



GuideMyGrades

— YOUR GOALS. OUR EXPERTISE. —

EDEXCEL GCSE PHYSICS: QUESTIONS BY TOPIC

Waves (4)

GCSE Physics (Higher) Topic 4

14 questions · 127 marks · Mark schemes included

Pearson Edexcel GCSE (9-1) Physics 1PH0, Higher Tier, June 2018 - June 2025

 guidemygrades.com

 [@Guidemygrades](https://www.instagram.com/Guidemygrades)

 [@Guidemygrades](https://twitter.com/Guidemygrades)

 [@Guidemygrades](https://www.youtube.com/Guidemygrades)

 info@guidemygrades.com

 Piccadilly Business Centre, Unit C, Aldow Enterprise Park
Blackett Street, Manchester, M12 6AE

HOW TO USE THIS BOOKLET

Questions run from the lowest mark tariff to the highest, so similar questions sit together.

Click any row below to jump straight to that question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

QUESTION	SOURCE	MARKS	PAGE
1. Q1	Paper 1 June 2018	6	4
2. Q1	Paper 1 November 2021	6	6
3. Q1	Paper 1 June 2023	6	8
4. Q1	Paper 1 June 2025	6	9
5. Q5	Paper 1 June 2018	9	12
6. Q5 <i>also Topic 5</i>	Paper 1 November 2020	9	15
7. Q6	Paper 1 November 2020	9	17
8. Q2	Paper 1 November 2021	9	19
9. Q3	Paper 1 June 2025	9	22
10. Q4 <i>also Topic 7</i>	Paper 1 June 2023	11	26
11. Q6 <i>also Topic 5</i>	Paper 1 June 2023	11	29
12. Q10	Paper 1 November 2020	12	33
13. Q10	Paper 1 June 2022	12	37
14. Q10	Paper 1 June 2024	12	41



QUESTIONS

14 questions · 127 marks · lowest tariff first



6-MARK QUESTIONS

4 questions in this booklet



1 Sonar is an example of a use of ultrasound.

(a) State **one** other example of a use of ultrasound.

(1)

(b) State an example of a use of infrasound.

(1)

WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

2



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

- (c) Figure 1 shows the depth of the sea, measured using sonar, at different distances from the shore.

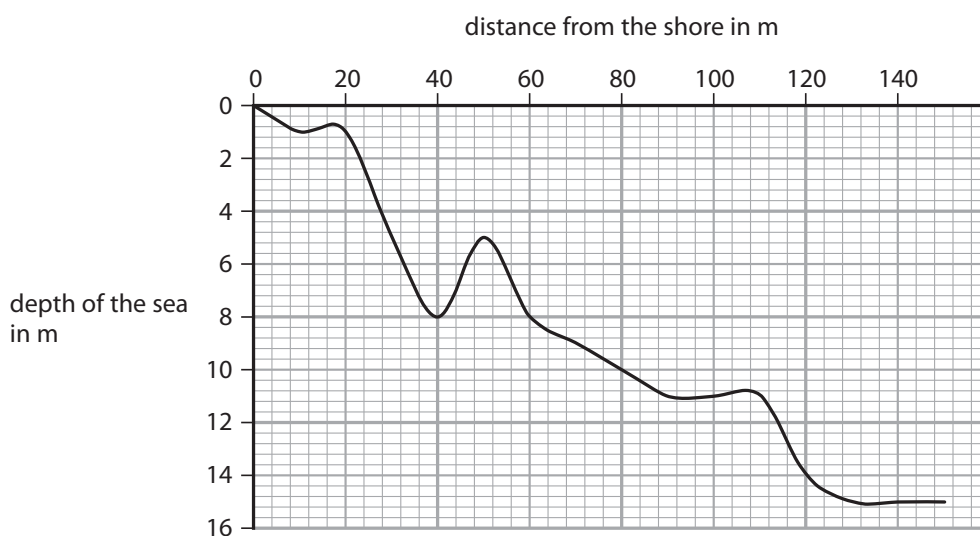


Figure 1

A technician on a boat uses sonar pulses to measure the depth of the sea when the boat is 120 m from the shore.

Calculate the **total** time of travel for the sonar pulse used to make this measurement.

The speed of the sonar pulse in seawater is 1600 m/s.

(4)

time of travel = ... s

(Total for Question 1 = 6 marks)



1 This question is about ultrasound.

(a) Which of these is a frequency of ultrasound?

(1)

- ☐ A 2.3 Hz
- ☐ B 23 Hz
- ☐ C 2.3 kHz
- ☐ D 23 kHz

(b) Ultrasound has many uses.

(i) One device called a pest repeller emits ultrasound.

The ultrasound keeps mice out of the garden.

Explain why the device affects mice but does not affect humans.

(2)

(ii) A technician has a different ultrasound device.

This device can emit and detect short pulses of ultrasound.

The device can also measure the time, in ms, from emitting a pulse to detecting the same pulse.

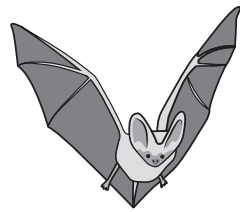
Describe how the technician can use this device to determine the speed of ultrasound in air.

(3)

(Total for Question 1 = 6 marks)



- 1 Figure 1 shows a bat and its prey.



bat



prey

not to scale

Figure 1

The bat emits a high frequency sound pulse to locate its prey.

The speed of sound in air is 330 m/s.

- (a) The wavelength of the sound is 11 mm.

Calculate the frequency of the sound.

(2)

Use the equation

$$v = f \times \lambda$$

frequency = ... Hz

- (b) The pulse returns to the bat after a time of 18 ms.

Calculate the distance from the bat to its prey.

(4)

distance = ... m

(Total for Question 1 = 6 marks)

1 This question is about both **infrasound** and **ultrasound**.

(a) Which of these is a frequency of **infrasound**?

(1)

- ☐ A 2.2 Hz
- ☐ B 2.2 kHz
- ☐ C 22 Hz
- ☐ D 22 kHz

(b) Figure 1 shows a technician standing in front of a wall.

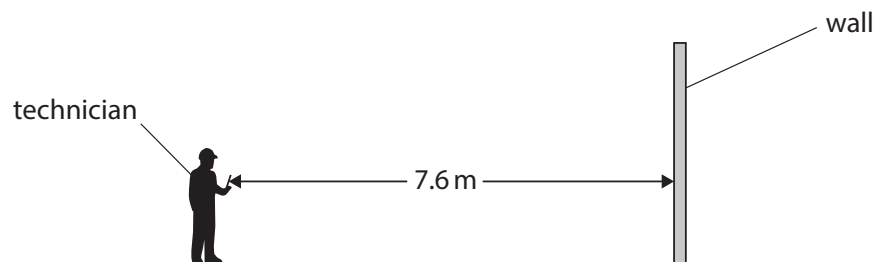


Figure 1

The technician has a device that can emit and detect **ultrasound**.

The device emits a pulse of **ultrasound** towards the wall and detects the echo of the pulse a short time later.

The wall is 7.6 m from the device.

The speed of **ultrasound** in air is 330 m/s.

Calculate the time between the emission of the pulse and the detection of the echo.

(3)

time = ... s

(c) Explain why humans cannot hear **infrasound**.

(2)

(Total for Question 1 = 6 marks)



9-MARK QUESTIONS

5 questions in this booklet



- 5 (a) Figure 7 shows a tuning fork.

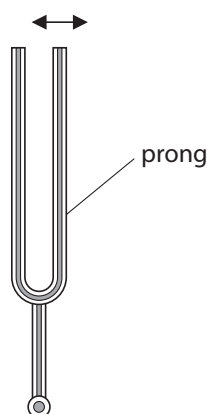


Figure 7

When the prongs of the tuning fork are struck, the prongs vibrate in the directions shown by the arrows on Figure 7.

Describe how the vibrating tuning fork causes a sound wave to travel through the air.

You may add to the diagram if it helps your answer.

(2)

.....

.....

.....

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

- (b) The following descriptions describe waves from different parts of the electromagnetic spectrum.

