

Waves

Mark Scheme



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1. Whether they're mechanical ripples in water or invisible electromagnetic fields, all waves share one crucial rule: they transfer energy, but they never transfer matter.

- a) The figure below shows a wave. Which distance represents the **amplitude** of the wave?

B – is the only correct answer.	1 mark
	Total: 1 mark

- b) Which row in the table gives the correct expressions for the **wavelength** and the **amplitude** of the wave?

D – is the only correct answer.	1 mark
	Total: 1 mark

- c) A student is watching a small cork bobbing up and down on a pond.
What is the frequency of these water waves?

A – is the only correct answer.	1 mark
	Total: 1 mark

- d) The figure below represents a heavy chain being snapped up and down by an athlete in a gym.
Which type of wave is shown, and which is the **amplitude** of the wave?

D – is the only correct answer.	1 mark
	Total: 1 mark

- e) A water wave travels across a pond. It has a frequency of 2.5 Hz and a wavelength of 0.4 m.

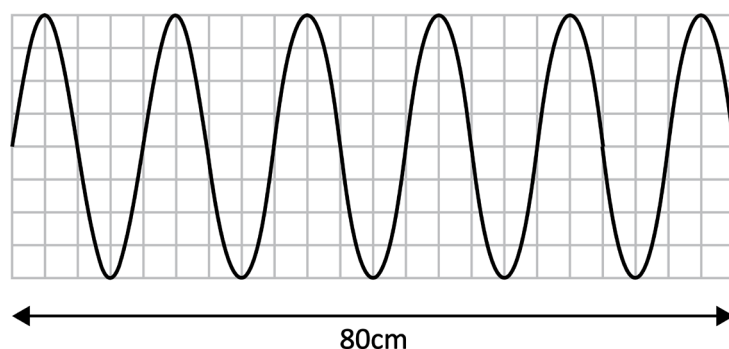
B – is the only correct answer.	1 mark
	Total: 1 mark

- f) A local radio station broadcasts a radio wave with a frequency of 800 kHz.
All radio waves travel at a speed of 300,000,000 m/s. What is the wavelength of this radio wave?

A – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 6 marks)

2. Some students are investigating water waves.
They produce waves by moving a piece of plastic up and down in a large tank of water.
The diagram shows the waves over a distance of 80 cm.



- a. State the number of wavelengths shown on the diagram.

6	1 mark
	Total: 1 mark

- b. Calculate the wavelength of the waves.

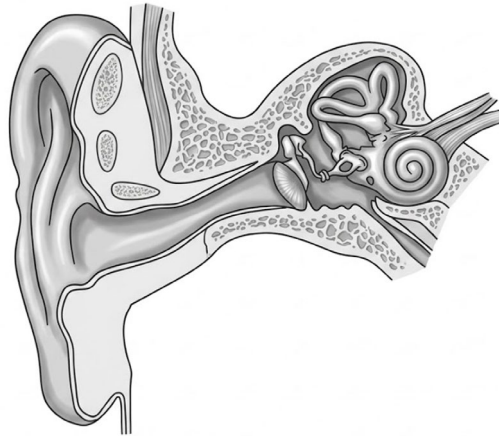
Distance $\div$ number of waves	
$80 \div 5$	1 mark
$= 16$	1 mark
	Total: 2 marks

- c. The students then produce a different wave.
This wave has a frequency of 2.5 Hz and a wavelength of 6.0 cm.
Calculate the speed of this wave.

Converts cm to m:	
$6.0 \text{ cm} = 0.06 \text{ m}$	1 mark
Uses $v = f \times \lambda$ and substitutes values:	
$v = f \times \lambda$	1 mark
0.15 (m/s)	1 mark
	Total: 3 marks

(Total for Question 2 is 6 marks)

3. Sound waves travel through the air and can be detected by the human ear.



Describe the process by which sound waves in the air are converted into signals that the brain can understand.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	Fragments of correct information are given. The answer consists of simple statements (for example "sound hits the eardrum and goes to the brain") without a clear, continuous logical sequence or detailed scientific vocabulary.
Level 2	3 - 4	A partially complete description is provided. The student identifies several key steps (e.g., eardrum vibrating, cochlea making signals), but the explanation may lack some detail, contain minor inaccuracies, or jump steps in the sequence.
Level 3	5 - 6	A detailed and coherent description is provided that logically follows the pathway of sound from the air to the brain. The steps are correctly sequenced, detailing the mechanical vibrations and their conversion to electrical signals. Relevant scientific terminology is used accurately throughout.

