Meteors and earthquakes

1 The photograph shows a meteor exploding above Russia in 2013.



(a) The noise from the explosion was described as the loudest sound ever detected on Earth.
However, human beings could not hear this sound.
State the **two** sound frequency ranges that human beings cannot hear.

(2)

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(b) Meteors sometimes collide with the Earth's surface.
These collisions produce both P-waves and S-waves.

(i) Which of the following is correct for a P-wave?

Put a cross (☒) in the box next to your answer.

(1)

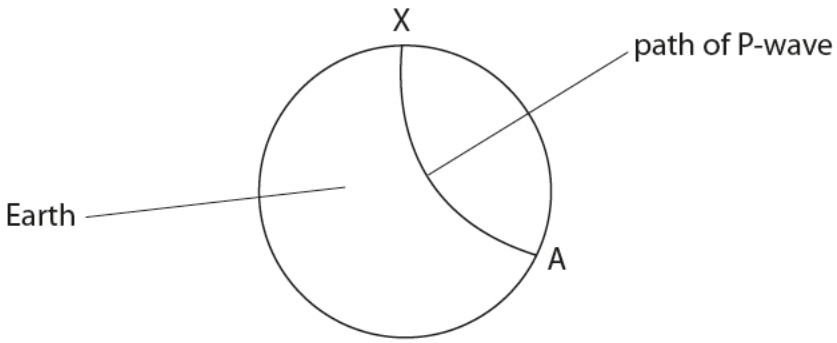
☐ **A** It is a transverse wave travelling faster than an S-wave.

☐ **B** It is a transverse wave travelling slower than an S-wave.

☐ **C** It is a longitudinal wave travelling faster than an S-wave.

☐ **D** It is a longitudinal wave travelling slower than an S-wave.

The diagram shows the path of a P-wave.
The P-wave travels from the collision at X, through the Earth, to another point, A.



(ii) Explain why the path of the P-wave is not a straight line.

(2)

(iii) Explain why there are regions on the Earth's surface where S-waves from the collision at X cannot be detected. You can add to the diagram to help your answer.

(3)

(iv) Describe how a meteor colliding with the Earth could set off an earthquake.

(2)

(Total for Question 4 = 10 marks)

2 Ultrasound from a fishing boat is used to find fish.

(a) (i) Which of these is correct for ultrasound waves?

Put a cross (☒) in the box next to your answer.

(1)

☒ **A** ultrasound waves have a frequency above 20 000 Hz

☒ **B** ultrasound waves have a frequency below 20 Hz

☒ **C** ultrasound waves have a wavelength above 20 000 Hz

☒ **D** ultrasound waves have a wavelength below 20 Hz

(ii) Complete the sentence by putting a cross (☒) in the box next to your answer.

The system that uses ultrasound to find fish is called

(1)

