

PHYSICS



EXAM QUESTION PACK

P5.1 WAVE BEHAVIOUR

SCORE

/150

PERCENTAGE

%

STEMUP

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Gateway Physics A (9-1)

Wave behaviour

Please note that you may see slight differences between this paper and the original.

Candidates answer on the Question paper.

OCR supplied materials:

Additional resources may be supplied with this paper.

Other materials required:

- Pencil
- Ruler (cm/mm)

Duration: Not set

Candidate forename		Candidate surname								
Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

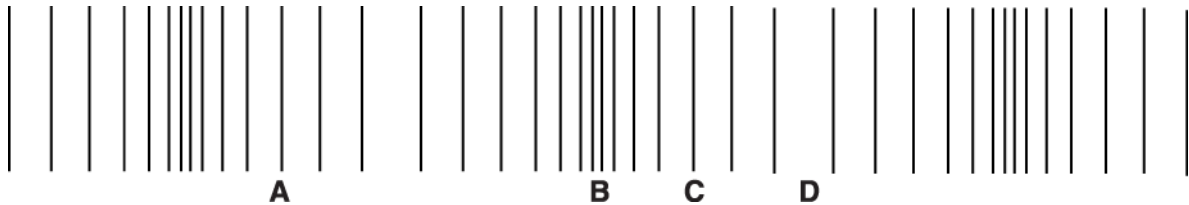
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions, unless your teacher tells you otherwise.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Where space is provided below the question, please write your answer there.
- You may use additional paper, or a specific Answer sheet if one is provided, but you must clearly show your candidate number, centre number and question number(s).

INFORMATION FOR CANDIDATES

- The quality of written communication is assessed in questions marked with either a pencil or an asterisk. In History and Geography a *Quality of extended response* question is marked with an asterisk, while a pencil is used for questions in which *Spelling, punctuation and grammar and the use of specialist terminology* is assessed.
- The number of marks is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is **150**.
- The total number of marks may take into account some 'either/or' question choices.

1(a) Ultrasound is a longitudinal wave.

Look at the diagram of a longitudinal wave.



(i) Which letter **best** shows a compression?

Choose from

A B C D

answer _____

[1]

(ii) Write down the name of the distance between A and C.

_____ [1]

(b) The frequency of an ultrasound wave is 25 000 Hz.

Can humans hear this ultrasound?

Explain your answer.

[2]

2(a) Rene researches the range of sounds that different people can hear.

Rene's research shows that

‘The average person has a hearing range from 20 Hz up to 20 000 Hz’.

Rene tests the hearing range of a group of people.

Look at the data she collects.

Person	Age	Lower frequency limit of hearing in Hz	Upper frequency limit of hearing in Hz	Frequency range of hearing in Hz
Jane	16	22	19000	18978
Alec	16	19	20000	19981
Dionne	16	24		
Niamh	16	16	21000	20984
Evangelos	16	15	20000	19985
average	16	19.2	19800	19780.8

- (i) Rene's original research showed a lower frequency limit of human hearing of 20 Hz.
The data she collects shows an average lower frequency limit of 19.2 Hz.
Suggest reasons for this difference.

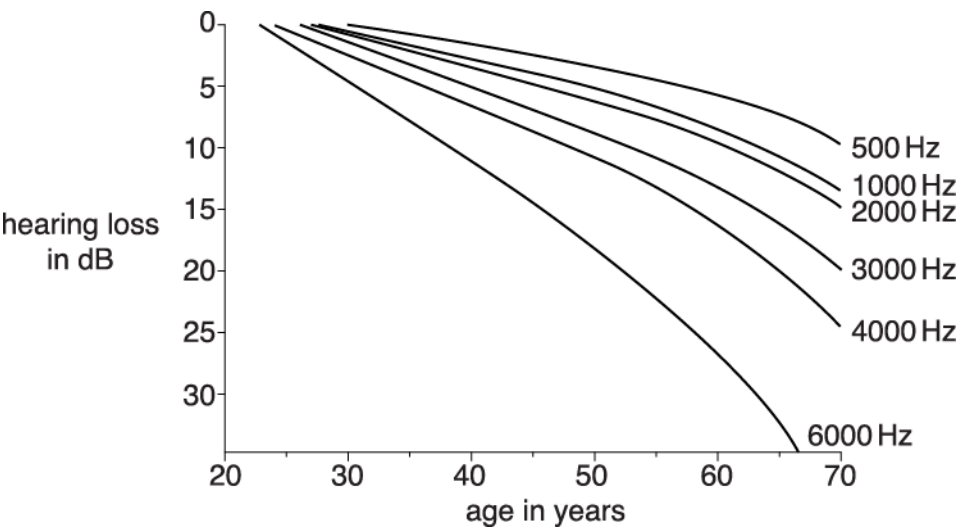
[3]

- (ii) Rene has not completed her table. She has lost some of her results.
Calculate the upper frequency limit of hearing for Dionne.

answer ----- Hz

[2]

(b) Look at the data on hearing level loss at different ages.
It shows the hearing loss in dB for different ages at six different frequencies.



(i) Describe the trends shown by the graph.

[2]

(ii) Scientists are developing hearing aids to help people hear high frequency sounds.
These hearing aids can detect sounds of frequency 6000 Hz and above and change them to sounds of half that frequency.

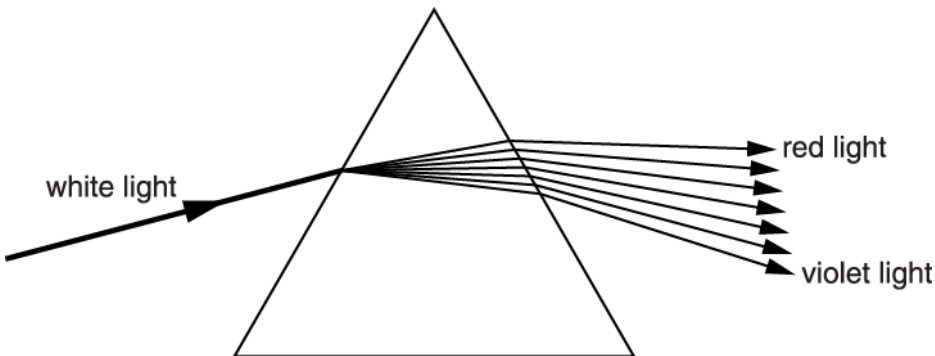
60 year olds can have difficulty hearing sounds above 6000 Hz.
Explain how these hearing aids can improve their hearing.
Use the data from the graph in your answer.

[3]

3

She shines a beam of white light through a prism.

Look at the diagram.



The white light disperses to produce a visible spectrum of colours.

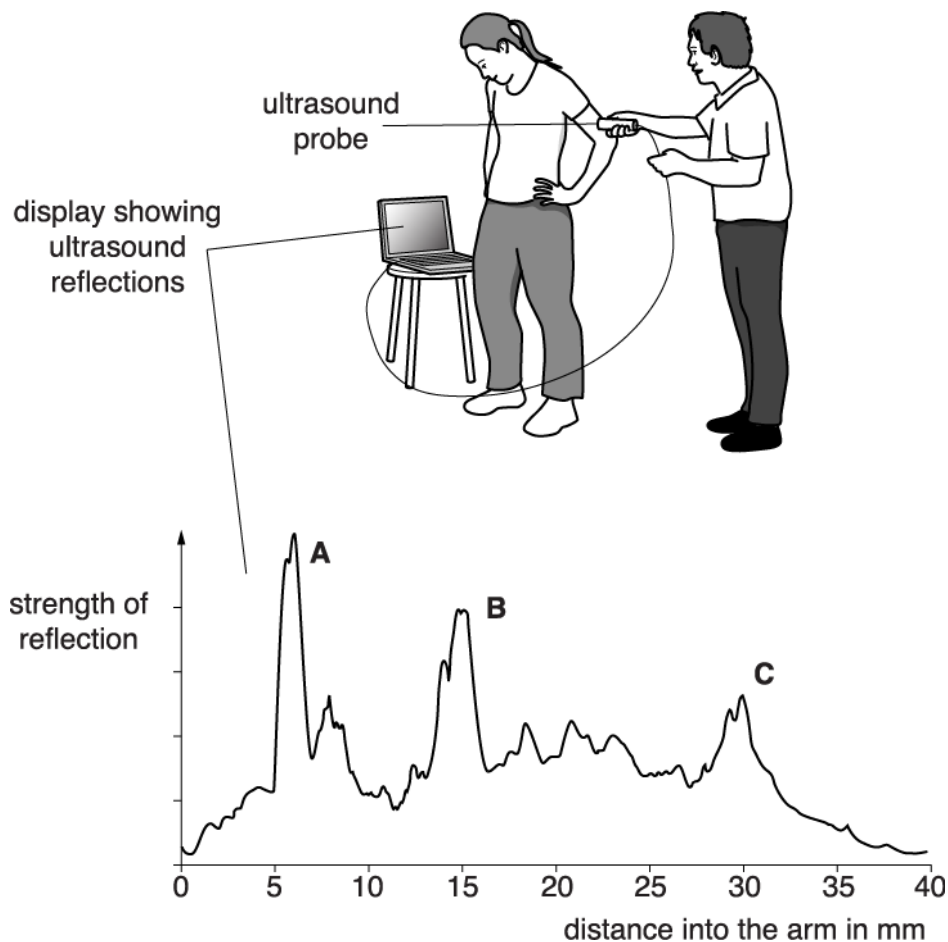
Explain why the white light disperses and why the colours deviate by different amounts.



The quality of written communication will be assessed in your answer to this question.

[6]

Becky has her body fat measured using ultrasound on her arm.



Ultrasound reflects strongly at different tissue layers inside the arm.

The body fat layer is just below the skin.

The different tissue layers in the arm are

- fat-muscle layer
- muscle-muscle layer
- muscle-bone layer

Why is ultrasound used rather than surgery or X-rays to measure body fat?

Explain what the display shows and how it can be used to find the thickness of body fat in Becky's arm.

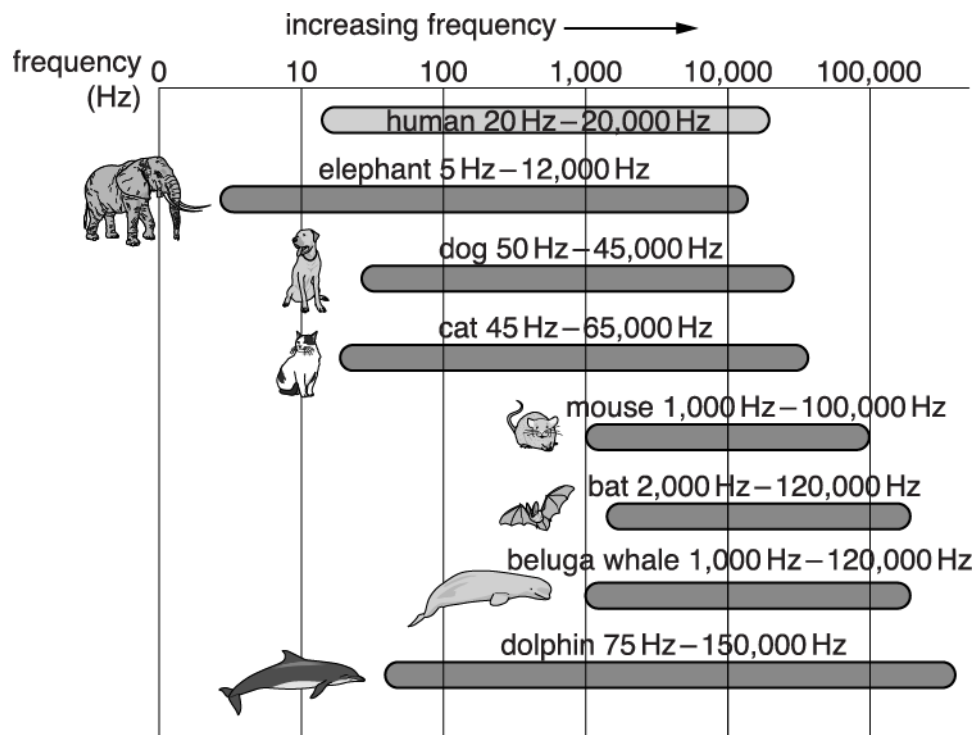


The quality of written communication will be assessed in your answer to this question.