Indicative content:	
Outer/Middle Ear (Mechanical vibrations): • Sound waves (pressure variations in the air) travel down the ear canal. • The waves hit the eardrum (tympanic membrane). • This causes the eardrum to vibrate. • The eardrum transmits these vibrations to the small bones / ossicles. • The small bones (hammer, anvil, stirrup) amplify the vibrations... • ...and transmit them to the cochlea. Signal conversion: • The vibrations are transferred to the cochlea. • The cochlea converts the vibrations into electrical impulses / signals. Transmission to brain: • These electrical impulses travel to the brain. • (They travel) via the auditory nerve.	
	Total: 6 marks

(Total for Question 3 is 6 marks)

4. When an earthquake occurs, it releases energy in the form of seismic waves that travel through the Earth. Scientists monitor these waves using a seismograph.

- a) Earthquakes produce both P-waves and S-waves.
P-waves are longitudinal waves. S-waves are transverse waves.

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

A description to include the following:	
In a transverse wave, the oscillations/vibrations are perpendicular (at right angles) to the direction of energy transfer.	1 mark
Allow "direction of wave travel" instead of energy transfer.	
In a longitudinal wave, the oscillations/vibrations are parallel to the direction of energy transfer.	1 mark
Both points must be clearly made for 2 marks.	
	Total: 2 marks

- b) A seismograph detects a P-wave travelling through the Earth's crust at a speed of 6000 m/s.
The wave has a frequency of 1.5 Hz. Calculate the wavelength of this P-wave.

$6000 = 1.5 \times \lambda$	1 mark
$\lambda = 6000 \div 1.5$	1 mark
$\lambda = 4000$	1 mark
	Total: 3 marks

- c) Calculate the period (the time for one complete wave cycle) of this 1.5 Hz P-wave.

$T = 1 \div 1.5$	1 mark
$T = 0.67$	1 mark
	Total: 2 marks

- d) A second seismograph station is located 420 km away from the epicentre of the earthquake.
The S-waves from the earthquake travel at a speed of 3500 m/s.

Calculate the time taken for the S-waves to reach this second station.

You must show your working and ensure your units are correct.

$420 \text{ km} = 420,000 \text{ m}$	1 mark
$3500 = 420\,000 \div t$	1 mark
$t = 420\,000 \div 3500$	1 mark
$t = 120$	1 mark
	Total: 4 marks

(Total for Question 4 is 11 marks)

5. Radar stations use microwaves to track aircraft in the air.

a. Describe how microwaves are used to detect the airplane.

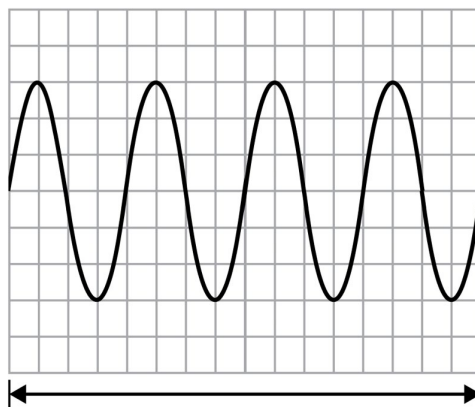
You may add to the diagram to help with your answer.

Any two from:	
- Microwaves are transmitted and reflect / bounce off the airplane. - The reflected waves are detected / received (by the radar station). - The time taken (for the wave to return) is measured / used to find the distance.	
	Total: 2 marks

b. Some students are investigating waves.

They produce waves by vibrating a long piece of string up and down.

The diagram shows the waves over a distance of 80 cm.



i. State the number of wavelengths shown on the diagram.

4	1 mark
	Total: 1 mark

ii. Calculate the wavelength of the waves.

20 cm	Allow 0.2 m	1 mark
		Total: 1 mark

c. The students vibrate the string faster to produce a different wave.

This new wave has a frequency of 2.5 Hz and a wavelength of 14.0 cm.

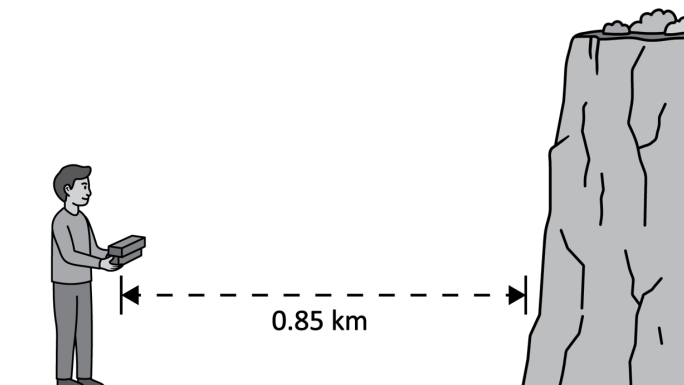
Calculate the speed of this wave **and** give the unit.

