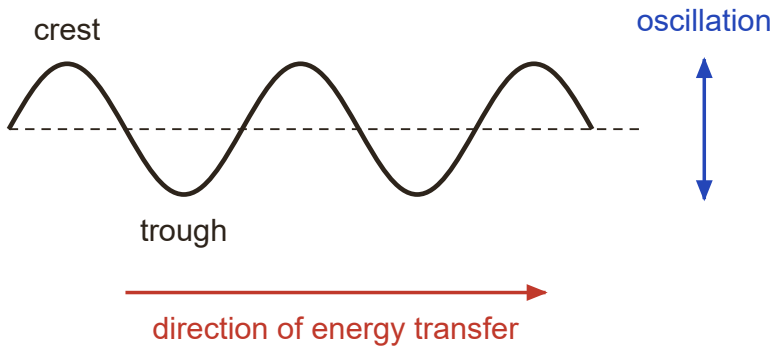
Notes

What a wave does

- A wave is a repeated oscillation (vibration) that transfers **energy** from one place to another.
- Waves transfer energy, and can carry information, but they do **not** transfer matter. The particles of the medium oscillate about fixed positions; only the wave moves on.
- Sound waves and water waves need a medium (a substance) to travel through. Electromagnetic waves, such as light, can also travel through a vacuum.

Transverse waves

- In a **transverse** wave the oscillations are **perpendicular** (at right angles) to the direction of energy transfer.

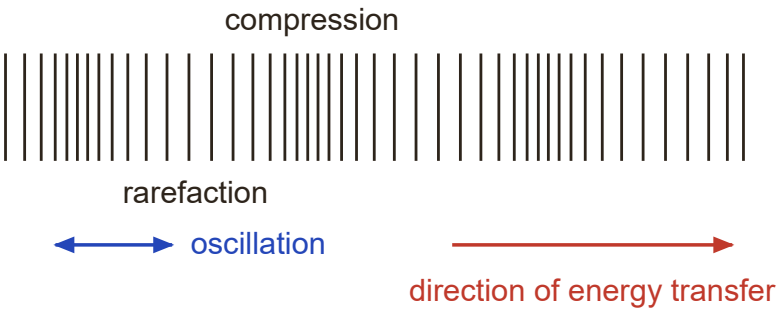


Transverse: the oscillation (blue) is at right angles to the energy transfer (red).

- Examples: ripples on the surface of water, waves on a stretched string or rope, and all electromagnetic waves (light, radio waves, X-rays and so on).
- A transverse wave has crests (peaks) and troughs.

Longitudinal waves

- In a **longitudinal** wave the oscillations are **parallel** to the direction of energy transfer.
- Example: sound waves in air. You can model one by pushing and pulling the end of a stretched slinky spring along its length.
- A longitudinal wave has **compressions** (particles close together) and **rarefactions** (particles spread out).



Longitudinal: the particles oscillate back and forth along the direction of energy transfer.

- In a sound wave, each air particle vibrates backwards and forwards about a fixed position and passes energy on to the next particle.

Evidence that the wave travels, not the medium

- Ripples: a cork or a leaf floating on water bobs up and down as the ripples pass, but it does not travel across the water with them.
- Sound: a loudspeaker playing music does not produce a wind, so the air is not flowing away from it. A strip of tissue paper held in front of a loudspeaker playing a low note vibrates backwards and forwards but is not blown away.
- In both cases the energy moves on, but the water or air particles stay in about the same place.

How to answer each type of question

Recall: name or identify the type of wave 1 mark each **Grade 3**

1. Transverse = oscillations at right angles to the direction of travel; longitudinal = oscillations along the direction of travel.
2. Remember: sound is longitudinal, and every electromagnetic wave is transverse.

Example. (a) Give **one** example of a longitudinal wave.
(b) Which of these is a transverse wave? Tick (✓) **one** box.
a sound wave in water / light from the Sun / a sound wave in air

Model answer.

(a) Sound waves in air (1)

(b) Light from the Sun (1)

Describe the difference between transverse and longitudinal waves 2 marks **Grade 5**

1. Write one statement about each type of wave.
2. Compare the direction of the **oscillations** with the direction of **energy transfer**.
3. Use the words 'perpendicular' and 'parallel'.

Example. Describe the difference between a transverse wave and a longitudinal wave.

Model answer. In a transverse wave the oscillations are perpendicular to the direction of energy transfer (1). In a longitudinal wave the oscillations are parallel to the direction of energy transfer (1).

Describe evidence that the wave, not the medium, travels 2 marks **Grade 6**

1. Say what you would observe (e.g. a small floating object).
2. Say how it moves: up and down, staying in about the same place.
3. Say what this shows: the wave (energy) moves on but the water does not.

Example. A student drops a stone into a pond. Ripples spread out across the surface. A leaf is floating on the pond.
Describe how the leaf could be used to show that the water itself does not travel across the pond with the ripples.

Model answer. The leaf moves up and down as the ripples pass (1). The leaf stays in about the same place and does not move across the pond with the ripples, so the wave travels but the water does not (1).

Describe how the particles move in a sound wave

3 marks | Grade 7

1. Say the particles vibrate backwards and forwards, parallel to the direction the wave travels.
2. Say they oscillate about fixed positions and pass energy on; they do not travel with the wave.
3. Use the words compression and rarefaction.

Example. A loudspeaker produces a sound wave in air.
Describe how the air particles move as the sound wave passes through the air.

Model answer.

Any three from:

the air particles vibrate backwards and forwards (1)

parallel to the direction of energy transfer / direction the wave travels (1)

this forms compressions, where particles are close together, and rarefactions, where they are spread out (1)

the particles oscillate about fixed positions and do not travel with the wave (1)

Don't lose marks

- Saying the oscillations are parallel or perpendicular 'to the wave' without saying 'to the direction of energy transfer' (or 'to the direction the wave travels').
- Saying that the water or air moves along with the wave. Waves transfer energy, not matter.
- Giving sound as an example of a transverse wave, or light as a longitudinal wave.
- Describing only one type of wave when the question asks for the difference.

More tips

Memory tricks

- Longitudinal: think 'along'. The vibrations go along the direction of travel.
- Transverse: think 'across'. A stadium wave is transverse: people move up and down while the wave moves sideways round the stadium.
- Slinky test: push and pull along the spring = longitudinal; shake it side to side = transverse.
- If it is electromagnetic, it is transverse. Sound is longitudinal.

Exam technique

- For 'describe the difference', write a full sentence about each type of wave. A sentence about only one type can score one mark at most.
- Use the specification words: oscillation, perpendicular, parallel, direction of energy transfer.
- On a diagram of a longitudinal wave, label a compression where the lines or particles are closest together and a rarefaction where they are furthest apart.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

Give examples of transverse and longitudinal waves

Transverse: ripples on water and all electromagnetic waves, such as light. Longitudinal: sound waves in air.

Grade 4

State what waves transfer

Waves transfer energy (and can carry information) from place to place, but they do not transfer matter.

Grade 5

Describe how transverse and longitudinal waves differ

Compare the direction of the oscillations with the direction of energy transfer: perpendicular for transverse, parallel for longitudinal.

Grade 5

Identify compressions and rarefactions

In a longitudinal wave, compressions are where the particles are close together and rarefactions are where they are spread out.

Grade 6

Describe evidence that the medium does not travel

A floating object bobs up and down as ripples pass but does not move across the water with them.

Grade 7

Explain how particles move in a sound wave

Air particles vibrate backwards and forwards about fixed positions, parallel to the direction of travel, passing energy on to their neighbours.

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