[6]

5(a) Rene researches the range of sounds that different animals can hear. She finds the lowest and highest frequency sounds the animals can hear.

Look at some of her research data.



(i) Which animal can hear the **lowest** frequency?

-----[1]

(ii) Which animal can hear the **highest** frequency?

-----[1]

(iii) Which animal has the largest frequency **range** of hearing?

-----[1]

(b) Rene's research shows that

‘The average person has a hearing range from 20 Hz up to 20 000 Hz.’

Rene tests the hearing range of a group of people.

Look at the data she collects.

Person	Lower frequency limit of hearing in Hz	Upper frequency limit of hearing in Hz	Frequency range of hearing in Hz
Jane	22	19000	18978
Alec	19	20000	19981
Dionne	24	20100	
Niamh	16	19800	19784
Evangelos	15	20000	19985
average	19.2		19760.8

Rene has not completed her table.

- (i) Which person has the largest frequency **range** of hearing?

Explain your answer using a calculation.

----- [2]

- (ii) Calculate the average upper frequency limit of hearing for this group of people.

answer ----- Hz

[2]

- (iii) Rene's original research shows a lower frequency limit of human hearing of 20 Hz.

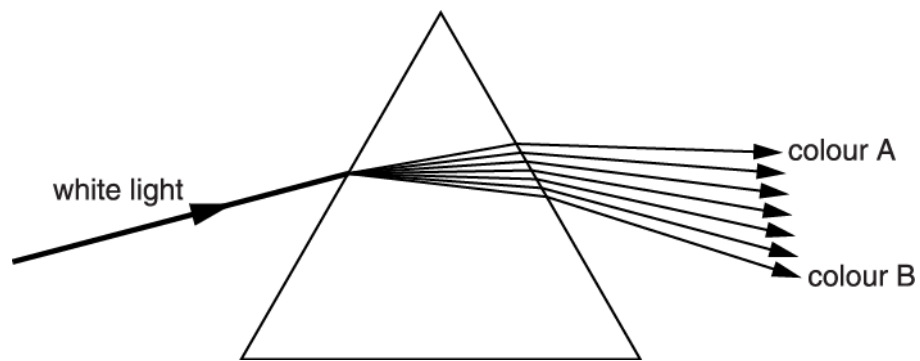
The data she collects shows an average lower frequency limit of 19.2 Hz.

Suggest reasons for this difference.

----- [3]

Chantal shines a beam of white light through a prism.

Look at the diagram.



Complete the sentences about the light.

Choose from

diffracts

frequency

green

amplitude

red

reflects

refracts

violet

wavelength

When the white light enters the prism it _____ and disperses into its seven colours.

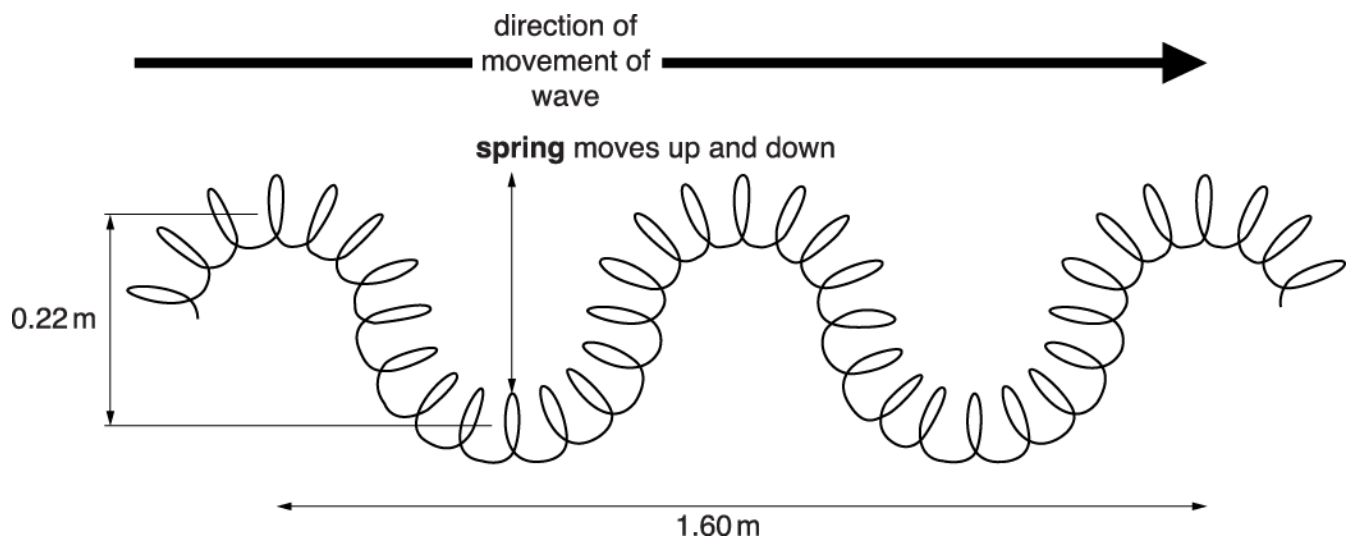
Colour A is _____ .

Colour B has the smallest _____

[3]

7 P waves and S waves are different.

P waves are longitudinal and S waves are transverse. Look at the diagram of a model of a wave made with a slinky spring.



The wave is made by moving the spring up and down with a frequency of 1.2 Hz.

Look at the diagram.

(i) Calculate the **speed** of the wave.

answer ----- m/s

[2]

(ii) What is the **amplitude** of the wave?

Choose from

0.11 m 0.22 m 0.80 m 1.60 m 1.82 m

----- [1]

8(a) Loud sounds can be dangerous and can damage human hearing.

Look at the table about the loudness of different sounds.

Source	Sound	Loudness in dB
A	Busy road traffic	70
B	Front row at a music festival	110
C	Large orchestra	98
D	Aircraft at take off	145
E	Normal conversation	60
F	Rustling leaves	10
G	Vacuum cleaner	80
H	MP3 player at maximum volume	100

Sounds above 90 dB can damage hearing.

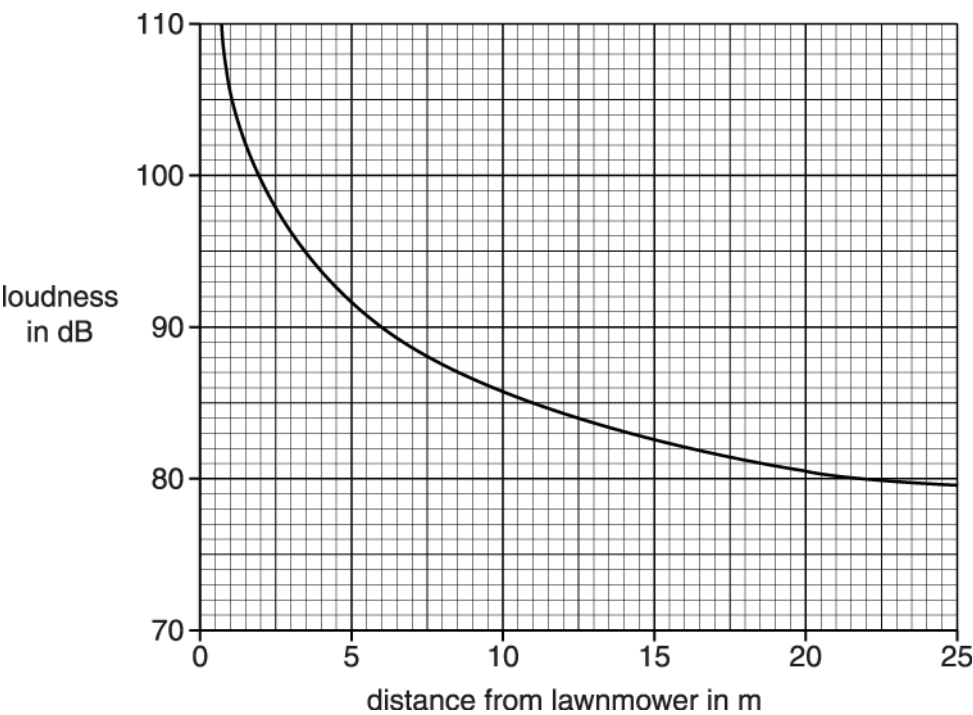
Which sources in the table are above 90 dB?

Choose from A B B D E F G H

answer ----- [2]

(b) Lawnmowers make loud sounds above the safe loudness level of 90 dB.

The graph shows how the loudness changes as you move away from a lawnmower.



(i) Describe how loudness is affected by distance.

----- [2]

(ii) Use the graph to find the loudness when you are 15 m away from the lawnmower.

----- dB

[1]

(iii) A gardener needs to wear ear protection when using the lawnmower.

People in a house nearby do **not** need ear protection when he is using the lawnmower.

Suggest reasons why the gardener needs to wear ear protection, but the people in the house do not.

[2]

(c) Sounds below 90 dB also can damage hearing if the sounds go on for a long time.

Look at the table on maximum safe exposure times.

Loudness in dB	Maximum safe exposure time
85	8 hours
88	
91	2 hours
94	1 hours
97	30 minutes
100	15 minutes
103	7.5 minutes
106	< 4 minutes

(i) Estimate the maximum safe exposure time for a loudness of 88 dB.

-----[1]

(ii) At 106 dB the maximum safe exposure time is < 4 minutes. What does this mean?

-----[1]

(iii) Ravi lives near a noisy factory.

The maximum safe exposure time to the sound from the factory is 32 hours.

Calculate the loudness of the sound from the factory.

-----[1]

9 An infrared wave travels at 2.0×10^8 m/s along an optical fibre.

The wavelength of the infrared wave is 9.0×10^{-7} m.

Calculate the frequency of the infrared wave.

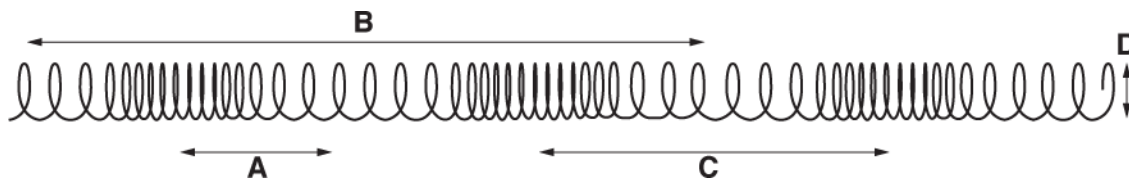
Give your answer to **two** significant figures.

Answer ----- Hz

[3]

10 Ultrasound is a longitudinal wave.

Look at the longitudinal wave in a slinky spring.



(i) Which arrow shows the **wavelength** of this slinky spring?

Choose from A B C D

answer -----[1]

(ii) We can observe the wave moving in the slinky spring and calculate its frequency.

Why is it **not** possible to use this method to find the frequency of an ultrasound wave?

-----[1]

11 A water wave has a frequency of 5.0 Hz and a wavelength of 3.0 m.

Calculate the speed of the water wave.

Answer ----- m / s [1]

12 A student measures the time it takes for the sound from a firework to reach the observer.

She takes 3 measurements of the time taken for four different distances, A, B, C and D.