Complete each description by adding the name of the wave.

Use the name of each wave only once. Each description refers to a different part of the electromagnetic spectrum.

(4)

Description 1

used in cooking

used in short-range communication

typical wavelength 900 nm

name of wave

Description 2

used in cooking

used in communication

typical wavelength 150 mm

name of wave

Description 3

used in communication

produced by oscillations in electrical circuits

typical wavelength 150 m

name of wave

Description 4

used in medical scanning

is emitted by the nucleus of an atom

typical wavelength $2.0 \times 10^{-3} \text{ nm}$

name of wave



15



- (c) When white light crosses the boundary between air and glass, it can split up into the colours of the spectrum.

Explain, in terms of speed, why the light behaves like this.

(3)

(Total for Question 5 = 9 marks)

DO NOT WRITE IN THIS AREA

DO NOT



- 5 (a) A radio station transmits on 97.4 MHz.

To receive the waves an aerial needs a length equal to half the wavelength of the radio waves being transmitted.

Calculate the length of the aerial needed.

The speed of the radio waves is 3.00×10^8 m/s.

(3)

length of aerial = ... m

- (b) To investigate refraction in a rectangular glass block a student uses the apparatus shown in Figure 5.

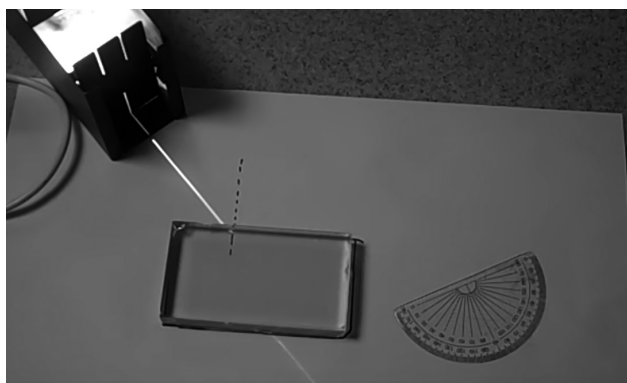


Figure 5

Describe how the student should measure the angle of refraction.

(2)

.....

.....

.....

.....

- (c) Figure 6 is a simplified diagram to show radio waves from a transmitter moving upwards, then meeting a boundary between lower and upper layers of the atmosphere.

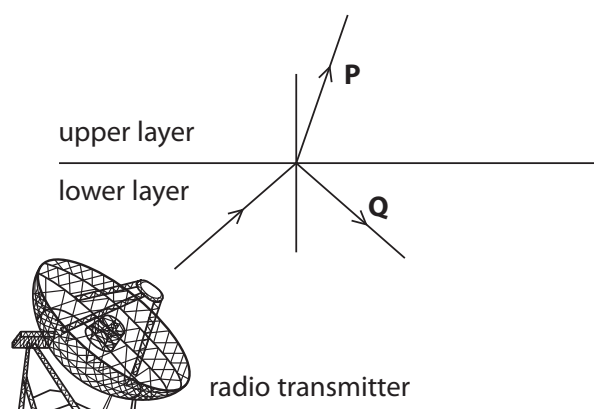


Figure 6

Explain what happens to the radio waves after they meet the boundary between the lower and upper layers as shown in Figure 6.

Your explanation should refer to changes in direction and speed of the waves.

(4)

(Total for Question 5 = 9 marks)

- 6 (a) Four students and their teacher do an experiment to measure the speed of sound in air.

The teacher stands at a distance and fires a starting pistol into the air.

The students see the flash when the pistol is fired.

They measure the time from when they see the flash to when they hear the bang.

A student drew a diagram of the arrangement as shown in Figure 7.

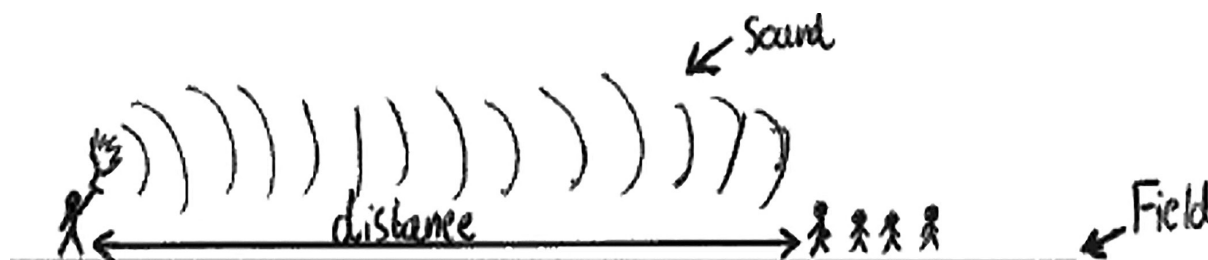


Figure 7

The students obtained a value of 240 m/s for the speed of sound.

The accepted value, in a science data book, is 343 m/s.

- (i) Calculate the difference between the students' value and the accepted value as a percentage of the accepted value.

(2)

percentage difference = ... %

- (ii) When the distance was 100 m, the students measured the following times:

0.43 s 0.35 s 0.50 s 0.38 s

Explain why their times vary so much.

(2)

.....

.....

.....

.....

(iii) Explain **one** way the students might improve this experiment.

(2)

(b) Figure 8 represents a sound wave coming from a loudspeaker and shows the effects on particles of the air at one instant in time.

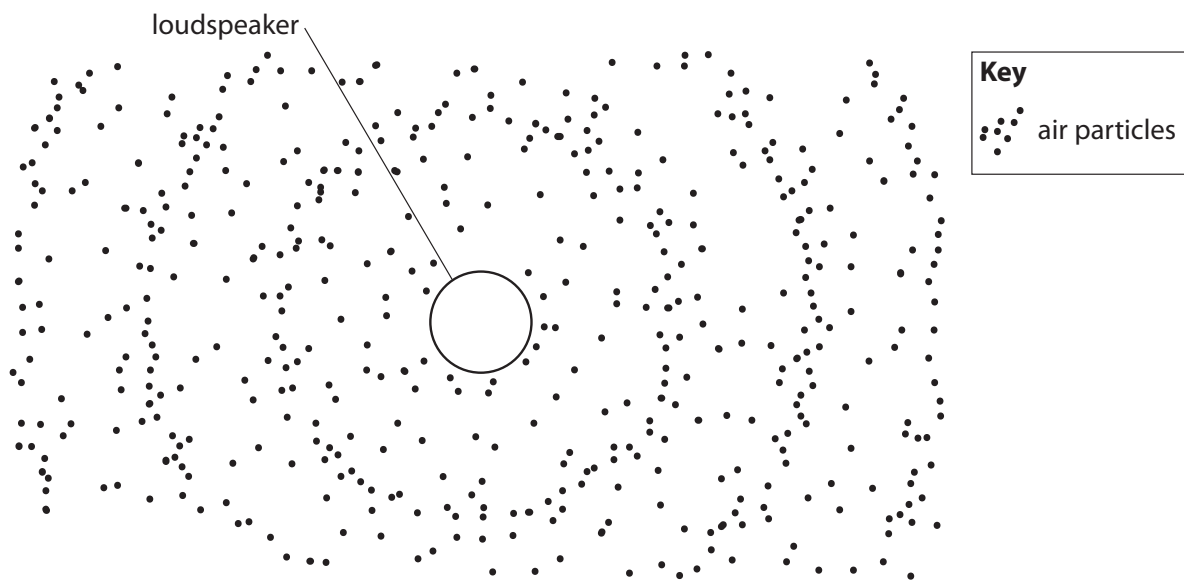


Figure 8

(i) Draw and label a distance of one wavelength in Figure 8.

(1)

(ii) Describe the motion of the particles as the wave travels through the air.

(2)

(Total for Question 6 = 9 marks)

- 2 (a) Figure 1 shows part of a wave.