$v = 2.5 \times 0.14$	1 mark
Speed = 35cm/s or 0.35 m/s	2 marks
	Total: 3 marks

(Total for Question 5 is 7 marks)

6. A student investigates the properties of sound waves.
They stand in a large open field facing a tall, vertical cliff.

The student bangs two wooden blocks together to create a loud sound wave.
They use a stopwatch to measure the time it takes to hear the echo.



The student hears the echo exactly 5.0 seconds after banging the blocks together.

- a. Calculate the speed of the sound wave in the air.
You must show your working and ensure your units are correct.

Unit conversion: $0.85 \text{ km} = 850 \text{ m}$	1 mark
Distance $= 850 \times 2 = 1700 \text{ m}$	1 mark
Time $= 5.0 \div 2 = 2.5$	
Calculation: $850 \div 2.5$ 340	
	Total: 4 marks

- b. The sound wave produced by the wooden blocks has a frequency of 2.5 kHz.
Calculate the wavelength of the sound wave.

Unit conversion: $2.5 \text{ kHz} = 2500 \text{ Hz}$	1 mark
$340 = 2500 \times \lambda$	1 mark
$\lambda = 340 \div 2500$	
$\lambda = 0.136$	
	Total: 4 marks

- c. Calculate the period (the time for one complete wave cycle) of this sound wave.
Give your final answer in milliseconds (ms).

$T = 1 \div 2500$	1 mark
$T = 0.0004$	1 mark
$T = 0.0004 \times 1000$ $T = 0.4 \text{ ms}$	1 mark
	Total: 3 marks

(Total for Question 6 is 11 marks)

7. A communication satellite in orbit transmits data back to Earth using radio waves.

a. State **three** properties that all waves have in common.

Any three from:	
• They transfer energy. • They can be reflected. • They can be refracted. • They can be diffracted. • They have an amplitude. • They have a wavelength / frequency / period. • They can undergo interference / superposition.	
	Total: 3 marks

b. Radio waves are a type of electromagnetic wave.

State the speed at which all electromagnetic waves travel through the vacuum of space.

300,000,000 m/s	1 mark
	Total: 1 mark

c. The satellite is located at a distance of 36,000 km from the satellite dish on Earth.

Calculate the time taken for a radio signal to travel from the satellite to the dish.

$36,000 \text{ km} = 36,000,000 \text{ m}$ or $3.6 \times 10^7 \text{ m}$	1 mark
$t = 36,000,000 \div 300,000,000$	1 mark
$t = 0.12$	1 mark
	Total: 3 marks

d. The radio signal transmitted by the satellite has a wavelength of 0.15 m.

Calculate the frequency of the radio signal.

Give your answer in standard form.

$3 \times 10^8 = f \times 0.15$	1 mark
$f = 3 \times 10^8 \div 0.15$	1 mark
$f = 2,000,000,000$	1 mark
$f = 2 \times 10^9$	1 mark
	Total: 4 marks

(Total for Question 7 is 11 marks)

8. A teacher uses a slinky spring to demonstrate different types of waves to a physics class.

There are two main types of wave: **transverse** waves and **longitudinal** waves.
Compare transverse waves and longitudinal waves.

In your answer, you should include:

- a description of how the particles/medium oscillate (vibrate) in each type of wave
- the names of the specific features found on each type of wave
- one real-world example of each type of wave.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	The student might state simple facts, such as naming one correct example or mentioning the word "parallel", but the answer lacks a clear comparative structure and misses several key points.
Level 2	3 - 4	A partially complete comparison is provided. The student addresses at least two of the prompt's bullet points for both wave types, OR completely addresses all three bullet points for one wave type but is weak on the other.
Level 3	5 - 6	A clear, detailed, and logically structured comparison is provided. The student successfully describes the direction of oscillation relative to energy transfer for both wave types, names the specific features of both, and provides a correct example for both. Scientific terminology is used accurately throughout.

Indicative content:	
Description of oscillations: Transverse: The oscillations / vibrations are perpendicular (at right angles) to the direction of energy transfer / wave travel. Longitudinal: The oscillations / vibrations are parallel to the direction of energy transfer / wave travel. Specific features: Transverse: Have peaks (crests) and troughs. Longitudinal: Have compressions (areas where particles are close together) and rarefactions (areas where particles are spread apart) Real-world examples: Transverse: Any electromagnetic wave (e.g., visible light, radio waves, microwaves, X-rays), water waves / ripples, seismic S-waves, waves on a string. Longitudinal: Sound waves, ultrasound, seismic P-waves.	
	Total: 6 marks

(Total for Question 8 is 6 marks)