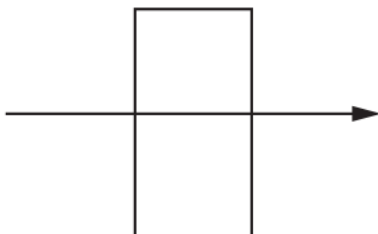
Distance	Time taken (s)		
	1st measurement	2nd measurement	3rd measurement
A	2.16	2.19	2.17
B	1.99	2.02	1.97
C	1.80	1.81	1.89
D	1.69	1.68	1.71

Which distance A, B, C or D, has the largest range of values?

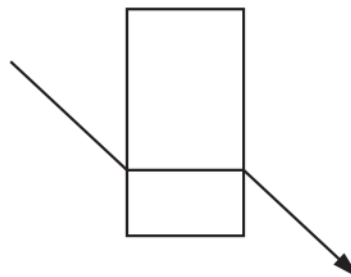
Your answer

[1]

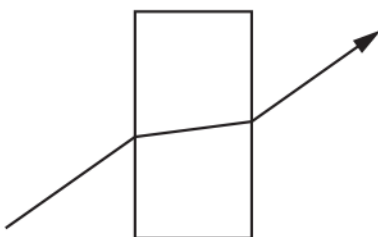
13 Look at the diagrams of a light ray as it passes from air through a glass block.



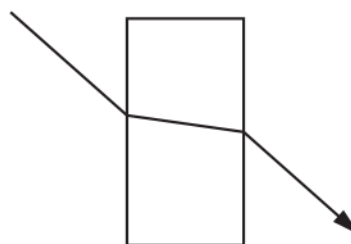
A



B



C



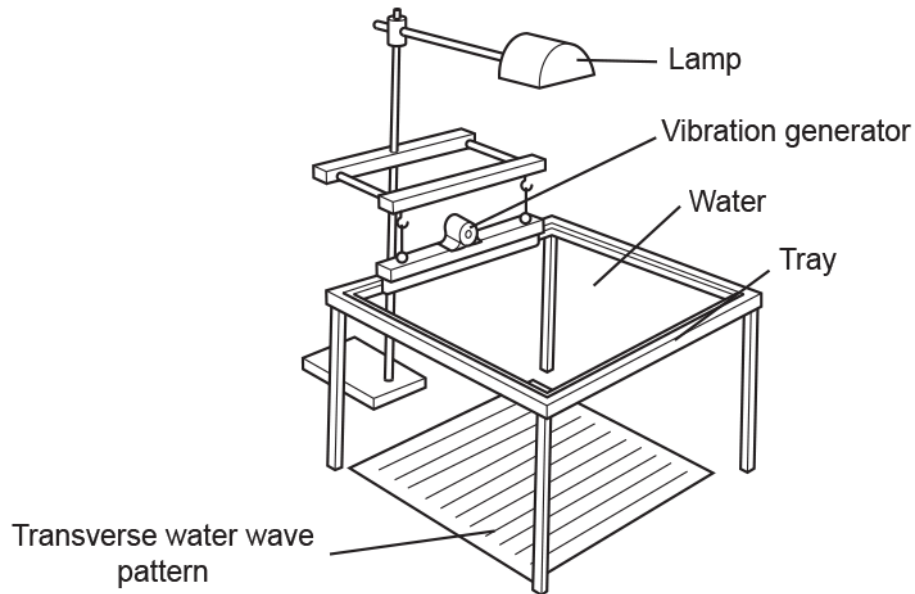
D

Which diagram shows an **incorrect** refraction?

Your answer

[1]

14(a) A teacher uses water waves in a ripple tank to demonstrate **transverse** waves.



She makes measurements of the water waves.

The frequency of the water waves is 0.5 Hz.

(i) Calculate the number of water waves produced in 5 seconds.

Answer = ... [1]

(ii) The teacher **increases** the frequency of the water waves.

Describe what happens to the speed **and** the wavelength of the water waves.

.....

.....

(iii) A student tries to describe water waves in the sea.

'The water waves move up and down. The water particles move all the way across the surface of the sea. This means that water moves in the direction of the waves.'

Part of his explanation is **incorrect**.

Write an improved and correct description about water waves in the sea.

- (b) A student watches a ball game on the school field.

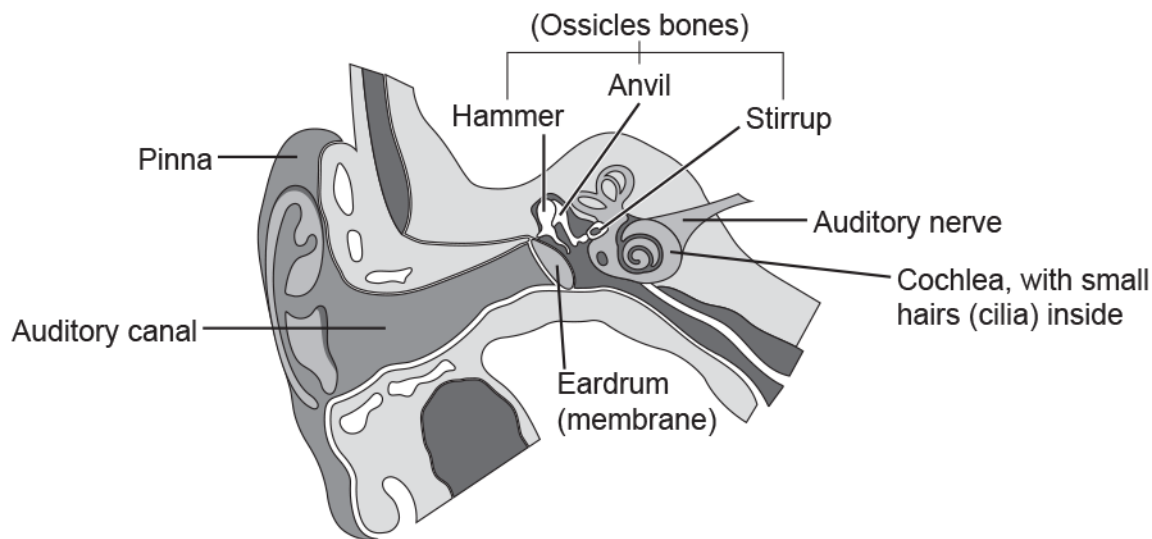
The student sees the ball being hit with a bat but he hears the sound a short time after. This is because the speed of light is much greater than the speed of sound.

Describe an experiment which measures the speed of **sound** in air. In your answer describe the measurements, calculations and procedures needed to gather **accurate** and **reliable** results.

You may draw a diagram as part of your answer.

[5]

(c) Look at the diagram of a human ear.



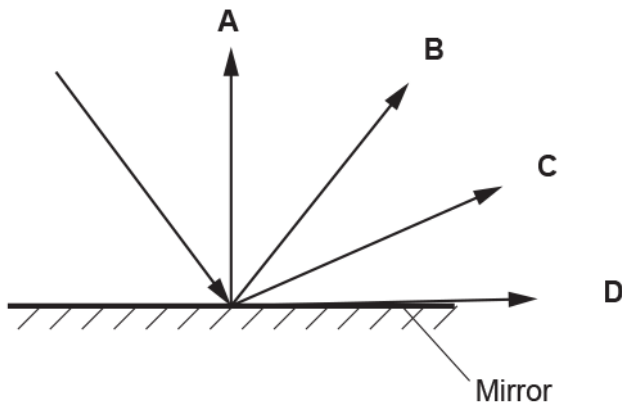
Sound wave disturbances, outside the ear, transfer energy to the small hairs (cilia) inside the cochlea.

The cochlea then sends nerve impulses along the auditory nerve to the brain.

Explain how sound wave disturbances in the air outside the ear transfer to the small hairs (cilia) inside the cochlea.

[3]

15 Which light ray shows the correct reflection from the plane (flat) mirror?



Your answer

[1]

16 A student measures the time it takes for the sound from a firework to reach the observer.

She takes 3 measurements of the time taken for four different distances, A, B, C and D.

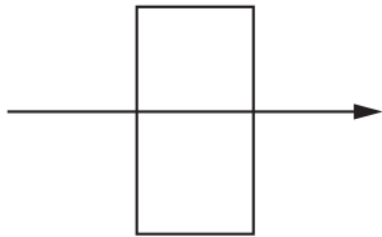
Distance	Time taken (s)		
	1st measurement	2nd measurement	3rd measurement
A	2.16	2.19	2.17
B	1.99	2.02	1.97
C	1.80	1.81	1.89
B	1.69	1.68	1.71

Which distance A, B, C or D, has the largest range of values?

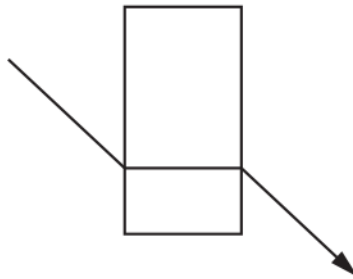
Your answer

[1]

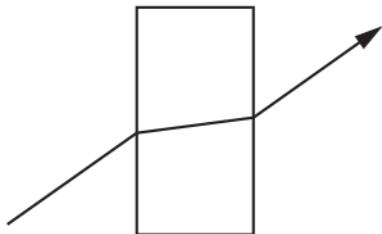
17 Look at the diagrams of a light ray as it passes from air through a glass block.



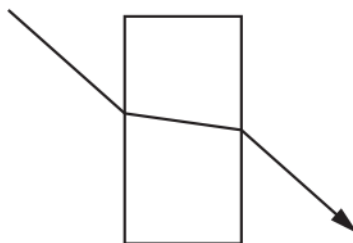
A



B



C



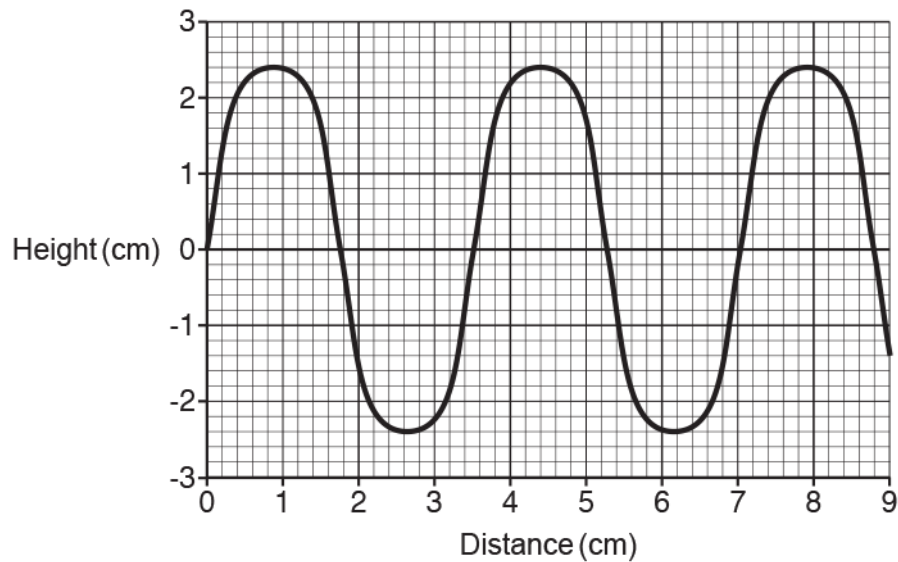
D

Which diagram shows an **incorrect** refraction?

Your answer

[1]

18(a) Look at the diagram of a water wave.



(i) What is the **wavelength** of this wave?

Answer = ... cm [1]

(ii) What is the **amplitude** of this wave?

Answer = ... cm [1]

(iii) The wavelength of the wave is changed to 25 cm. Two waves are produced each second.

Use the equation: Wave speed = Frequency $\times$ Wavelength

Calculate the speed of the wave.

Answer = ----- m/s [2]

(b) Water waves are transverse and sound waves are longitudinal.

(i) Describe how water particles move in a **transverse** water wave.

----- [1]

(ii) Describe how air particles move in a **longitudinal** sound wave.