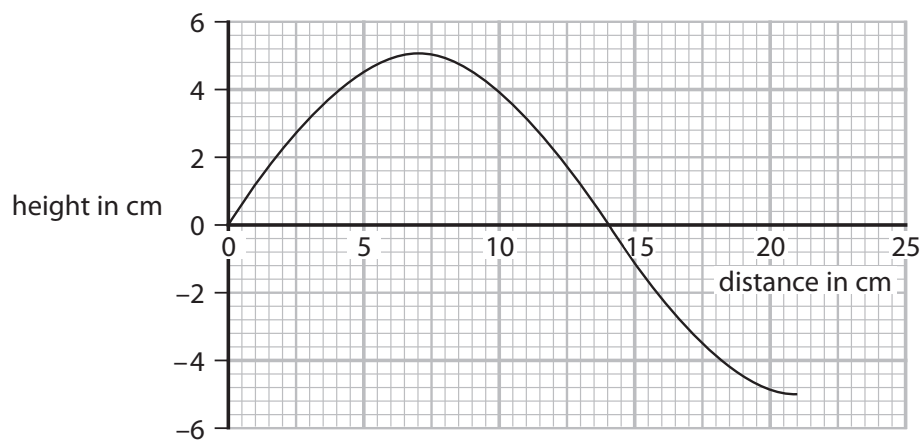


Figure 1

Use data from Figure 1 to calculate the wavelength of the wave.

(2)

wavelength = ... cm

- (b) (i) Figure 2 shows a student sitting on the shore of a lake watching ripples on the surface of the water moving past a toy boat.

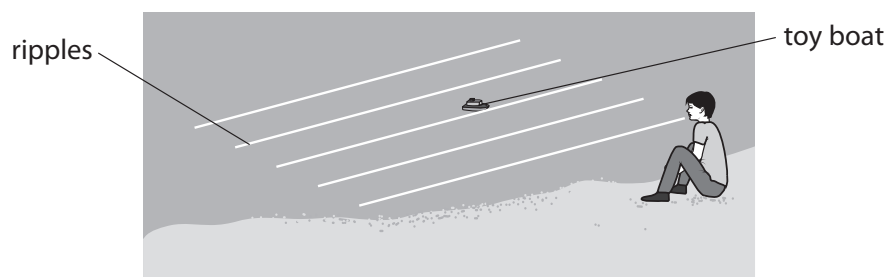


Figure 2

The student has a stopwatch.

Describe how the student could determine the frequency of the ripples on the lake.

(3)

.....

.....

.....

.....

.....

.....

- (ii) The speed of a water wave is 1.5 m/s.

The frequency of the wave is 0.70 Hz.

Calculate the wavelength of this wave.

Use the equation

$$v = f \times \lambda$$

(2)

wavelength = ... m



(iii) Water waves are transverse waves.

Describe the difference between transverse waves and longitudinal waves.

(2)

(Total for Question 2 = 9 marks)



- 3 (a) Figure 5 is a diagram of part of a water wave.

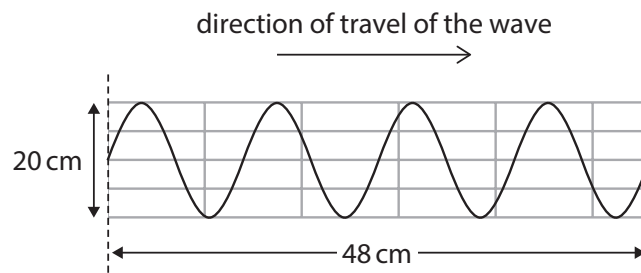


Figure 5

- (i) Use data from Figure 5 to determine the amplitude of the wave.

(1)

amplitude = ... cm

- (ii) Use data from Figure 5 to determine the wavelength of the wave.

(1)

wavelength = ... cm

- (iii) The water wave shown in Figure 5 is generated in a large tank.

A student observes the wave.

Describe how the student could determine the wave speed of the wave.

(2)

.....

.....

.....

.....

- (b) When an earthquake happens, waves are transmitted through the Earth. Figure 6 is a diagram of a part of the Earth's crust.

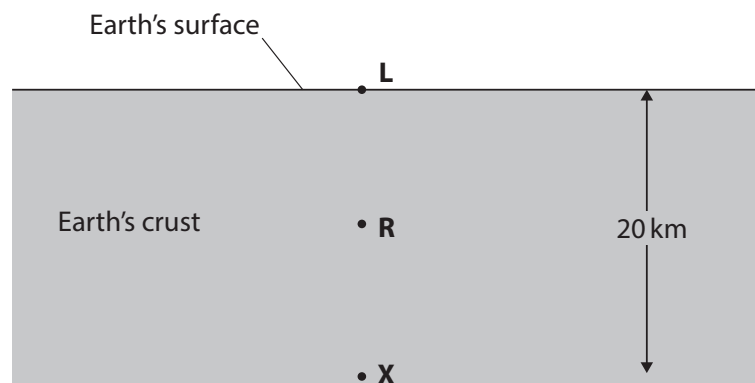


Figure 6

An earthquake happens at point **X**, 20 km below the Earth's surface.

An earthquake wave from **X** is detected at point **L**.

This earthquake wave is a transverse wave.

- (i) State **one** other example of a transverse wave.

(1)

- (ii) A point in the crust is labelled **R** in Figure 6.
There is a rock at point **R**.

Describe the effect that this earthquake wave has on the rock at **R** as the wave passes through the rock.

You may add to Figure 6 to help your answer.

(2)

(iii) The wave from **X** reaches **L** 3.8 seconds after it passes through **R**.

The speed of the wave is 4500 m/s.

Calculate the distance between **X** and **R**.

(2)

distance = ... m

(Total for Question 3 = 9 marks)



11-MARK QUESTIONS

2 questions in this booklet



- 4 (a) Figure 6 shows two objects, **E** and **D**.

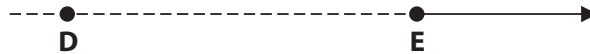


Figure 6

E emits a sound.

D detects the sound.

E is moving in the direction shown by the arrow, but **D** is not moving.

E emits a sound of wavelength 1.86 m.

D measures the wavelength of this sound as 1.98 m.

- (i) Calculate the difference between the wavelength that **E** emits and the wavelength that **D** detects.

(1)

difference in wavelength = ... m

- (ii) The velocity of sound is 330 m/s.

Calculate the velocity of **E**.

(2)

Use the equation

$$\text{velocity of E} = \frac{\text{velocity of sound} \times \text{difference in wavelength}}{\text{wavelength E emits}}$$

velocity of **E** = ... m/s

(b) The wavelength of light emitted from distant galaxies is different when the light is detected on Earth.

Explain how this difference in wavelength shows that the Universe is expanding. (2)

(c) CMB radiation provides evidence that the Universe had a definite beginning.

Use the table in Figure 7 to give a typical value for the wavelength of CMB radiation.

type of radiation	typical wavelength
gamma rays	$1.0 \times 10^{-12} \text{ m}$
X-rays	$3.0 \times 10^{-11} \text{ m}$
ultraviolet	200 nm
visible	600 nm
infrared	$4.0 \mu\text{m}$
microwaves	1.0 mm
radio waves	50 m

Figure 7 (2)

wavelength = ...

(d) During the evolution of a star, the nebula collapses and becomes a main sequence star.

(i) State what causes the nebula to collapse. (1)

(ii) Explain why the nebula stops collapsing as it becomes a main sequence star.

(3)

.....

.....

.....

.....

.....

.....

.....

(Total for Question 4 = 11 marks)



- 6 (a) Figure 9 shows two technicians, L and M, measuring the speed of sound in air.

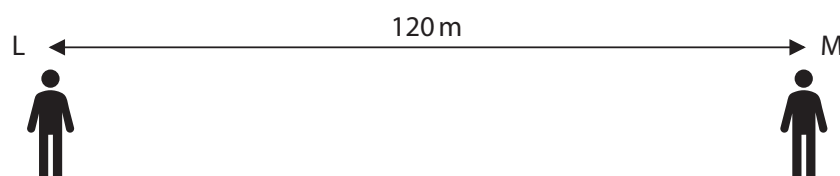


Figure 9

L fires a starting pistol.