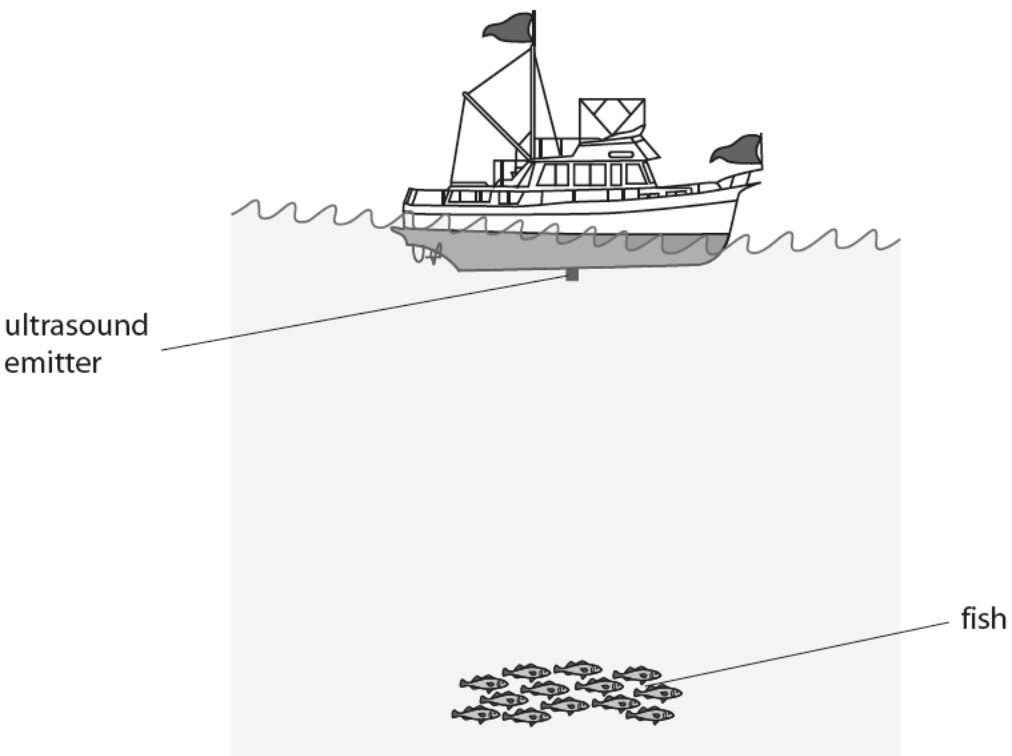
☒ **A** fibre optics

☒ **B** satellite transmission

☒ **C** sonar

☒ **D** thermal imaging

(iii) The diagram shows a fishing boat above some fish.



Describe how ultrasound waves are used to detect the fish.

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

(2)

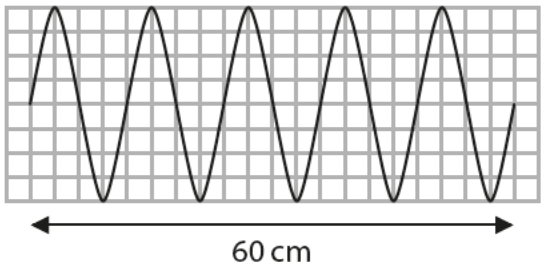
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(b) Some students are investigating waves.
They produce waves by moving a piece of wood up and down in a tank of water.
The diagram shows the waves over a distance of 60 cm.



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

(1)

number of wavelengths = ...

(ii) Calculate the wavelength of the waves.

(1)

wavelength of waves = ... cm

(c) The students produce a different wave.
This wave has a frequency of 1.7 Hz and a wavelength of 8.0 cm.

Calculate the speed of this wave.

(2)

speed of wave = ... cm/s

(Total for Question 2 = 8 marks)

Earthquakes

3 (a) Complete the sentence by putting a cross (☒) in the box next to your answer.

Waves from an earthquake are

(1)

- ☐ **A** transverse waves only
- ☐ **B** electromagnetic waves only
- ☐ **C** both transverse and electromagnetic waves
- ☐ **D** both transverse and longitudinal waves

(b) The Earth's surface is made up of many tectonic plates.
The interior of the Earth is a source of thermal energy.

Describe how this thermal energy can cause earthquakes.

You may draw a labelled diagram to help with your answer.

(3)