----- [1]

19(a) A student watches a ball game on the school field.

The student sees the ball being hit with a bat but he hears the sound a short time after. This is because the speed of light is greater than the speed of sound.

He decides to do an experiment to measure the speed of sound waves in air.

Describe which measurements he needs to measure this speed.

----- [2]

(b) Which equation is used to calculate speed?

-----[1]

(c) Describe one way he could get valid results for this experiment.

-----[1]

20 Fig. 20.1 shows thinking, braking and stopping distances for the same car travelling at different speeds.

Speed (m/s)	Thinking distance (m)	Braking distance (m)	Stopping distance (m)
8	6	6	12
16	12	24	36
32	24	96	120

Fig. 20.1

Describe how the **thinking distance** changes when the speed doubles.

Use data from the table in your answer.

-----[1]

21 A sound wave travels in air and enters water.

What happens to the sound wave as it enters the water?

	Speed	Frequency	Wavelength
A	decreases	decreases	decreases
B	decreases	stays the same	decreases
C	increases	increases	increases
D	increases	stays the same	increases

Your answer

[1]

22 An electromagnetic wave transfers energy.

Which row in the table is correct?

	Electromagnetic wave	Energy transfer
A	Infra-red	From a heating element of a toaster to the bread inside
B	Radio	From a radio to a transmitter
C	Gamma rays	From a high voltage supply to heating water in food
D	X-rays	From bones in the body to an X-ray machine

Your answer

[1]

23 The table contains descriptions of wavelength and frequency.

Which row in the table is correct?

	Wavelength	Frequency
A	Distance between a peak and its neighbouring trough.	Number of waves that go past a point in a second.
B	Distance between neighbouring peaks.	Number of waves that go past a point in a second.
C	Distance between neighbouring troughs.	Time period in seconds.
D	Height of the wave.	Number of waves produced.

Your answer

[1]

24(a) A student investigates reflection and refraction of light rays.

The student sends a ray of red light into a glass prism.

Fig. 18.1 shows the light ray as it leaves the glass prism.

On Fig. 18.1 complete the ray of light as it travels towards and through the glass prism.

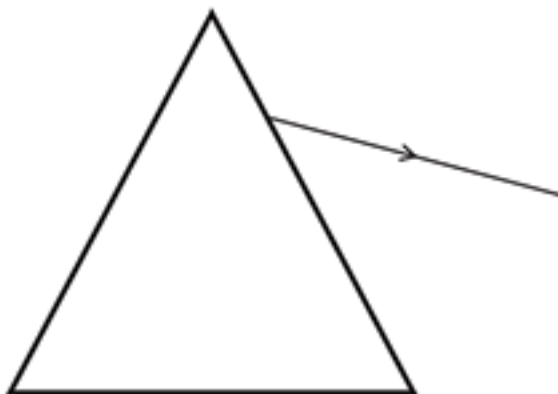


Fig. 18.1

[2]

(b) Fig. 18.2 shows two mirrors placed at 90° to each other.

A light ray hits one of the mirrors at 45° .

On Fig. 18.2 complete the ray of light as it reflects from both mirrors.

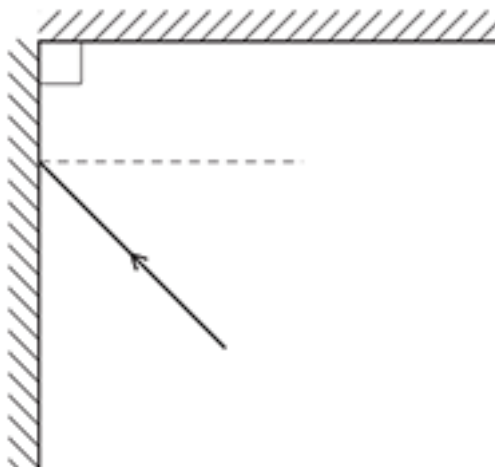


Fig. 18.2

[2]

25(a) Some students try to measure the speed of sound, as shown in Fig. 24.1.

One student makes a loud sound by clapping her hands.

The sound of the clap reflects from the gym wall causing an echo.

Another student measures the time between hearing the clap and hearing the echo.

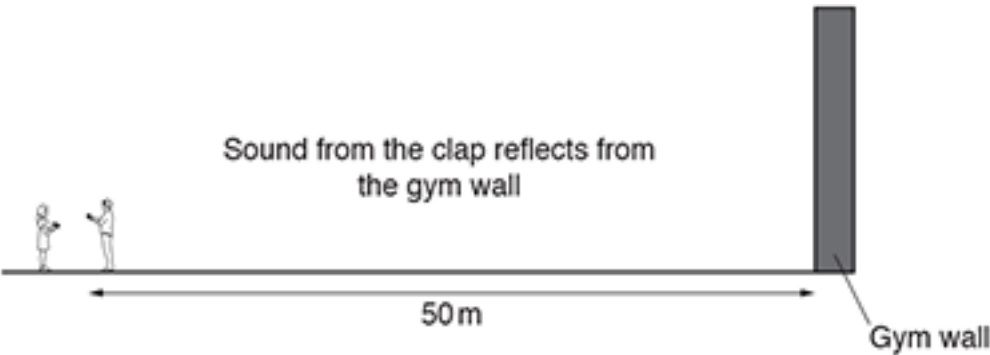


Fig. 24.1

They repeat the experiment three times and record their results in the table below.

Distance to wall (m)	Time 1 (s)	Time 2 (s)	Time 3 (s)	Mean time (s)
50	0.28	0.32	0.54	

(i) The student did not pay attention when recording time 3.

Calculate the **mean** time taken for the sound of the clap to return, using suitable values from the table.

Mean time taken = ... s [1]

(ii) Calculate the speed of sound for the clap.

Use your answer to (i) and the equation: distance travelled = speed × time

Give your answer to significant figures.

Speed of sound = ... m / s [4]

(iii) Describe **two** ways to improve and develop their method.

- 1
- 2

[2]

(b) Ultrasound wave pulses are used by vets to scan inner tissues inside animals.

The ultrasound pulses partially reflect from different layers of tissue. These reflected wave pulses (echoes) are collected by the detector as shown in Fig. 24.2.

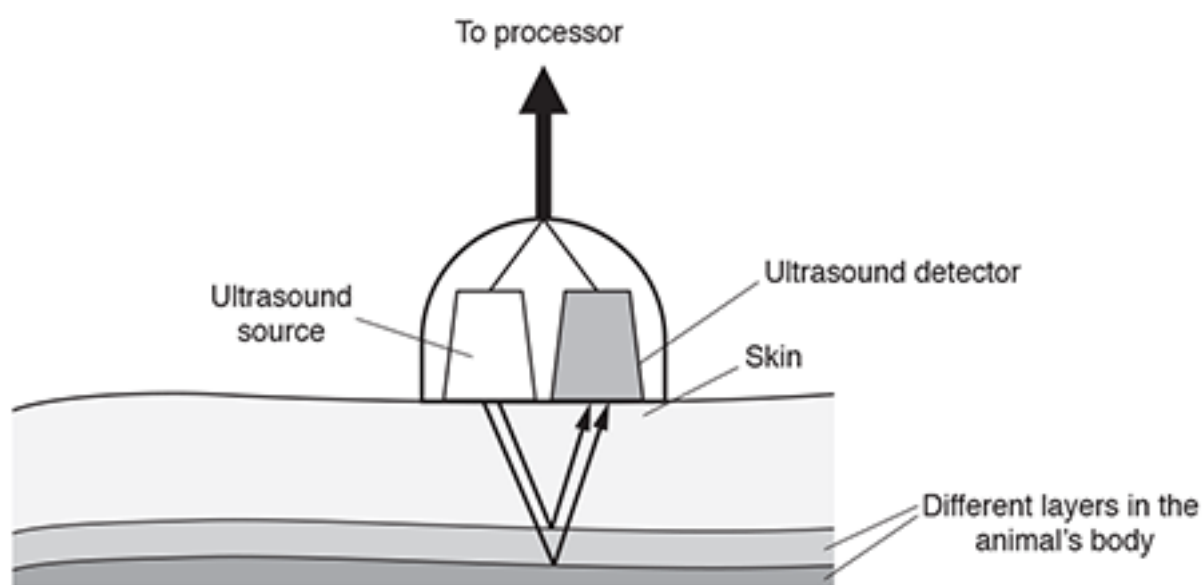


Fig. 24.2

In a scan using ultrasound pulses, three layers of tissue are detected, with each layer having a different thickness.

Describe and explain how the results from the detector can show:

- that there are three layers
- that each layer has a different thickness.

[3]

26 A teacher measures the speed of water waves in a ripple tank.

What apparatus should she use?

- A Ammeter and stopwatch
- B Newton-meter and ruler
- C Ruler and protractor
- D Ruler and stopwatch

Your answer

[1]

- 27 Which statement is **true** for electromagnetic waves?
- A High frequency electromagnetic waves have a long wavelength.
- B High frequency electromagnetic waves have no wavelength.
- C Low frequency electromagnetic waves have a long wavelength.
- D Low frequency electromagnetic waves have a short wavelength.

Your answer

☐

[1]

- 28 A sound wave travels in air and enters water.

What happens to the sound wave as it enters the water?

	Speed	Frequency	Wavelength
A	decreases	decreases	decreases
B	decreases	stays the same	decreases
C	increases	increases	increases
D	increases	stays the same	increases

Your answer

☐

[1]

29 An electromagnetic wave transfers energy.

Which row in the table is correct?

	Electromagnetic wave	Energy transfer
A	Infra-red	From a heating element of a toaster to the bread inside
B	Radio	From a radio to a transmitter
C	Gamma rays	From a high voltage supply to heating water in food
D	X-rays	From bones in the body to an X-ray machine

Your answer

[1]

30(a) Fig. 20.1 is a graph of a wave.

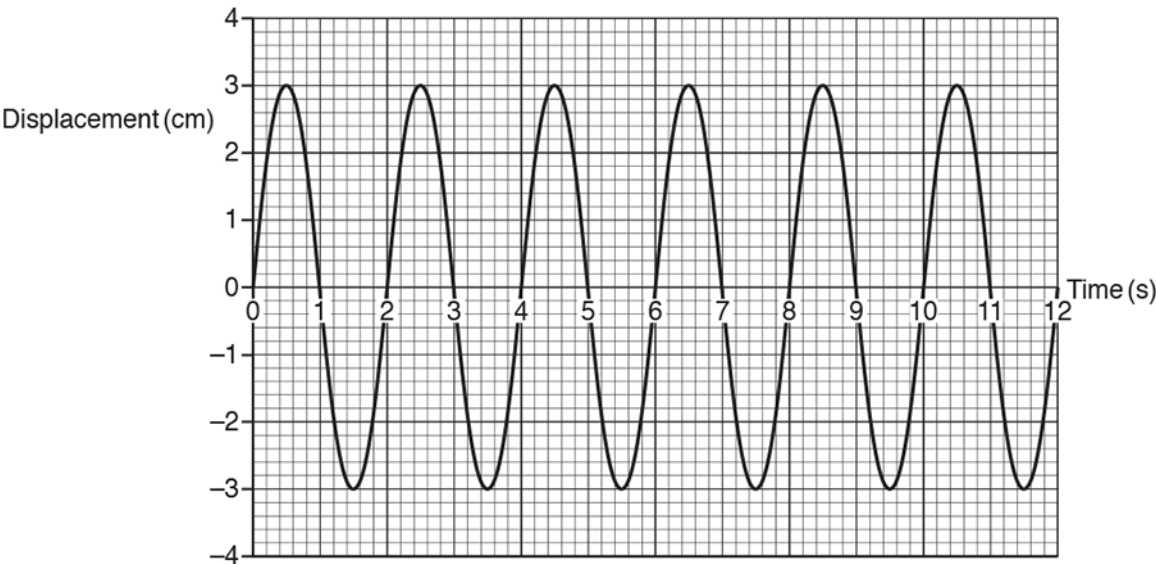


Fig. 20.1

(i) Use the graph in Fig. 20.1 to work out the time period of the wave.