M starts a stopwatch when first seeing the smoke from the starting pistol.

M stops the stopwatch when hearing the bang made by the starting pistol.

The distance between L and M is 120 m.

M's reaction time is 0.23 s.

The speed of sound in air is 330 m/s.

- (i) Calculate M's reaction time as a percentage of the time sound takes to travel from L to M.

(3)

.....%

- (ii) Which of these would improve the technicians' measurement of the speed of sound?

(1)

- ☐ A Use a firework 'banger' instead of the starting pistol.
- ☐ B Use a stop clock that measures time in minutes.
- ☐ C Increase the distance between L and M.
- ☐ D Decrease the distance between L and M.

- (b) Figure 10 shows the difference in refraction of sound waves and light waves when these waves travel from air into water.

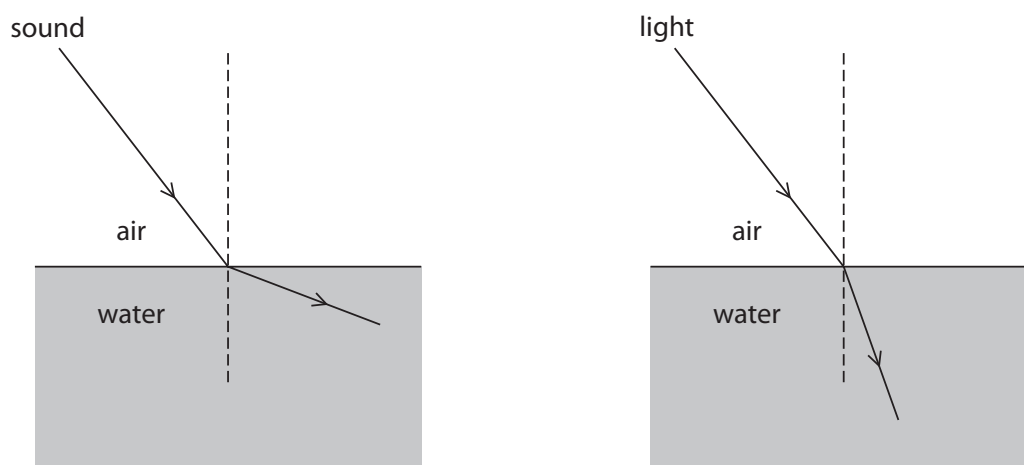


Figure 10

Explain why the refraction of the sound wave is different from the refraction of the light wave in Figure 10.

(3)

.....

.....

.....

.....

.....

.....

(c) Light is one example of an electromagnetic wave.

Light can transfer energy from a lamp to the leaf of a plant, causing chemical reactions in the leaf.

Describe examples of **two** other electromagnetic waves transferring energy.

(4)

1

.....

.....

.....

2

.....

.....

.....

(Total for Question 6 = 11 marks)



12-MARK QUESTIONS

3 questions in this booklet



- 10 Figure 14 shows the hearing responses of a human, a mouse and a bird over a range of frequencies of sound.

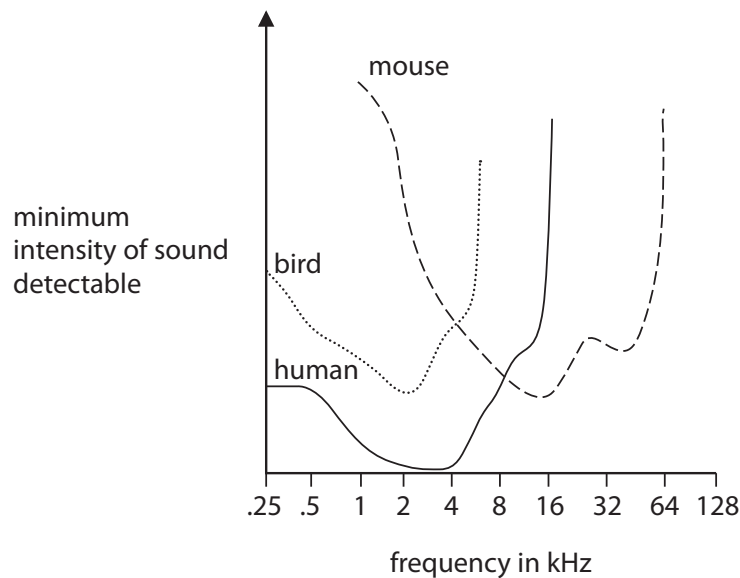


Figure 14

- (a) (i) Describe **two** differences between the hearing responses of the human and the mouse.

(2)

1

2

- (ii) A farmer wants to use an alarm to scare away these birds.

State which frequency would be most effective.
Give the appropriate units.

(1)

frequency

(iii) State the reason for your choice of frequency in (ii).

(1)

.....

.....

.....

(b) Describe the difference between 'infrasound' and 'ultrasound'.

(2)

.....

.....

.....

.....



(c) A transducer can transmit and detect ultrasonic waves.

Figure 15 shows ultrasonic waves transmitted by the transducer on the bottom of a ship.

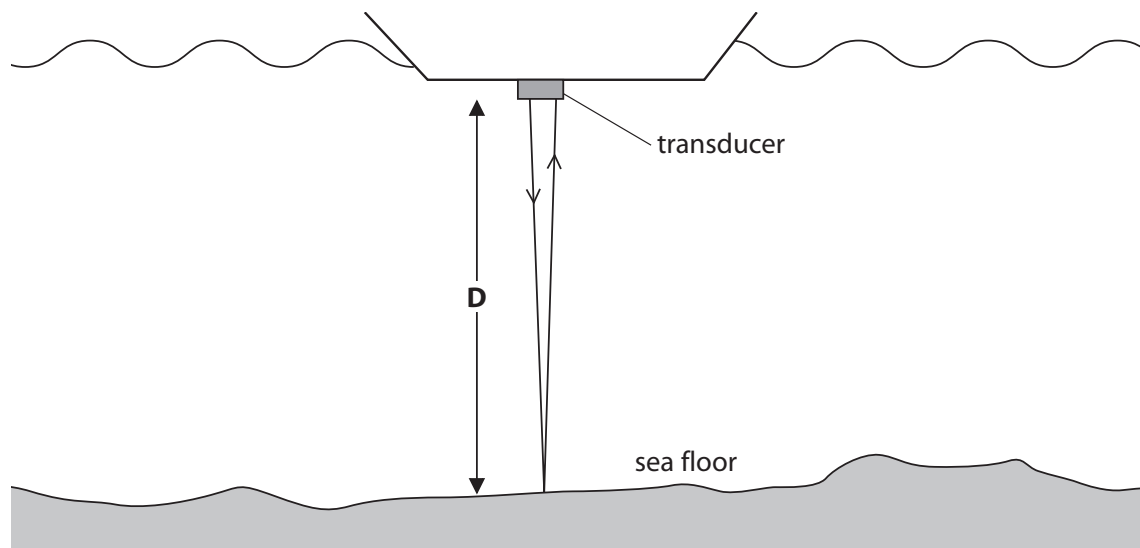


Figure 15

The waves reflect off the sea floor and are received back at the transducer.

The waves travel at 1500 m/s.

The time between transmission and reception is 48 milliseconds.

Calculate the depth of water, D , shown in Figure 15.

(2)

depth of water, $D =$ m



(d) Explain how vibrations from earthquakes may be used to study the core of the Earth.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 10 = 12 marks)



10 (a) The human ear can only detect frequencies below ultrasound and above infrasound.

(i) Which of these gives the approximate range of frequencies for the human ear?

(1)

- ☐ **A** 2 kHz to 2 Hz
- ☐ **B** 20 kHz to 20 Hz
- ☐ **C** 2000 kHz to 2 kHz
- ☐ **D** 200 kHz to 20 kHz

(ii) Suggest **two** reasons why there are limits to the frequencies that a human ear can detect.

(2)

1

.....

2

.....



(b) Ultrasound can be used to find cracks in metals.

Figure 13a shows the signals emitted and received when the metal bar has no cracks.