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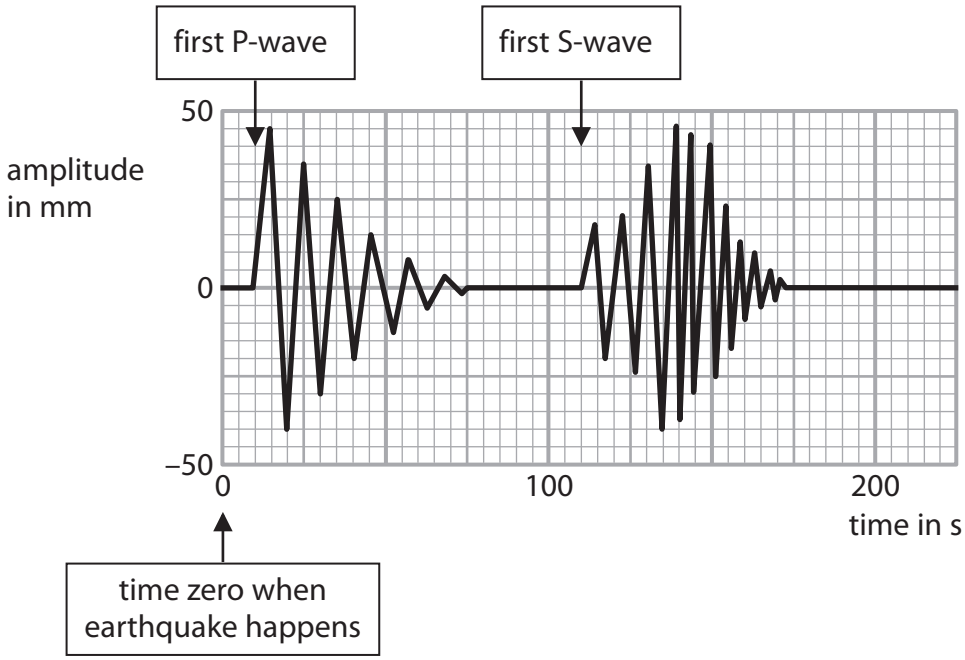
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(c) The chart shows the arrival of earthquake waves at an earthquake monitoring station.



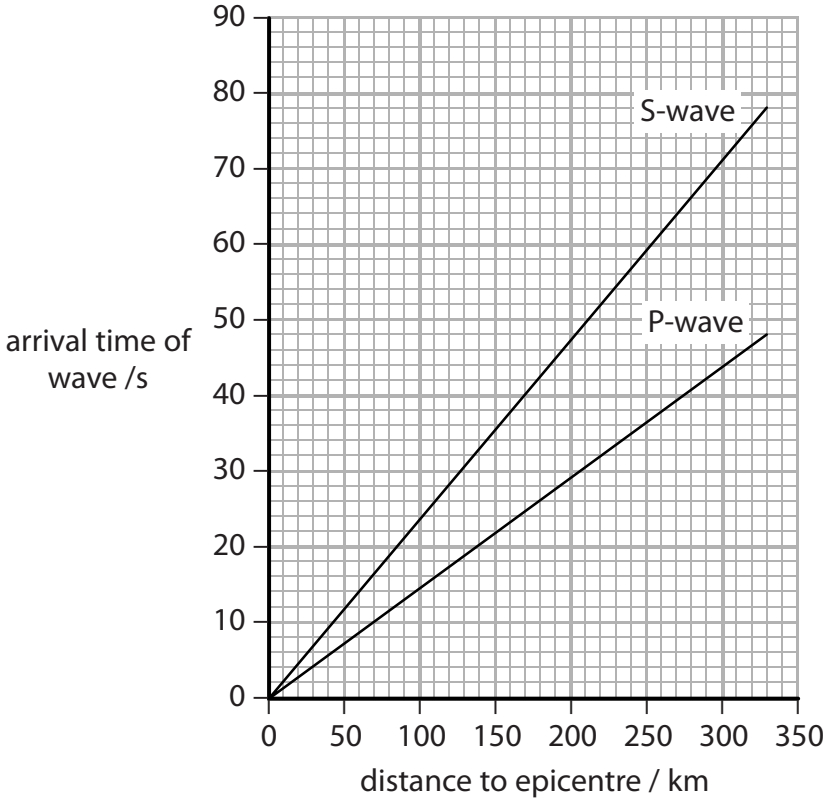
The S – P time (S minus P time) for earthquake waves is the time difference between the arrival of the first P wave and the first S wave.

Use the chart to estimate the S – P time for the earthquake waves shown.

(2)

S – P time = ... seconds

(d) The location of an earthquake is known as an epicentre.
The S – P time for earthquake waves can be used to estimate the distance between the monitoring station and the epicentre.
The graph shows how the arrival times of S and P waves are related to their distances from the epicentre of an earthquake.