Time period of the wave = ... s [1]

(ii) Use the graph in Fig. 20.1 to work out the amplitude of the wave.

Amplitude = ... cm [1]

(iii) The frequency of the wave in Fig. 20.1 is 0.5 Hz.

What is meant by the term **frequency**?

[1]

- (b) A water wave has a frequency of 0.25 Hz and a wavelength of 6.0 m.

Calculate the speed of the wave.

Speed of the wave = ... m / s [3]

- (c) Surface water waves can be modelled using a slinky spring.

A student holds one end of the spring on a table. The other end is fixed to a wall.

Fig. 20.2 shows the spring viewed from above the table.

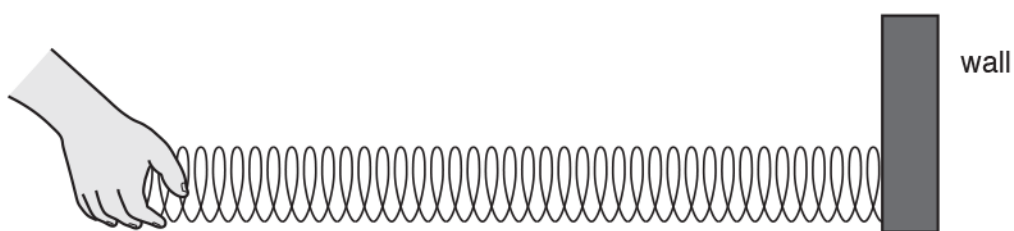


Fig. 20.2

- (i) Draw two arrows on the diagram in Fig. 20.2 to show the movement of the student's hand when he makes a transverse wave.

[1]

- (ii) Describe what happens to the transverse wave at the wall.

----- [1]

(iii) In Fig. 20.3 the student stops moving his hand.

This is what the coils in the spring look like after a short time:

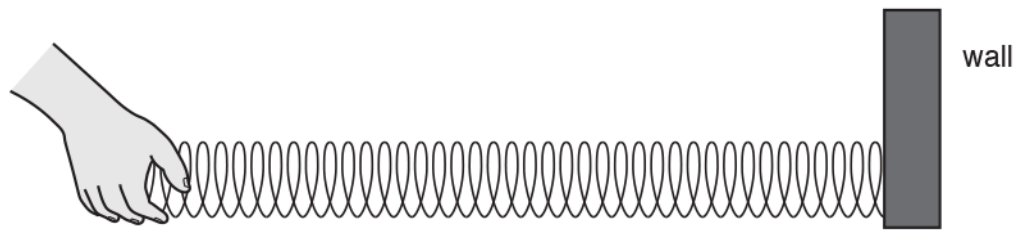


Fig. 20.3

This model of a water wave shows that the wave travels **not** the water.

Explain why.

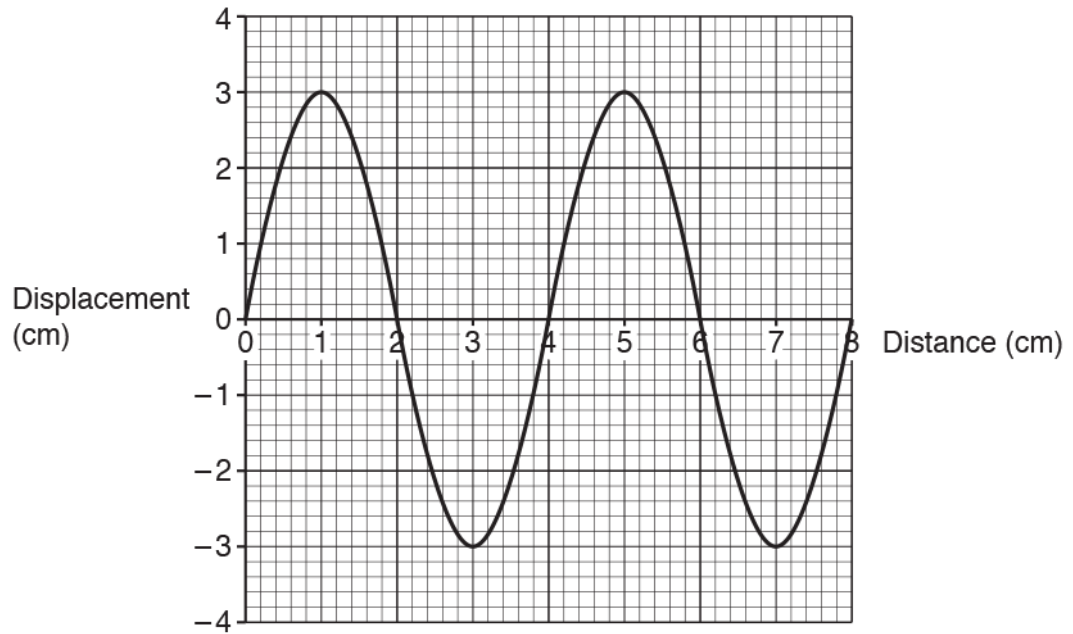
.....

.....

.....

[1]

31 Look at the diagram of a wave.



What is the wavelength of the wave?

- A 2 cm
- B 3 cm
- C 4 cm
- D 6 cm

Your answer

[1]

32(a) Ripples are made on the surface of the water. The ripples can be used to model waves.

(i) State the type of wave modelled by the ripples.

----- [1]

(ii) Describe how the water molecules move as the wave travels across the pond.

----- [1]

(iii) 10 ripples hit the side of the pond in 20 seconds.

Calculate the frequency of the ripples.

Frequency = ... Hz [2]

(b) Student **A** and student **B** drop stones into a pond.

(i) Student **A** measures the frequency and wavelength of the water ripples. **Table 17.1** shows his results:

Frequency (Hz) of ripples	0.6
Wavelength (m) of ripples	0.1

Table 17.1

Calculate the wave speed of the ripples.

Use the equation: wave speed = frequency $\times$ wavelength

Wave speed = ...m / s [2]

(ii) Student **B** measures the same ripples as student **A**.

She measures:

- The distance one ripple travels.
- The time it takes the ripple to travel this distance.

Table 17.2 shows student **B**'s results:

Distance ripple travels (m)	2.40
Time taken (s)	30.0

Table 17.2

Name the equipment student **B** uses to measure the distance and time.

Distance

Time

[2]

(iii) Use results in **Table 17.2** to calculate the wave speed of the ripples.

Wave speed = ...m / s [1]

(iv) Student **A** and student **B** obtained different answers for the wave speed of the ripples.

Suggest why.

.....
.....
..... [1]

33 The maximum frequency of sound that a person can hear changes as they get older.

Which row in the table explains this change?

	Maximum frequency of sound a person can hear	What part of the ear is damaged?
A	Decreases with age	Cochlea
B	Decreases with age	Eardrum
C	Increases with age	Cochlea
D	Increases with age	Eardrum

Your answer

[1]

34 Six wave peaks hit a wall in one minute.

Determine the frequency of the waves.

- A 0.1 Hz
- B 6 Hz
- C 10 Hz
- D 360 Hz

Your answer

[1]

35(a) Ultrasound waves can be used to create an image of part of the inside of a body.

Ultrasound waves have a higher frequency than ripples on the surface of water.

Describe **another** difference between ultrasound waves and ripples on the surface of water.

Explain your answer.

[2]

(b) The graph in Fig. 19.1 shows how displacement of an ultrasound wave varies with distance.

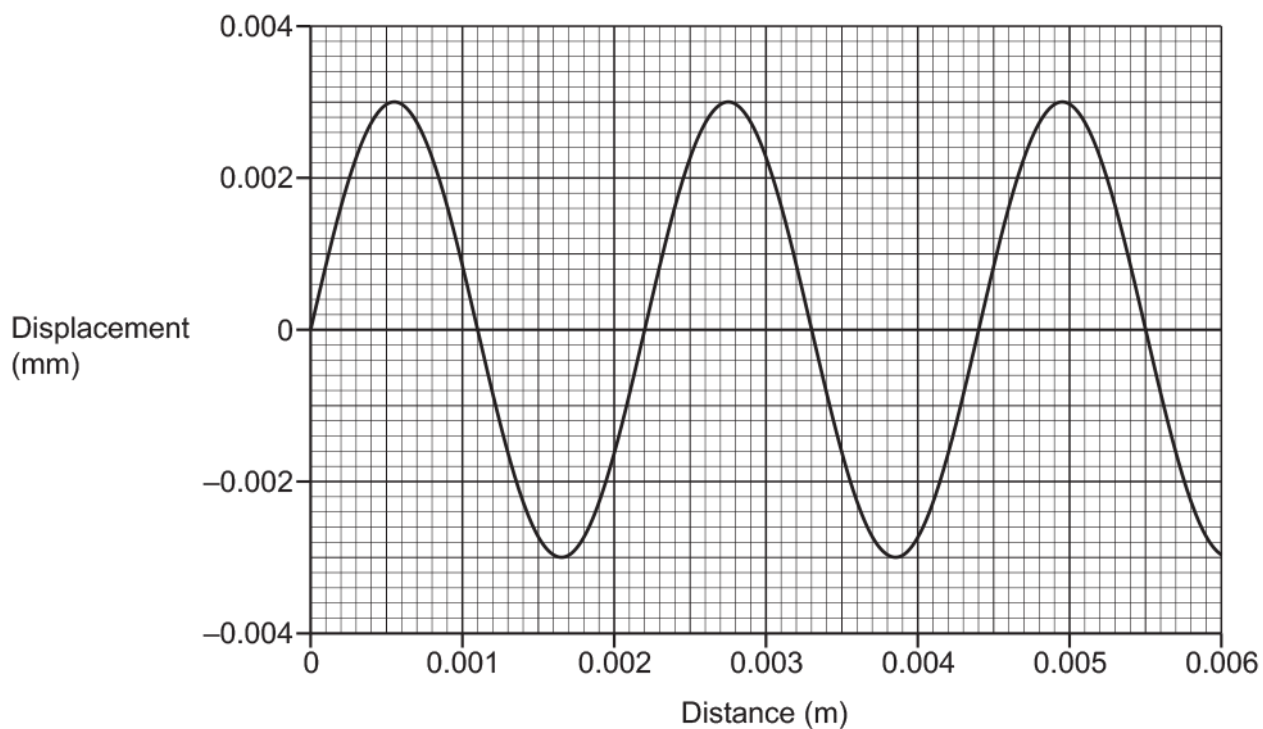


Fig. 19.1

(i) Use the graph in Fig. 19.1 to determine the wavelength of an ultrasound wave.

Wavelength = ... m [1]

(ii) The speed of ultrasound waves in (i) is 4500 m / s.

Calculate the frequency of the ultrasound wave in Fig. 19.1.

Use the equation: wave speed = frequency $\times$ wavelength

Give your answer in **standard form** and to **2 significant figures**.

Frequency = ... Hz [4]

(c) Doctors can use an ultrasound scan to measure the size of a person's kidney.