Figure 13b shows the signals emitted and received when the metal bar has a crack.

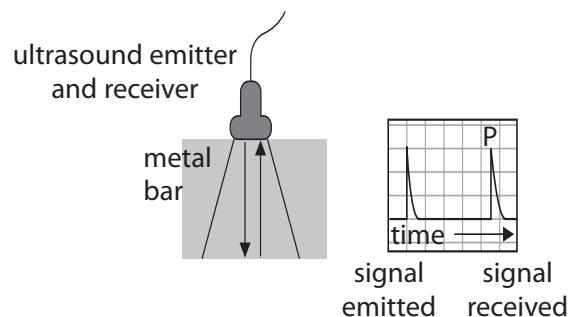


Figure 13a

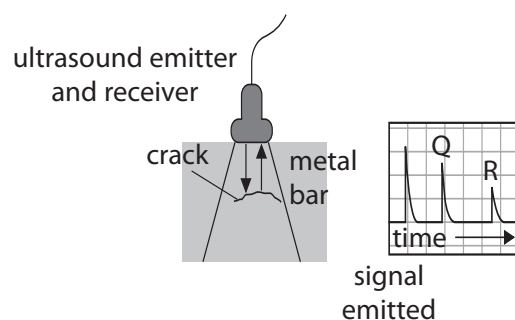


Figure 13b

(i) Explain how the signals in Figure 13a and Figure 13b show that there is a crack in the metal bar in Figure 13b.

(2)

.....

.....

.....

.....

(ii) Suggest **one** reason why the amplitude of signal R in Figure 13b is smaller than the amplitude of signal P shown in Figure 13a.

(1)

.....

.....

*(c) The table in Figure 14 gives information about seismic waves, S waves and P waves, produced by an earthquake.

S waves	P waves
transverse	longitudinal
slow moving	fast moving
travel through solids	travel through liquids and solids

Figure 14

Figure 15 shows

- the paths of some S waves and P waves coming from an earthquake
- the types of wave detected in different regions (A, B and C) of the Earth's surface.

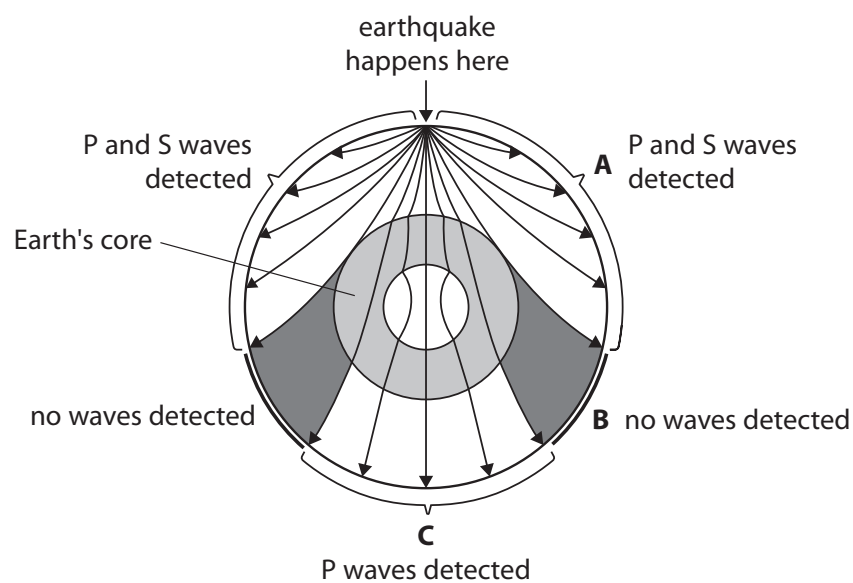


Figure 15

Explain what the diagram in Figure 15 shows about the density of the Earth and the nature of the Earth's core.

Use information from the table in Figure 14 and the diagram in Figure 15 in your answer.

(6)

(Total for Question 10 = 12 marks)



10 (a) Which row of the table shows two transverse waves?

(1)

☐ A	infrasound	infrared
☐ B	infrared	ultraviolet
☐ C	ultrasound	infrasound
☐ D	ultraviolet	ultrasound

(b) Figure 16 is an energy diagram for a sound wave incident on a sound-insulating board.

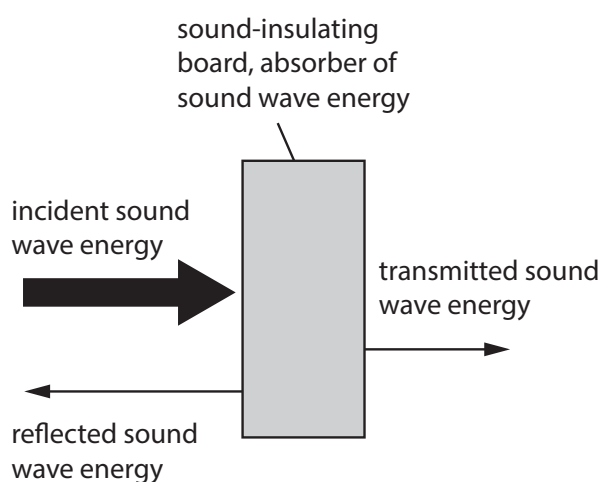


Figure 16

(i) The incident energy is 0.25 J.

The absorbed energy is 67 % of the incident energy.

The reflected energy is 15 % of the incident energy.

Calculate the amount of the transmitted energy.

(2)

transmitted energy = ... J

(ii) Give **one** way to reduce the percentage of energy transmitted through the sound-insulating board.

(1)

(c) The ratio of the absorbed energy E_a to incident energy E_i is the coefficient of absorption of sound α .

$$\alpha = \frac{E_a}{E_i}$$

The table in Figure 17 gives the coefficient of absorption for various materials.

material	$\alpha = \frac{E_a}{E_i}$
curtains	0.55
painted walls	0.02
wood floors	0.10
carpeted floors	0.60

Figure 17

Explain why rooms with carpets and curtains are less noisy than rooms without them.

Use the information given in Figure 17 in your answer.

(2)



(6)



(Total for Question 10 = 12 marks)

MARK SCHEMES

official Pearson Edexcel mark schemes



Question Number	Answer	Additional Guidance	Mark
1(a)	foetal scanning (1)	ignore sonar ACCEPT echo location accept other examples e.g. dog whistle cat scarer bat detector kidney stones cleaning jewellery baby scanner pregnancy scanner faults in structures	(1) AO 1 1

Question Number	Answer	Additional Guidance	Mark
1(b)	studying the Earth's structure (1)	accept other examples e.g. detect meteor(ites) seismic activity named animals communicating e.g. elephants giraffes whales	(1) AO 1 1

Question Number	Answer	Additional guidance	Mark
1(c)	recall (1) $v = \frac{x}{t}$ rearrangement (1) $t = \frac{x}{v}$ substitution (1) $\frac{14 \times 2}{1600}$ evaluation (1) 0.018 (s)	substitution and rearrangement in either order max 3 marks if 14 used as distance accept numbers that round to 0.018 e.g. 0.0175 (s) award full marks for the correct answer with no working	(4) AO 1 1 AO 2 1

(Total for Question 1 = 6 marks)

Question number	Answer	Mark
1(a)	D 23 kHz A,B and C are not correct because they are all below 20 kHz	(1) AO2

Question number	Answer	Additional guidance	Mark
1(bi)	An explanation linking: frequency (1) in mouse hearing range but not in human hearing range (1)	accept wavelength relevant frequency value with unit eg >20 kHz	(2) AO2

Question number	Answer	Additional guidance	Mark
1(bii)	A description to include: send pulse to a wall/reflecting surface OR detect the echo (1) measure distance (to wall and time to echo) (1) use speed = $2 \times \frac{\text{distance}}{\text{time}}$ (1)	accept measure time to receive echo OR reflection back OR record time to echo/return	(3) AO3

(Total for Question 1 = 6 marks)