The S – P time for a particular earthquake was 20 seconds.
Use the S – P time to estimate the distance between the monitoring station and the epicentre of this earthquake.

(2)

distance to epicentre of earthquake = ... km

(e) Many earthquakes and volcanoes are linked to the production of infrasound waves.

Describe what is meant by **infrasound waves**.

(2)

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(Total for Question 4 = 10 marks)

Scaring cats with ultrasound

4 Anna uses a device to keep cats away from her garden.
This device emits some ultrasound waves that cats do not like.



(a) Which of these could be the frequency of the ultrasound waves?

Put a cross (☒) in the box next to your answer.

(1)

☒ **A** 23 z

☒ **B** 2300 Hz

☒ **C** 230 Hz

☒ **D** 23 Hz

(b) State another use for ultrasound waves.

(1)

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(c) Anna has good hearing but she cannot hear the ultrasound waves from the device. However, a cat can hear them.

Explain this difference.

(2)

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(d) Anna finds a leaflet about how the device works.

- A cat approaches the device.
- Heat from the cat is emitted as infrared rays.
- The device detects these infrared rays.
- Then the device emits ultrasound waves.
- These waves scare the cat away.

(i) The speed of the ultrasound waves is 340 m/s.
The ultrasound takes 0.047 s to reach the cat.

Calculate the distance between the device and the cat.

distance (m) = wave speed (m/s) × time (s)

(2)

distance = ... m

(ii) The infrared rays from the cat take much less than 0.047 s to reach the device. The infrared rays and the ultrasound waves travel the same distance.

Suggest why the infrared rays take much less time than the ultrasound waves.

(2)

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(Total for Question 1 = 8 marks)

Elephants and infrasound

5 (a) Sound travels through the air as longitudinal waves.

Describe how the air particles move when a sound wave passes.

(2)

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(b) Elephants call to each other using infrasound.
People cannot hear these infrasound calls.

Which of the following statements is the reason that people cannot hear infrasound?

Put a cross (☒) in the box next to your answer.

(1)

☒ **A** the amplitude of infrasound is too big

☒ **B** the frequency of infrasound is too low

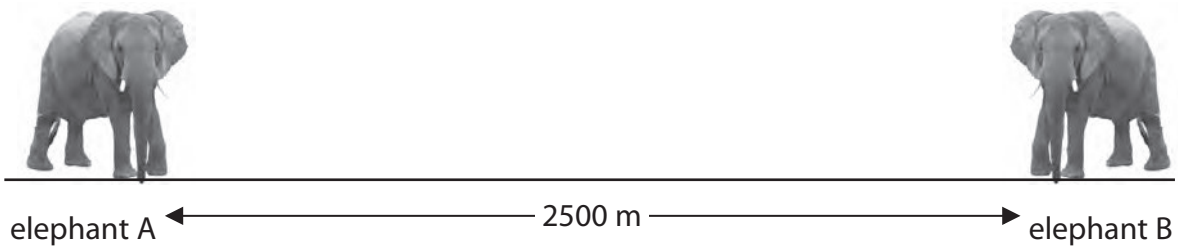
☒ **C** the speed of infrasound is too fast

☒ **D** the wavelength of infrasound is too short

(c) Both infrasound waves and ultrasound waves are types of sound waves.
They are used by animals to communicate.

Two elephants use infrasound waves for long distance communication.
The distance between these two elephants is 2500 m.

not to scale



Elephant A emits an infrasound call.
When elephant B hears the infrasound, it calls back.
Elephant A hears the answering call from elephant B.
The speed of infrasound is 340 m/s.

(i) Show that the minimum time for elephant A to call and hear an answer from elephant B is about 15 s.

(3)

(ii) An elephant's infrasound call has a range of 4000 m.
Each infrasound call lasts between 2 s and 10 s.
Each elephant usually waits about 30 s before it calls again.

Suggest a reason why elephants wait 30 s before calling again.

(1)

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(d) Describe a use of infrasound that does not involve animals.

(2)

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(Total for Question 3 = 9 marks)