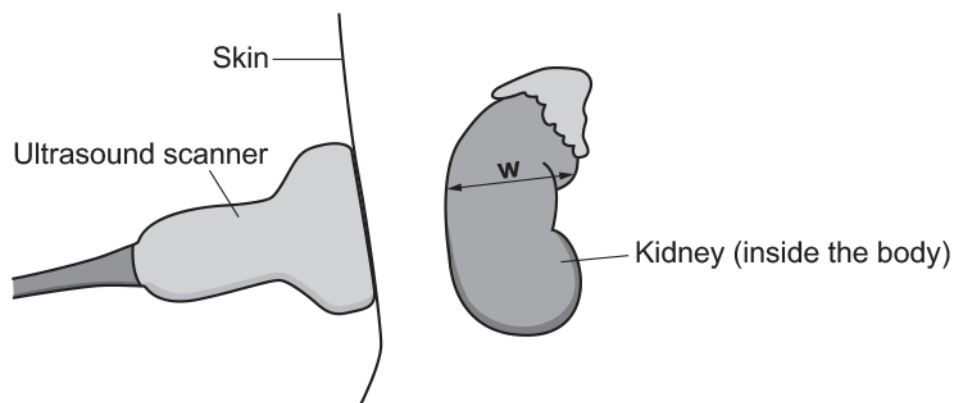


Fig. 19.2

Complete the sentences using the words below.

Each word may be used once, more than once, or not at all.

Increases **Decreases** **Stays the same**

The ultrasound scanner is made from a solid ceramic material.

As the wave enters the body, the speed

As the wave enters the body, the frequency

[2]

(d)

(i) Explain what happens to the ultrasound wave when it reaches the kidney.

----- [2]

(ii) Fig. 19.2 shows the thickness of the kidney, w .

Explain how ultrasound waves are used to measure w .

----- [2]

(e) A doctor uses an ultrasound scan instead of X-rays to measure the kidneys.

Explain why.

----- [1]

END OF QUESTION PAPER

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
1	a	i	B [1]	1	more than one scores 0 marks if answer line blank allow correct answer indicated in list or on diagram Examiner's Comments Nearly all could identify a compression on a longitudinal wave.
		ii	wavelength [1]	1	Examiner's Comments Recognising the distance between the same point on consecutive waves as wavelength discriminated very well. This proved to be far more challenging than when presented as the distance between two consecutive compressions.
	b		no (no mark) (idea that) we can't hear high pitched sounds [1] BUT We cannot hear 20 000 (Hz) (or above) scores [2]	2	'yes' scores [0] allow (idea that) 25 000 (Hz) is higher than we can hear [1] allow frequencies above a threshold: eg. Can't hear above 18 000 (Hz) [1] allow 20kHz allow correct references to wavelength for [1] Examiner's Comments On this 2 mark question most candidates stated that the ultrasound could not be heard as the frequency or pitch was too high [1]. Better answers qualified that by adding the upper threshold of 20 000Hz [1].
			Total	8	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
2	a	i	ideas of: (for test group) inaccurate or unreliable measurement(s) [1] (for test group) small(er) sample in group / [1] (for test group) group not representative / research more representative [1]	3	Eg. Equipment may be faulty [1] Eg. method may be flawed [1] Eg. large(r) sample in research [1] allow example of how the group is not representative Eg. Test group, some have a hearing impairment [1] Eg. All aged 16 in test group / AW [1] Eg. (test group) result(s) look anomalous [1] <u>Examiner's Comments</u> Few scored all three marks and the majority only one mark, usually referring to the age. Rather fewer mentioned the small test sample.
		ii	19 000 [2] but if answer is incorrect or incomplete then: evidence of multiplying average by 5 [1] or <u>80 000 + Dionne</u> [1] 5	2	If no answer on answer line check table <u>Examiner's Comments</u> Most calculated the average correctly as 19000Hz [2]. Although some treated the average as an included person and quite a few used the wrong column.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b	i	any 2 from: greater hearing loss with ageing [1] greater hearing loss with greater frequency [1] rate of hearing loss increases with ageing [1] rate of hearing loss increases with increasing frequency [1]	2	Eg. as you get older your ability to hear reduces [1] BUT allow as you get older your ability to hear higher frequencies reduces [2] <u>Examiner's Comments</u> Most scored one mark with better candidates scoring the second for correct reference to the frequency. Some didn't spot the frequency loss and there were communication problem with some candidates describing the graph.
		ii	hearing aid lowers (6000Hz) sounds to 3000(Hz) [1] (with hearing aid) less hearing loss at 3000(Hz) / lower frequency sounds heard more easily [1] (at age 60) hearing aid reduces hearing loss by 10 – 15(dB) / AW [1]	3	Look for use of data in answers. Allow other value of frequency correctly halved [1] ignore just frequency halved Eg. better hearing (range) at 3000(Hz) Eg. (at 60) aid reduces hearing loss from 27 to 13 (dB) Allows halves hearing loss [1] <u>Examiner's Comments</u> There were problems with candidates communicating their ideas. Few answered it fully, using data on frequency, hearing loss and applying this to the function of a hearing aid.
			Total	10	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
3			Level 3: (5 – 6 marks) Answer shows understanding of For higher frequencies the speed slows / direction changes the most. AND for higher refractive index the speed slows / direction changes the most. Quality of written communication does not impede communication of the science at this level. Level 2: (3 – 4 marks) Answer shows understanding of the nature of the colour of light. Quality of written communication partly impedes communication of the science at this level. Level 1: (1 – 2 marks) Answer shows a simple appreciation of the nature of light. Quality of written communication impedes communication of the science at this level. Level 0: (0 marks) Insufficient or irrelevant science. Answer not worthy of credit.	6	This question is targeted up to grade A* NB. Answers can be given (ORA) in terms of red light. Indicative scientific points may include: Level 3: - violet light has highest frequency / shortest wavelength and speed slows most / direction changes the most / AW - violet light has highest refractive index and slows most / direction changes the most / AW Level 2: - EITHER violet light slows down most - OR violet light has higher frequency / shorter wavelength - OR violet light has higher refractive index Level 1: - EITHER light slows down when entering glass - OR different colours have different speed changes - OR different colours have different refractive index - OR different colours have different frequencies / wavelength Use the L1, L2, L3 annotations in Scoris; do not use ticks. <u>Examiner's Comments??</u> This six-mark level of response question on dispersion was intentionally challenging assessing over a grade range up to A*. It discriminated well. There were very few good complete answers with references to refractive index usually omitted. There were many good answers that scored five marks in term of frequency or wavelength. Common misconceptions in this question were to do with the misuse of scientific

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					words. Diffraction and reflection were frequently interchangeable with refraction. Also many got the wavelengths and colours mixed up although these often gained level one marks for the idea than different colours have different frequencies.
			Total	6	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
4	[Level 3] descriptions about all three from: –ultrasound v surgery –ultrasound v X rays –detailed information about the display Quality of written communication does not impede communication of the science at this level (5 – 6 marks) [Level 2] descriptions about any two from: –ultrasound v surgery –ultrasound v X rays –basic information about the display Quality of written communication partly impedes communication of the science at this level (3 – 4 marks) [Level 1] descriptions about any one from: –ultrasound v surgery –ultrasound v X rays –basic information about the display Quality of written communication impedes communication of the science at this level (1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to A*. ultrasound used rather than surgery may include: non-invasive / no damage to human / no scars (more) accurate method fat thickness can be measure at different parts of the body quick method ultrasound used rather than X rays may include: produces images / readings / results for soft tissue does not damage living cells allow reverse arguments e.g. x rays do not show soft tissue detailed information about the display may include: peak A is at 5 – 7 (mm) peak A is at the fat-muscle layer the thickness of fat in the arm is 5 – 7 (mm) peaks A B and C are at different depths in the body basic information about the display may include: each peak is at a tissue boundary waves reflect from tissue boundary the first peak shows the body fat thickness (shows) reflections at different depths / distances Use the L1, L2, L3 annotations in scoris. Do not use ticks. <u>Examiner's Comments</u> This was a six-mark level of response question to do with ultrasound scans. It was targeted at a range of grades up to A* and it discriminated well showing the full range of marks. The question asked candidates to compare its use for

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					measuring body fat with using surgery or X-rays. There was also an ultrasound graph to prompt answers. The three areas for marking were discussing ultrasound versus X-rays, ultrasound versus surgery and the display itself. Many answers failed to mention surgery at all and a significant number did not refer clearly enough (or at all) to the graph and what it showed. Ultrasound versus X-rays was well covered by most with references to its inability to detect soft tissues or its ability to ionise cells or increase the risk of cancer. Regarding the display weaker candidates thought that each peak was a fat layer. Surgery as hinted at already was often omitted when a simple statement such as it can cause scars or a greater risk of infection would have got many answers a higher level of marks.
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
5	a	i	elephant (1)	1	Examiner's Comments Almost all selected the correct animal.
		ii	dolphin (1)	1	Examiner's Comments Almost all selected the correct animal.
		iii	dolphin (1)	1	Examiner's Comments Almost all selected the correct animal.
	b	i	Dionne (1) 20 100 – 24 (is largest value) OR 20 076 (is largest value) (1)	2	The calculated value may be shown in the table If Dionne is calculated to be less than 19985 (Evangelos) then award one mark for naming Evangelos. Examiner's Comments Almost all scored at least one mark and many scored two for selection of the person with the largest range, frequently supported by appropriate calculation.
		ii	19 780 scores (2) but if answer is incorrect or incomplete then: $\frac{19\,000 + 20\,000 + 20\,100 + 19\,800 + 20\,000}{5}$ (1)	2	Mark answer on line But if no answer given and value calculated in table mark the answer calculated in the table. Examiner's Comments Most scored at least one mark for the attempt to calculate the mean from the data. Almost all higher ability candidates scored two marks. The most frequent reason for not scoring the full two marks was incorrect completion of the final calculation of the mean.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	Any three from inaccurate measurements (1) unreliable measurements (1) idea of different sample size (1) the sample is not representative (1) some (may) have a hearing defect (1) different ages in the sample (1) other named and described reason why the sample is unrepresentative (1)	3	Eg. Equipment may be faulty [1] Examiner's Comments This was less well-answered across the full range. Most frequently candidates recognised that disability and age were the most significant reasons for inconsistency in the data. Very few candidates made reference to the very small sample size or inaccuracy in making measurements.
			Total	10	
6			(... it) REFRACTS (and). (1) (... colour A is) RED . (1) (... has the shortest) WAVELENGTH . (1)	3	not reflects <u>Examiner's Comments</u> ??Most scored [2] usually for knowing the order of the spectrum produced by the dispersion through a prism.
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
7		i	speed = 0.96 (m/s) [2] but if answer is incomplete then 0.80×1.2 [1]	2	allow correct substitution of a reasonable wavelength only acceptable alternatives allowed are: 1.92 [1] (i.e. 1.60×1.2) [1] 0.48 [1] (i.e. 0.4×1.2) [1] but ignore other wavelengths when awarding this mark <u>Examiner's Comments</u> This question was about p and s waves and it was better answered than equivalent questions in the past. In part (i) a few used the correct wavelength (0.8m) to calculate the speed [2]. Rather more used two wavelengths (1.6m) to calculate the speed as 1.92 [1]. This distinction discriminated well.
		ii	0.11(m) [1]	1	if not answer on line allow correct answer indicated in list <u>Examiner's Comments</u> This question was about p and s waves and it was better answered than equivalent questions in the past. In part (ii) a popular incorrect response for the amplitude was 0.22 although about 40% halved this value correctly [1] in their answers.
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
8	a		Maximum 2 marks B (Front row music festival) C (Large orchestra) D (Aircraft at take-off) H (MP3 player at maximum volume)	2	Mark letters on the line first If nothing on the line accept circled or ticked or underlined letters All 4 correct (with none wrong) [2] BUT 3 or 4 correct with one wrong [1] No mark awarded if 2 incorrect Examiner's Comments Almost all selected the 4 loudest sounds.
	b	i	Loudness reduces with (increasing) distance [1] BUT (idea that) loudness falls quickly (with increasing distance) at first and slower later [2]	2	allow higher level answers allow it changes very little after 22 to 24 metres [1] Examiner's Comments Most scored [1] mark for loudness decreasing with distance from source. Very few gained [2] for interpreting the decreasing gradient as the rate of decrease dropping with increasing distance.
		ii	82 to 83 (dB) [1]	1	Examiner's Comments Most used the graph correctly to find the loudness. When mistakes were made it was usually due to incorrectly reading from the loudness axis rather than incorrect construction of lines on the graph