1(a)	substitution and rearrangement (1) $(f =) \frac{330}{11(\times 10^{-3})}$ evaluation (1) 30 000 (Hz)	award full marks for the correct answer without working 30 or 300 or 3000 scores 1 mark	(2) AO2
-------------	---	---	--------------------------

	Answer	Additional guidance	Mark
1(b)	Two possible methods: selection (1) distance = speed x time substitution (1) (total distance =) $330 \times 18 \times 10^{-3}$ evaluation of total distance (1) 5.9(4) (m) evaluation of distance from bat to prey (1) 3.0 (m) OR selection (1) distance = speed x time division of time by 2 (1) 9×10^{-3} substitution (1) (total distance =) $330 \times 9 \times 10^{-3}$ evaluation of distance from bat to prey (1) 3.0 (m)	speed = distance / time $330 = d / 18 \times 10^{-3}$ $330 \times 18 \times 10^{-3}$ scores mp1 and mp2 allow their distance divided by 2 for MP4 allow 2.97 (m) 5.94 scores 3 marks 5.94 to any other power of 10 scores 2 marks 2.97 or 3 to any other power of 10 scores 3 marks speed = distance / time $330 = d / 9 \times 10^{-3}$ $330 \times 9 \times 10^{-3}$ scores mp1 and mp2 and mp3 allow 2.97 (m) 2.97 or 3 to any other power of 10 scores 3 marks award full marks for the correct answer without working	(4) AO2

Total for Question 1 = 6 marks.



Question Number	Answer	Mark
1(a)	The only correct answer is A 2.2 Hz <i>B, C and D are not correct because they are too high.</i>	(1) A01.1

Question Number	Answer	Additional guidance	Mark
1(b)	selection of $\text{speed} = \frac{\text{distance}}{\text{time}}$ (1) rearrangement and substitution (1) time = $\frac{7.6}{330} (\times 2)$ evaluation (1) 0.046 (s)	time = $\frac{\text{distance}}{\text{speed}}$ allow values that round to 0.046 e.g. 0.04606 award full marks for the correct answer without working 0.023(03) scores 2 marks	(3) A02.1

Question Number	Answer	Additional guidance	Mark
1(c)	an explanation linking frequency / Hz (of infrasound) (1) is too low (1) ALTERNATIVE named ear part (1) effect (1)	below our hearing range below 20 Hz scores 2 marks cochlea / hairs / membrane / ossicles / bones / ear drum not able to vibrate / too stiff / too flexible / too thick / too thin	(2) AO2.1

Total for Question 1 = 6 marks

Question Number	Answer	Additional guidance	Mark
5(a)	a description to include: (the prong makes the) air vibrate/oscillate (1) in the same direction as /parallel to the wave travels (1)	causes compressions and rarefactions in air transfers ke to air longitudinal credit can be given for a labelled diagram	(2) AO 1 1

Question Number	Answer	Additional guidance	Mark
5(b)	in this order infrared (wave) / IR (1) micro(wave) (1) radio (wave) (1) gamma (ray/wave)(1)	accept μ(wave) accept γ not X	(4) AO 1 1

Question Number	Answer	Additional guidance	Mark
5(c)	an explanation linking: (the colours have) different wavelengths (1) different wavelengths / colours travel at different speeds (1) so refract by different amounts (1)	allow the word frequencies for wavelengths for refract allow bend/change direction/follow different path	(3) AO 2 1

(Total for Question 5 = 9 marks)



Question number	Answer	Additional guidance	Mark
5 (a)	recall and rearrangement (1) $\lambda = \frac{v}{f}$ evaluation (1) 3.08 (m) (so) length of aerial = 1.54 m (1) check working $\frac{3 \times 10^8}{2} = 1.5 \times 10^8$ gets only 1 mark for ecf	$\frac{3.0 \times 10^8}{97.4 \times 10^6}$ accept 3.1 (m) award 1 mark for wavelength that rounds to 3.1 to any other power of 10 independent mark. allow ECF from candidate's wavelength accept 1.5 (m) award 2 marks for 1.5 to any other power of 10 award full marks for the correct answer without working Allow 1.46 rounded to 1.5 for 1 mark only if it is ecf from mp2	(3)

Question number	Answer	Additional guidance	Mark
5 (b)	A description including two from: trace / mark where the ray went into and out of(through) the glass block / line on either side of glass block(1) (remove block) join entry and exit points (of ray of light) (1) use the protractor to measure the angle between the refracted/drawn ray and the normal (1)	accept 90° line etc.	(2)

Question number	Answer	Additional guidance	Mark
5 (c)	explanation linking: wave P refracts (towards the normal) (1) because P slows down (1) AND wave Q is reflected (at an equal angle from the boundary) (1) without change of speed of Q (1)	accept 'upper layer' for 'P' accept 'wavelength decreases' accept 'bends' for 'refracts' in this instance accept 'lower layer' for 'Q' accept 'wavelength unchanged' accept 'wave Q bounces off' (at an equal angle) allow one mark for refraction and reflection if no other mark awarded	(4)

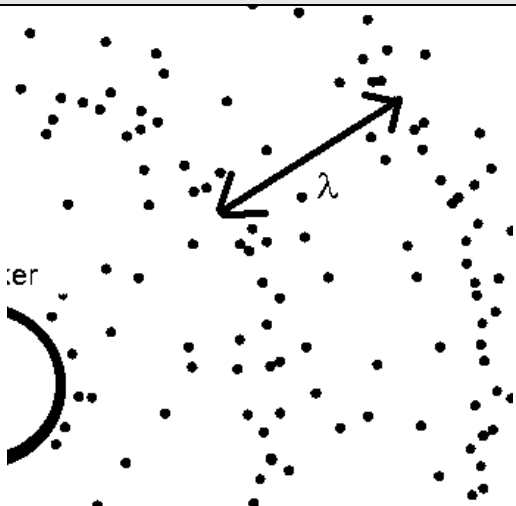
Total for Question 5 = 9 marks



Question number	Answer	Additional guidance	Mark
6 (a)(i)	substitution (1) $\% \text{ difference} = \frac{(240 - 343)}{343} \times 100$ evaluation (1) (-) 30 (%)	OR $343 - 240$ in numerator award full marks for the correct answer without working allow 1 mark for division by 240 yielding 43% allow one mark for $\frac{240 \times 100}{343} = 70\%$	(2)

Question number	Answer	Additional guidance	Mark
6 (a) (ii)	explanation linking any two of: reaction time is significant (with 0.5s or less) (1) the reaction time will be different for each of the students (1) effects on reaction times (1) students are at different distances (from starting pistol) (1) anticipation of flash / bang (1)	accept reaction time is large compared with travel time differences in perception / acuity of light and sound	(2)

Question number	Answer	Additional guidance	Mark
6(a)(iii)	explanation linking: use a (much) longer distance OR use electronic timer (1) with effect (1) reduces/eliminates the significance/impact of the reaction time OR gives a more manageable time to measure	all stand the same distance from the starting pistol (1)	(2)

Question number	Answer	Additional guidance	Mark
6(b)(i)	 (1)	any similar distance labelled wavelength / λ between the equivalent of 2 consecutive compressions	(1)

Question number	Answer	Additional guidance	Mark
6(b)(ii)	description including any two from: particles vibrate / oscillate/ move backwards and forwards (1) along a radius/ parallel to direction of travel/ energy transfer (1) about mean /fixed positions (1)	allow air for particles in same direction as wave allow one mark for 'sound is a longitudinal wave' if no other mark awarded	(2)

Total for Question 6 = 9 marks

Question number	Answer	Additional guidance	Mark
2(a) CS1	uses data taken from x axis (1) 28(cm) (1)	 award full marks for correct answer without working	(2) AO3

Question number	Answer	Additional guidance	Mark
2 b(i) CS1	a description to include count the number of waves(1) (arriving/passing a point) in a specific time(1) use frequency = $\frac{\text{number of waves}}{\text{time}}$ (1)	 ignore in one second count the number of waves in one second scores 2 marks (MP1 and MP3) find the time between one wave and the next scores 2 marks (MP1 and MP2)	(3) AO1