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	any two from Gardener above safe level / 90dB AW [1] People in house under safe level /90dB AW [1] (idea that) gardener is exposed to the noise for more time [1]	2	allow (idea that) gardener is very close (so it is much louder) [1] allow (idea that) sound is stopped by walls or windows [1] Examiner's Comments Almost all scored at least [1] and many scored [2] for loudness being too high very close by or that the walls or windows blocked sounds
	c	i	4 (hours) [1]	1	allow 3 – 6 (hours) Examiner's Comments Almost all interpolated correctly within the allowed range
		ii	Less than (4 minutes) [1]	1	NOT less than or equal to 4 minutes allow up to 4 minutes [1] Examiner's Comments Most recognised the mathematical symbol correctly. Often the mark was not gained due to describing it as "4 minutes or less".
		iii	Any value from 78 to 79 (dB) [1]	1	Examiner's Comments This discriminated well with very few candidates able to process the data (showing exponential decay in exposure time with loudness) to calculate loudness.
			Total	10	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
9			2.2×10^{14} Hz (3) if incorrect or incomplete then allow: 2.22×10^{14} Hz or 2.222×10^{14} Hz (2) or 2.0×10^{14} or 2.2 or 2.22..etc (1) or (for correct substitution) $f = \frac{2 \times 10^8}{9 \times 10^{-7}} \quad (1)$	3	Allow any other value that rounds to 2.2×10^{14} (2) Allow 2.2×10^x or $2.22... \times 10^x$ (1)
			Total	3	
10		i	C (1)	1	if answer line blank allow answer in correct place on the diagram
		ii	any one from movement of air (particles) (1) can't see air particles (1) (frequency) too high (1)	1	allow the air particles are moving too fast (1) ignore cannot see the wave
			Total	2	
11			15.0 (m / s) (1)	1	Allow 15
			Total	1	
12			C ✓	1 (AO1.2)	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
13			B ✓	1 (AO2.2)	<u>Examiner's Comments</u>  Candidates found this question challenging and many candidates selected distractor A as their answer. Key  Misconception Candidates knew that the ray should enter and leave the block in the same direction (options A and B). However, the ray is also refracted as it enters the glass block and this is independent of the angle of incidence. Therefore option B is the only correct answer.
			Total	1	

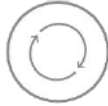
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
14	a	i	2 ½ or 2.5 ✓	1 (AO1.2)	Examiner's Comments Most candidates were able to calculate the number of waves produced. The most common error made was to divide the time by the frequency instead of multiplying the time by the frequency.
		ii	Speed is unchanged / stays the same ✓ Wavelength reduces ✓	2 (AO2.1) (AO2.1)	Answer must indicate idea of speed Answer must indicate idea of wavelength IGNORE answers that merely state 'no change and reduces' Examiner's Comments Most candidates correctly stated that the wavelength would decrease. The majority of candidates stating that wave speed would also increase while only the highest ability candidates knew that that wave speed would be unchanged.
		iii	Any two from: Water / particles move up and down / oscillate vertically ✓ Water / particles move at 90° / perpendicular to the direction of wave (travel) / AW ✓ Energy moves in direction of the wave (travel) / AW ✓	2 (AO2 × 2.1)	IGNORE any statements that are just repeated from the question. IGNORE water waves move up and down ALLOW energy moves at 90° to wave vibrations / movement ✓✓ Examiner's Comments Candidates found this question very challenging and many misinterpreted what they were being asked to do. Most candidates did not identify that the second and third statements about water wave were incorrect and many merely rewrote the student's original statement. The most common mark gained was for the idea of the water moving perpendicular to the direction of the wave motion. Only the highest ability candidates gained full credit.

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
	b	(Idea of) action to produce sound and seen by observer / received by receiver ✓ Measure an appropriate distance eg between source and observer or between microphone(s) / speaker ✓ Measure an appropriate time eg between seeing action and hearing sound or on CRO / or frequency from signal generator ✓ (Idea of) calculating speed = distance / time or velocity = frequency x wavelength ✓ (Idea of) improvements to experiment eg repeat and average readings / retake readings if they are anomalous / use a different method / use different equipment / use longer distances ✓	5 (AO1.1) (AO2.2) (AO2.2) (AO3.2b) (AO3.3b)	ALLOW marks to be awarded from a clear diagram ALLOW higher level methods eg using standing waves ALLOW equation in any form <u>Examiner's Comments</u> This question assessed AO1, AO2 and AO3 and discriminated well between the lower and higher ability candidates. Many correct experiments were suggested, for example practical improvements to the ball being hit by a bat making use of echoes, microphones and oscilloscope, as well as less practical suggestions in a school setting involving the use of fireworks and explosions. Some candidates made vague references to 'using a computer' that could not be credited. Most candidates realised that it was necessary to measure a time, but did not clearly specify what time they should measure. Almost every candidate gained some credit, many for stating the correct equation to calculate speed or for the idea of taking multiple readings and then using the average value. Exemplar 2 Two students with a stop clock and measuring tape could stand to each other over a distance of around 200 metres (which they could measure and using a measuring tape). One student could then use some sort of body language (eg putting his thumb up) to show that he is going to start and to start the stop watch. As soon as the other student hears him he could stop the stopwatch. They could repeat this several times and swap roles to get more accurate results and decrease the chance of human error. They could then find an average time and do Distance ÷ time to find an average speed.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					This candidate gained full credit. The response included: • a suitable experiment • an appropriate time and distance measured • an equation to calculate the speed • the improvement of repeating and averaging the readings in order to improve accuracy and reduce the effect of operator error on their observations.
	c		Any 3 from: Outer ear (pinna) / auditory canal transfers sound to ear drum ✓ Ear drum vibrates ✓ Ossicles / small bones / anvil, hammer or stirrup vibrate ✓ Ossicles / small bones / anvil, hammer or stirrup amplify vibration ✓ Liquid in cochlea transmits movement (to small hairs) ✓ Small hairs / cilia vibrate ✓	3 (AO1.1) (AO2 × 2.1)	ALLOW ear drum moves in and out <u>Examiner's Comments</u> Most candidates gained at least 1 mark for either the eardrum, ossicles or cilia vibrating. Good responses were able to mention all 3 of these vibrations. Candidates who achieved zero or 1 mark, did not use the word 'vibrate', merely listing the parts of the ear that the sound travelled through.
			Total	13	
15			B ✓	1 (AO 1.1)	<u>Examiner's Comments</u> This question was generally answered well. Some candidate incorrectly selected either A the normal or C.  AfL With ray diagrams, candidates should always identify the normal, before working out further positions of the rays.
			Total	1	

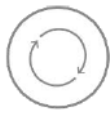
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
16			C ✓	1 (AO 1.2)	Examiner's Comments This question was answered correctly by most candidates and many had added a column to the table to determine the range for each of the four distances.
			Total	1	
17			B ✓	1 (AO 2.2)	Examiner's Comments Candidates found this question very challenging and the most common response was distractor A.  AfL A better way for candidates to approach this question would be to consider refraction occurring with a change of speed and the effect across a wavefront. In diagram A, a change of speed would change the speed of all parts of the wavefront by the same amount so that the wavefront would continue to move 'in step'. Response B is the correct answer since it would not be possible to have an angle of refraction of 0° with an angle of incidence greater than 0°. Similarly, for the emergent ray it would not be possible to have an angle of refraction greater than 0° if the angle of incidence is 0°.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
18	a	i	3.5 (cm) ✓	1 (AO 1.1)	ALLOW 3.4 to 3.6 Examiner's Comments One in five candidates answered this question correctly. Some candidate confused wavelength with the amplitude. Another common response was 9 cm.
		ii	2.4 (cm) ✓	1 (AO 1.1)	Examiner's Comments Many candidates read the vertical axis incorrectly and gave values that were around 2.4 cm but not that specific value (for example 2.5 cm).  Misconception A common incorrect answer was 4.8 cm, where candidates confused the peak to peak value with amplitude. Other candidates confused amplitude with the wavelength.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.5 (m/s) award 2 marks 2×25 OR 2×0.25 ✓ 0.5 (m/s) ✓	2 (AO 2 x 2.1)	ALLOW 50 Examiner's Comments Most candidates were credited with one mark for multiplying 2 by 25 to give an answer of 50. Fewer candidates appreciated that this was 50 cm/s while the unit on the answer line was m/s.  AfL Encourage candidates to check the unit used on the answer line. This additional information can help them to understand the question and the equations they should use.
	b	i	(Particles move) up and down / oscillate/vibrate vertically/at right angles to the direction of the wave ✓	1 (AO 1.1)	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	(Particles move) forwards and backwards / oscillate/vibrate parallel to the direction of the wave / AW ✓	1 (AO 1.1)	Examiner's Comments Very few candidates were able to express a clear understanding of the motion of particles caused by the progress of a transverse water wave, or a longitudinal sound wave. A number of candidates stated used ambiguous descriptions such as 'the particles would move side to side', which could apply to both transverse and longitudinal waves.  OCR support The Waves in Matter transition guide (from KS3 to KS4) provides guidance on the teaching about waves. http://www.ocr.org.uk/Images/318139-waves-in-matter-transition-guide.pdf
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
19	a		Distance (between source and observer) ✓ Time (for sound to travel between source and observer) ✓	2 (AO 2 x 1.1)	Do not accept distance / time the ball travels Do not accept metres / seconds <u>Examiner's Comments</u> Some candidates wrote a list of quantities that could be measured with no description: speed, distance, time, frequency and wavelength. These candidates could not be credited with any marks as they had not answered the question. Candidates were expected to describe how the distance that the sound would travel and the time for the sound to travel were needed to calculate the speed. Many candidates ignored the context for the question and referred to measuring the distance the ball travels.
	b		Speed = distance ÷ time ✓	1 (AO 1.1)	ALLOW distance ÷ time <u>Examiner's Comments</u> This question was answered well by candidates. Some candidates quoted the wave equation which was not appropriate to the experiment. A significant number of candidates incorrectly gave the correct equation as <i>speed = distance × time..</i>
	c		Takes several readings / take averages / increase distance ✓	1 (AO 3.3a)	ALLOW no wind IGNORE increase time <u>Examiner's Comments</u> Most candidates suggesting repeating the experiment and calculating an average. Some candidates suggested using different distances and then plotting a graph. Other candidates suggested increasing the distance to the observer.
			Total	4	