Question number	Answer	Additional guidance	Mark
2 b(ii) CS1	substitution (1) $1.5 = 0.7 \times \lambda$ rearrangement and evaluation $2.1(4) \text{ m}$	$\frac{1.5}{0.7}$ allow $\frac{0.7}{1.5}$ for 1 mark award full marks for correct answer without working. $\lambda = v/f$ scores 1 mark	(2) AO2

Question number	Answer	Additional guidance	Mark
2 b(iii) CS1	A description to include: mention of oscillations/vibrations (1) EITHER transverse – (oscillations) perpendicular to direction of wave (travel) (1) OR longitudinal - (oscillations) in same direction as wave (travel) (1)	up and down OR side to side (movements) OR back and forth transverse movement up and down but longitudinal is side to side (1 mark only)	(2) AO1

Total marks for Question 2H = 9



Question Number	Answer	Additional guidance	Mark
3(a)(i)	10(.0) (cm)		(1) AO1.1

Question Number	Answer	Additional guidance	Mark
3(a)(ii)	12(.0) (cm)		(1) AO1.1

Question Number	Answer	Additional guidance	Mark
3(a)(iii)	a description to include time a wave (crest) over a measured/fixed/known/stated distance (1) use (speed =) $\frac{\text{distance}}{\text{time}}$ (1) ALTERNATIVE METHOD (determine frequency by measuring) the time taken for a set number of waves to pass a point (1) use (speed =) $f \times \lambda$ (1)	measure how long it takes for a wave to travel a set distance measure distance travelled in a stated time (count) the number of waves in a specified time 'measure frequency' is not sufficient for this mark use (speed =) $f \times (0.)12$	(2) AO1.2

Question Number	Answer	Additional guidance	Mark
3(b)(i)	any one from electromagnetic (wave) (1) ripples/water (waves) (1) (waves on a) string (1)	radio(waves) / microwaves / IR / infrared / visible / light / UV / ultraviolet / X(-ray) / gamma / γ allow sea / ocean / tidal wave ignore waves on a spring ignore earthquake or seismic P or S	(1) AO1.1

Question Number	Answer	Additional guidance	Mark
3(b)(ii)	a description to include: (causes it to) vibrate/oscillate (1) perpendicular/at right angles to (the direction of travel of) the wave (1)	can be shown on diagram allow shake in this context allow double headed arrow(s) $\leftrightarrow$ or $\updownarrow$ centred on R on diagram (to show vibration) allow “up and down” or “forwards and backwards” for vibration perpendicular/at right angles to (direction of) energy transfer allow horizontal arrow(s) $\rightarrow$ or $\leftarrow$ centred on R on diagram (to show direction) allow side to side OR left to right OR in and out for perpendicular $\leftrightarrow$ centred on R scores 2 marks ignore possible eventual consequences e.g. rock breaks up / heats up	(2) AO2.1

Question Number	Answer	Additional guidance	Mark
3(b)(iii)	calculation of distance from R to L (1) $(= 4500 \times 3.8)$ $= 17\,000 \text{ (m)}$ calculation of distance from X to R (1) $(= 20\,000 - 17\,000)$ $= 3000 \text{ (m)}$ ALTERNATIVE METHOD calculation of time X to L (1) $(20\,000 / 4500 =) 4.44$ calculation of distance from X to R (1) $(= (4.44 - 3.8) \times 4500)$ $= 3000 \text{ (m)}$	accept 17 100 allow ECF from MP1 accept numbers which round to 3000 e.g. 2900 accept numbers which round to 3000 e.g. 2900 award full marks for the correct answer without working	(2) AO2.1

Total for Question 3 = 9 marks



Question number	Answer	Additional guidance	Mark
4 (a) (i)	$(1.98 - 1.86) = (+/-) 0.12$		(1) AO2

	Answer	Additional guidance	Mark
4(a)(ii)	$(\text{velocity} =) \frac{330 \times 0.12}{1.86} \quad (1)$ $(+/-) 21.3 \text{ (m/s)} \quad (1)$	ecf from 4ai accept numbers that round to 21 (m/s) award 1,2 marks for (i) and (ii) for the correct answer for (ii) even without working	(2) AO2



	Answer	Additional guidance	Mark
4 (b)	(there is) an increase in wavelength (of light) (1) shows <u>galaxies</u> are moving away (from Earth) (1)	allow wavelength stretches allow red shift ignore shift to red end of spectrum ignore objects / stars / planets	(2) AO1

	Answer	Additional guidance	Mark
4 (c)	1(.0) (1) mm (1)	Allow values between 1.0 and 1.9 allow 1×10^{-3} m or 0.001 m for 2 marks if nothing in answer line, credit answer indicated in table	(2) AO3

	Answer	Additional guidance	Mark
4 (d)(i)	gravitational attraction / gravitational force (causing collapse) (1)	allow gravity ignore weight ignore gpe ignore gravitational energy	(1) AO1

	Answer	Additional guidance	Mark
4 (d)(ii)	An explanation linking: (gravity causing) increase in temperature (1) (until hot enough for) fusion (1) (until) balance (between gravity and fusion/thermal) (1)	allow increase in pressure/density hydrogen to form helium allow nuclear reactions ignore fission allow equilibrium / counteracts	(3) AO1

Total for Question 4 = 11 marks.

	Answer Additional guidance	Mark
--	-------------------------------	------



6(a)(i)	calculation of time of travel (1) $(120/330 =) 0.36(36)$ (s) substitution (1) $\frac{0.23 \times 100}{0.36(36)}$ evaluation (1) 63 (%)	ecf from MP1 for MP2&3 accept values that round to 64 or 63 accept values that round to 0.64 or 0.63 for 2 marks award full marks for the correct answer without working	(3) AO2
----------------	--	--	--------------------------

	Answer	Mark
6(a)(ii)	C Increase the distance between L and M. A, B and D are incorrect as these would not improve the technicians' measurement	(1) AO3

	Answer	Additional guidance	Mark
6(b)	an explanation linking: (refraction caused by) change in speed (1) sound speeds up (when entering water) (1) light slows down (when entering water) (1)	allow 3 marks for sound speeds up and light slows down (when entering water) allow 2 marks for sound speeds up (when entering water) OR light slows down (when entering water) if no other marks scored allow 1 mark for description of any speed change (when entering water) if no other marks scored allow 1 mark for wavelength changes ignore references to transverse, longitudinal.	(3) AO1

	Answer	Additional guidance	Mark
6(c)	example 1 e-m wave (1) corresponding result of energy transfer (1) example 2 e-m wave (1) corresponding result of energy transfer (1)	e.g. radio waves: communication, oscillations (of electrons) in wires microwaves: cooking, communications and satellite transmissions, internal heating of body cells, increase KE/vibration of water molecules infrared: cooking, thermal imaging, optical fibres, television remote controls, skin burns ultraviolet: security marking, fluorescent lamps, detecting forged bank notes and disinfecting water, damage to surface cells and eyes, skin cancer x-rays: observing the internal structure of objects, airport security scanners and medical x-rays, mutation or damage to cells in the body, cancer gamma rays: including sterilising food and medical equipment, and the detection of cancer and its treatment, mutation or damage to cells in the body, cancer additional effect for visible light scores 1 mark e.g. : including vision, photography and illumination	(4) AO1

Total for Question 6 = 11 marks.

	Answer	Mark
--	--------	------

Question number	Answer	Additional guidance	Mark
10(a)(i)	Any two valid differences e.g. mice are (more) sensitive to higher frequencies (than humans) (1) humans are (more) sensitive to lower frequencies (than mice) humans have a lower intensity of sound (threshold) to just hear (1) mice have two minima on the graph, humans one (1)	humans more sensitive (overall / for lower frequencies) two particularly sensitive frequencies	(2) grad

Question number	Answer	Additional guidance	Mark
10(a)(ii)	number and unit must both be correct to get the mark 2.5 kHz OR 2.5 kilohertz	acceptable range 2.0 to 3.0 kHz 2.0 to 3.0 kilohertz	(1) cler

Question number	Answer	Additional guidance	Mark
10(a)(iii)	(this frequency corresponds with) most sensitive / the minimum (frequency) (1)		(1) grad

Question number	Answer	Additional guidance	Mark
10 (b)	description including: infrasound < 20 Hz (1) ultrasound > 20 000 Hz (1)	 award 1 mark for infrasound lower frequency than ultrasound OR reverse argument	(2) grad

Question number	Answer	Additional guidance	Mark
10 (c)	recall and substitution (1) $D = \frac{1}{2} v \times t = \frac{1}{2} 1500 \times 0.048$ evaluation (1) 36 (m)	 award full marks for the correct answer without working award 1 mark only for 72 m (i.e. $\frac{1}{2}$ ignored)	(2) grad

Question number	Answer	Additional guidance	Mark
10 (d)	An explanation linking any four from use of seismometers (1) waves can be refracted in the interior of the earth (1) (showing) different densities (1) some seismic waves are longitudinal and some transverse (1) S/transverse waves cannot pass through liquid (1) S wave / transverse wave shadow zone shows part of the earth must be liquid (1) P / longitudinal waves can go through the core/liquid (1) mention S and P waves (1)	S/transverse waves can only pass through solids	(4) exp

Total for Question 10 = 12 marks

Question Number	Answer	Mark
Q10(a)	B 20k Hz to 20 Hz <i>A is not correct because 2Hz is an infrasound frequency</i> <i>C is not correct because 2000kHz is an ultrasound frequency</i> <i>D is not correct because 200kHz is an ultrasound frequency</i>	(1) AO1

	Answer	Additional guidance	Mark
10 (a) (ii)	An explanation linking any two of :- the size of the parts of the (inner) ear (1) vibrations at (limited) range of frequencies/range of sounds most common as adapted through evolution (1) (membrane) variations in stiffness/width/thickness (1) different parts vibrate at different frequencies (1) eardrum not sensitive enough to detect low/high frequencies (1) brain cannot interpret low/high frequencies (1)	allow length of cochlea allow cochlea allow ultrasound / infrasound allow ultrasound / infrasound	(2) AO2

	Answer	Additional guidance	Mark
10 (b) (i)	An explanation linking two of: the crack reflects/bounces back /echoes the signal (1) in a shorter time/ before it reaches the base of the metal (1)	Q is reflection from crack/P and R are reflections from the base	(2) A03

	Answer	Additional guidance	Mark
10 (b) (ii)	One from:- less of the pulse reaches the base (1) some energy is absorbed by the crack (1) some energy is reflected by the crack (1)	allow less of the pulse is reflected/bounces off base allow signal/wave/energy/ultrasound for pulse allow signal/wave/pulse/ultrasound for energy allow signal/wave/pulse/ultrasound for energy	(1) A01

Question number	Indicative content	Mark
10c	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 3 marks AO3 Strand1 3marks When there is an Earthquake At A • Longitudinal and transverse waves detected • P arrive before S. • must be travelling in a solid because S waves only travel through solids • the region just under the Earth's crust (mantle) must be a solid • the diagram show the waves refracting so the mantle must be getting more dense as it gets deeper At B • No S waves or P waves detected • S waves do not pass through liquid so do not get to B • P waves pass through liquid but are refracted at a solid/ liquid boundary so do not arrive at B • The core of the Earth must be liquid to stop both P and S waves arriving at B At C • No S waves arrive at C • P waves arrive at C at different times because the waves have travelled at different speeds. • This suggests the very centre of the Earth would be solid because the P waves that go through the solid would travel faster and arrive before those that just travelled through liquid	(6) AO1 AO3

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Interpretation and evaluation of the information attempted but will be limited with a focus on mainly just one variable. Demonstrates limited synthesis of understanding. (AO3)
Level 2	3–4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Interpretation and evaluation of the information on both variables, synthesising mostly relevant understanding. (AO3)
Level 3	5–6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Interpretation and evaluation of the information, demonstrating throughout the skills of synthesising relevant understanding. (AO3)

Level	Mark	Additional Guidance	General additional guidance – the decisions within levels
	0	No rewardable material	
Level 1	1-2	<u>Additional guidance</u> Elements of physics present i. e. isolated knowledge of principles, two unconnected statements from any section	<u>Possible candidate responses</u> core is liquid/ mantle (crust) is solid waves refract P waves change direction S and P waves travel through mantle(crust) at A, S and P waves detected at B, no waves detected at C, only P waves detected S waves are transverse P waves are longitudinal
Level 2	3-4	<u>Additional guidance</u> Some knowledge of principles with a logical connection made in ONE section and a statement in ONE other Or From ONE section detailed knowledge of principles with logical connections	<u>Possible candidate response</u> at A, S and P waves are detected so must pass through solid at B no waves are detected, the waves change direction/ Region B is the shadow zone at C, P waves are detected because they go straight through the Earth/can travel through the core in Earth's core there are different densities/waves change direction
Level 3	5-6	<u>Additional guidance</u> Detailed knowledge of principles with logical connections made in TWO of the sections	<u>Possible candidate response</u> at A, S and P waves are detected so must pass through solid and refract/curve at B, no waves are detected because S waves do not pass through liquid core and P waves are refracted away by the liquid. At C, only P waves are detected because they can pass through the liquid core and change direction in the core(refracted) In the Earth's core there is refraction of waves/ inner and outer core have different densities

Total for Question 10 = 12 marks



10 (a)	B infrared ultraviolet A incorrect as infrasound is a longitudinal wave C ultrasound and infrasound are both longitudinal waves D ultrasound is a longitudinal wave	1 AO1.1
---------------	---	-------------------------------------

Question	Answer	Additional guidance	Mark
10(b)(ii)	one from increase the thickness (of it/ the absorber /the insulating board) (1) make the surface (of board) more reflective / make the board more absorbing (1) make board less/more dense (1) put an airgap in the insulating board (1) add another material with different density adjacent to board (1)	do not accept 'add more insulation' on its own ignore mass, surface area, volume, amount and size allow change the density (of the board)	1 AO3.1

Question	Answer	Additional guidance	Mark
10 (c)	An explanation linking more absorption giving less reflection of sound (coefficient of) absorption / α is greater (for carpets / curtains than walls / wood floors) or more of the incident energy/sound is absorbed (1)	ignore references to insulation	2 AO3.1

Question number	Indicative content	Mark
*10 (d)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 • ultrasound pulses used • ultrasound has frequency above 20 kHz • boat has device for producing pulses • ultrasound pulses emitted • ultrasound pulses travel through sea water • pulses reflected by/bounce off/echo off ocean bed • pulses reflected/travel back to boat • time between emission and receipt of pulse measured by device on the boat • velocity of sound in sea water known • use of $v=d/t$	6 AO1.2 A labelled diagram may give some information that is credit worthy
	• speed of sound = distance/time • $d=v \times t$ • either distance halved or time halved prior to calculation of distance accept 'sonar' for ultrasound	

Command verb: Explain

AO targeting: 6 marks AO1 strand 1

Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)



Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> isolated facts about measuring depth of ocean	<u>Possible candidate responses</u> sound emitted from boat sound goes through the sea sound bounces back / echoes time measured $\text{distance} = \text{velocity} \times \text{time}$ uses ultrasound (pulse)
Level 2	3–4	<u>Additional guidance</u> limited description of determination of depth of ocean	<u>Possible candidate responses</u> sound emitted from boat travels to ocean bed and is reflected and time taken from emission to receipt of wave is measured or $\text{distance} = \text{velocity} \times \text{time}$
Level 3	5–6	<u>Additional guidance</u> detailed description of determination of depth of ocean	<u>Possible candidate responses</u> ultrasound pulse emitted from boat ultrasound pulse travels to ocean bed and is reflected time taken for emission to receipt of pulse is measured velocity of sound in sea water known $\text{distance travelled} = \text{velocity} \times \text{time}$ halve distance / halve time measured to calculate depth of ocean Any two from three of ultrasound, pulse, halving of distance or time
			required for Level 3.

Total for question 10 =12 marks