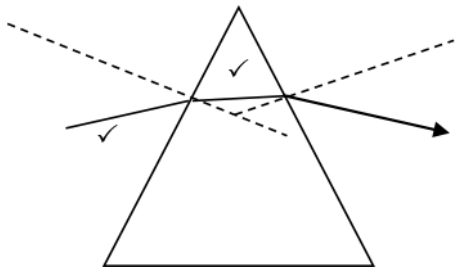
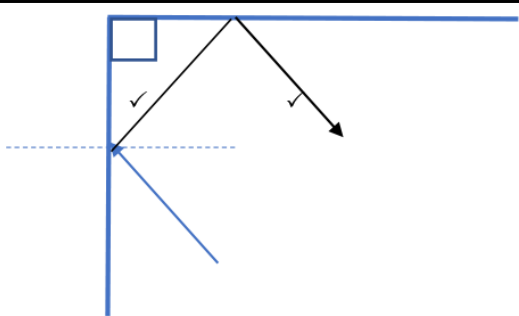
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
20			Thinking distance doubles ✓	1 (AO1.1)	ALLOW higher level answer: thinking distance is (directly) proportional to speed Examiner's Comments Around half the candidates stated that thinking distance also doubled and used data from the table to demonstrate their answer. Many of the candidates who did not gain credit stated that the thinking distance increases but without using the information from the question of the speed doubling. Other candidates did not answer the question set but explained factors that could affect thinking distance. A few candidates referred to the 'thinking time' doubling.  AfL When investigating stopping distances, candidates should be encouraged to understand fully the terms thinking distance, braking distance, thinking time, braking time. Encourage candidates to underline the important parts of the question – in this case thinking distance (which was already emboldened) and speed doubles.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
21			D ✓	1 (AO 2.2)	<u>Examiner's Comments</u> This question assessed candidates' knowledge of refraction of sound waves. Around a third of candidates did not know that a sound wave travels faster in water than air.  Misconception Many candidates had the misconception that a sound wave slows down when it enters water and incorrectly chose option B.
			Total	1	
22			A ✓	1 (AO 1.2)	<u>Examiner's Comments</u> Most candidates successfully applied their knowledge of electromagnetic waves to identify that the energy transfer for row A was correct.
			Total	1	
23			B ✓	1 (AO 1.1)	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
24	a		Diagram showing correct refractions 	2 (AO 2x1.2)	If diagram is incorrect, maximum of one mark from: any rising line in air before the prism ✓ a line in the prism close to horizontal by eye and joining the exit ray ✓ IGNORE any arrows on rays <u>Examiner's Comments</u> This question proved very difficult for most candidates. Although some candidates could accurately draw the ray of light as it travelled through the glass prism, only the more able gained 2 marks.
	b			2 (AO 2x1.2)	One mark for each correct reflection of about 90° by eye IGNORE any arrows on rays
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
25	a	i	Mean = $(0.28 + 0.32) = 0.30$ (s) ✓	1 (AO 1.2)	ALLOW 0.3 (s) DO NOT ALLOW answers with all 3 readings used giving a mean of $(0.28+0.32+0.54) / 3 = 0.38$ (s) <u>Examiner's Comments</u>  AfL Candidates need to be aware that anomalous readings in a set of results, due to a mistake or lack of attention, are not included in calculations of the mean.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 333 (m/s) award 4 marks Use of distance = 100 m ✓ Recall (s =) d / t ✓ 100 / 0.3 ✓ (s =) 333 (m/s) (3 sig. figs.)✓	4 (AO 2.1) (AO 1.2) (AO 2.1) (AO 2.1)	ALLOW ECF from 24(a)(i) ALLOW 100 ÷ 0.38 ✓✓✓ ALLOW 263 (m/s) ✓✓✓✓ ALLOW ECF for 3rd and 4th marking points if incorrect distance is used ALLOW 50 ÷ 0.3 or 166.7 ✓✓ ALLOW 50 ÷ 0.38 or 131.6 ✓✓ ALLOW 132 ✓✓✓ ALLOW 167 ✓✓✓ <u>Examiner's Comments</u> The majority of candidates could rearrange the equation provided, substitute values and give their answer to 3 significant figures. However, many candidates did not take into account that the sound travelled 100m to the wall and back again so used 50m in their calculations instead. AfL A number of candidates gave two possible versions of rearranging the equation leading to two different answers. Candidates should be aware that marks cannot be awarded when they do this, even if one of the versions is correct.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	Any two from: Inconsistent results should be repeated ✓ More readings of time should be done and the mean calculated ✓ (Explanation of) clap-echo method ✓ Larger/different distances used ✓	2 (AO 2×3.3b)	Clap-echo method effectively may gain 2 marks as it also uses the idea of multiple readings. <u>Examiner's Comments</u> This Assessment Objective 3 question required candidates to analyse information in order to develop the experimental procedure of the students (in Question 24(a)). There is evidence that over half of the candidates did not read the question carefully as they suggested improvements relating to other methods such as videoing, using microphones etc. Many candidates suggested taking more readings but did not mention calculating the mean and therefore could not score the mark.
	b		idea of 3 echoes/reflections/returning pulses (from each pulse) / AW✓ takes different times to travel (there and back) through different layers/distances/thicknesses / time (interval) between echoes is different/not regular / AW ✓✓ BUT the thicker the layer/the longer the distance, the bigger the time interval/takes longer to travel (there and back) / AW ✓✓	3 (AO 3×2.1)	ALLOW (idea of measuring) the time taken for the wave to be reflected back (for different layers) <u>Examiner's Comments</u> This question assessed candidates' ability to apply their knowledge of ultrasound. It proved challenging to a number of candidates and about one third did not gain any credit. Candidates used their knowledge of ultrasound but often did not relate this to the question asked, or their answers were not specific enough e.g. the number of pulses shows that there are 3 layers of tissue.
			Total	10	
26			D ✓	1 (AO1.2)	<u>Examiner's Comments</u> The majority of candidates correctly identified that a ruler and a stopwatch should be used to measure the speed of water waves. A common incorrect response was an ammeter and stopwatch.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
27			C ✓	1 (AO1.1)	<u>Examiner's Comments</u> This question was also based on the electromagnetic spectrum section of the specification. Candidates had a better understanding of the main groupings of the electromagnetic spectrum from long to short wavelengths and from low to high frequencies. An alternative way of answering this question is to apply the wave equation realising that the speed of electromagnetic waves in a vacuum is constant.
			Total	1	
28			D ✓	1 (AO2.2)	<u>Examiner's Comments</u> This question proved very challenging. Many candidates incorrectly gave the answer as B without realising that the question referred to a sound wave. Candidates needed to know that sound travelled faster in water than in air.
			Total	1	
29			A ✓	1 (AO1.1)	<u>Examiner's Comments</u> This question required candidates to read the options carefully. Many candidates did not realise the direction was important.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
30	a	i	2 (s) ✓	1 (AO1.2)	<u>Examiner's Comments</u> A small proportion of candidates gained this mark for a period of 2 s. The majority of candidates wrote 12 s being the total time shown. A few candidates wrote 1 s.
		ii	3 (cm) ✓	1 (AO1.2)	<u>Examiner's Comments</u> Over half the candidates scored the mark for 3 cm. The common incorrect answer was 6 cm (peak to trough).
		iii	the number of (complete) waves / oscillations in a / per <u>second</u> ✓	1 (AO1.1)	ALLOW '2 waves in a second' ✓ <u>Examiner's Comments</u> Candidates often did not refer to a time of one second. The word "amount" was often used instead of "number". Many vague responses such as "how many times something happens" or "how fast something is" were seen. Candidates are expected to define frequency (and wavelength).  AfL Candidates should be able to know and apply basic wave terms such as amplitude, wavelength, frequency and period.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1.5 (m/s) award 3 marks Wave speed = frequency × wavelength / $v = f \times \lambda$ ✓ = 0.25 × 6 ✓ 1.5 (m/s) ✓	3 (AO1.2) (AO2.1) (AO2.1)	Examiner's Comments Candidates needed to recall the wave equation and substitute the numbers. Many candidates gained the marks on this question. Candidates who did not do well on this question often did not write an equation in their answer. Exemplar 2 (b) A water wave has a frequency of 0.25 Hz and a wavelength of 6.0m. Calculate the speed of the wave. <i>frequency × wavelength = wave speed</i> $0.25 \times 6 = 1.5$ Speed of the wave = ... 1.5 m/s [3] This candidate has stated the equation with the wave speed as the subject. The candidate has then substituted the numbers before calculating the answer. AfL For calculations, candidates should show their working. The following steps are useful: 1. Recall equation (if not given in the question) 2. Rearrange equation 3. Substitute the numbers into the equation 4. Calculate the answer 5. Consider significant figures or decimal places
	c	i	(transverse) Wave movement shown ✓	1 (AO2.2)	Examiner's Comments This question required candidates to demonstrate their understanding of the differences between transverse and longitudinal waves. Many candidates drew arrows pointing left to right towards the barrier

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	Reflection at wall ✓	1 (AO1.2)	ALLOW bounces back / comes back towards the hand <u>Examiner's Comments</u> It was expected that candidates would state that the wave would be reflected. Candidates should be encouraged to use technical terms such as "reflect" rather than "bounce". Many candidates stated that the wave would stop at the wall.
		iii	The coils / slinky /spring are in the same place (as before the wave) / AW ✓	1 (AO1.1)	The coils do not travel from one end to the other Must have reference to coils / slinky / spring <u>Examiner's Comments</u> This was a challenging question. Many candidates answered it by describing water waves rather than referring to the slinky spring model. To gain credit candidates needed to explain that the coils remain in the same positions.
			Total	9	
31			C ✓	1 (AO2.2)	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
32	a	i	<u>Transverse</u> ✓	1 (AO1.1)	
		ii	Molecules/Particles move <u>perpendicular/</u> <u>right angles</u> (to the direction of energy transfer/water surface) ✓	1 (AO1.1)	ACCEPT at right angles/ 90° (to direction of travel) ACCEPT up and down1
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.5 (Hz) award 2 marks Frequency = number of waves per second / = 10 ÷ 20 ✓ f = 0.5 (Hz) ✓	2 (AO2 × 2.1)	ACCEPT ½
	b	i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.06 (m / s) award 3 marks Speed = 0.6 × 0.1 ✓ Speed = 0.06 (m / s) ✓	2 (AO2 × 2.1)	
		ii	Distance is measured with a metre-rule OR tape measure ✓ Time is measured with a stop-watch ✓	2 (AO2 × 1.2)	ACCEPT metre-ruler DO NOT ALLOW ruler
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.08 (m / s) award 3 marks Speed = distance ÷ time ✓ = 2.4 ÷ 30 ✓ = 0.08 (m / s) ✓	3 (AO1 × 1.2) (AO2 × 2.1)	
		iv	Uncertainty/difficulty in measuring distance ✓ OR Human reaction time in starting/stopping stopwatch ✓	1 (AO3.2a)	ALLOW AW
			Total	12	
33			A ✓	1 (AO1.1)	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
34			A ✓	1 (AO2.2)	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
35	a		Ultrasound waves are <u>longitudinal</u> ✓ OR Ripples are <u>transverse</u> ✓ Oscillations/vibrations (of particles) in ultrasound/longitudinal waves are <u>parallel</u> to the direction of energy transfer / ultrasound has compressions and rarefactions ✓ OR Oscillations/vibrations (of particles) in the ripples/transverse waves are <u>perpendicular</u> to the direction of energy transfer ✓	2 (AO2 × 1.1)	ALLOW direction of travel/propagation for energy transfer IGNORE direction of wave motion
	b	i	0.0022 (m) ✓	1 (AO2.2)	
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 2.0×10^6 (Hz) award 4 marks (Rearrange: frequency =) speed / wavelength OR (f =) $4500 / 0.0022$ ✓ (f =) 2 045 455 (Hz) ✓ (f =) 2 000 000 (Hz) ✓ (f =) 2.0×10^6 (Hz) ✓	4 (AO1.2) (AO2 × 2.1) (AO1.2)	ALLOW ecf from (i) ALLOW three marks for 2.0 MHz ALLOW a mark for their answer to 2 significant figures ALLOW a mark for their answer in standard form
	c		Decreases ✓ Stays the same ✓	2 (AO2 × 2.1)	
	d	i	(Partial) reflection/absorption at the front of the kidney ✓ (Partial) reflection at the back of the kidney ✓	2 (AO2 × 2.1)	Both of the marking points can be awarded by a suitably clear diagram (or additional drawings on the given diagram) ALLOW 1 mark maximum for just reflection/bounces back
		ii	Measure the <u>time</u> between reflections ✓ Use distance = $\frac{1}{2} \times \text{speed} \times \text{time}$ (to find the size) ✓	2 (AO2 × 2.2)	ALLOW distance = speed × time and mention of time halve

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	e		There is no (known) risk associated with ultrasound / ultrasounds are safer than X-rays / X-rays pass through soft tissue (so would not detect the kidney) / X-rays are ionising (radiation) ✓	1 (AO1.1)	ALLOW X-rays used to detect bones/pass through kidney ALLOW ultrasound detects soft tissue/organs
			Total	14	