

AQA GCSE PHYSICS (HIGHER) • 8463

PHYSICS



EXAM QUESTION PACK

4.6.1 WAVES IN AIR, FLUIDS AND SOLIDS (PACK 3)

SCORE

/155

PERCENTAGE

%

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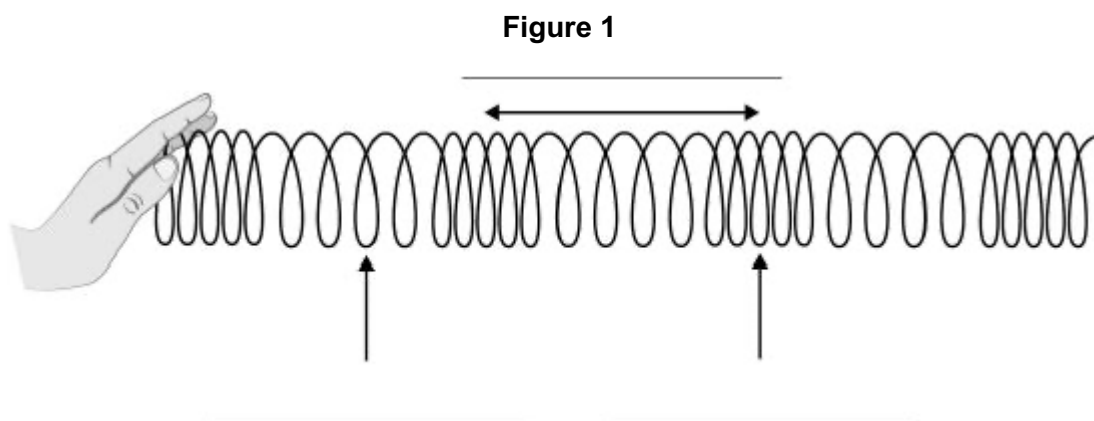
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Q1.

Figure 1 shows a slinky spring used to model a sound wave.



- (a) Label the arrows on **Figure 1**

Choose the answers from the box.

amplitude	compression	frequency
rarefaction	wavelength	

(3)

- (b) What type of wave is a sound wave?

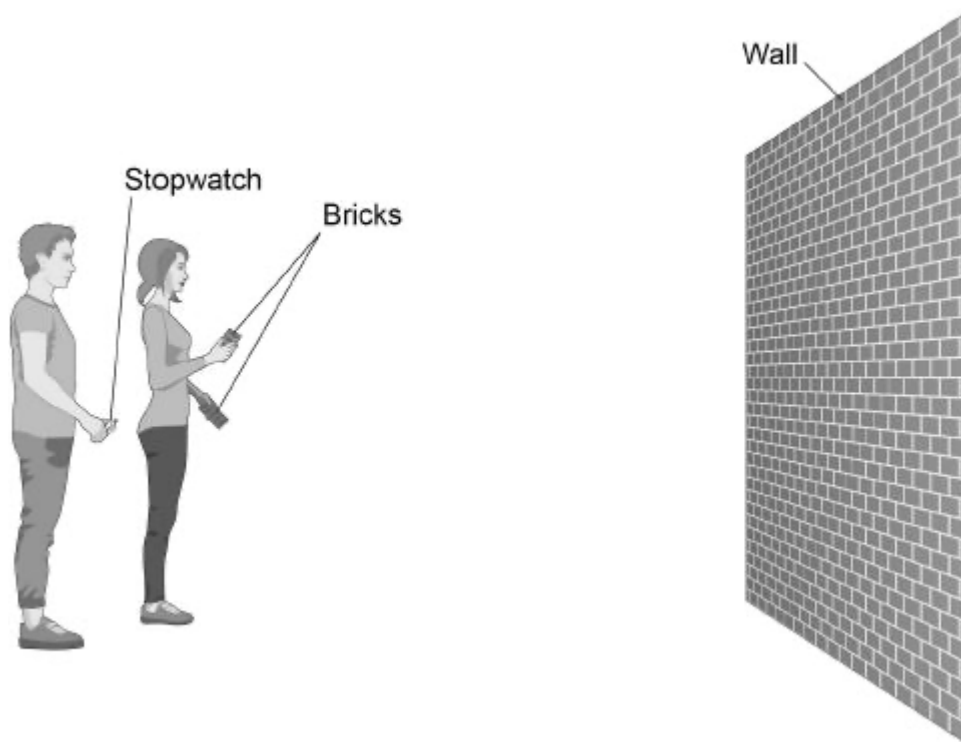
Tick **one** box.

electromagnetic	☐
longitudinal	☐
transverse	☐

(1)

- (c) **Figure 2** shows two students measuring the speed of sound in air.

Figure 2



One student bangs two bricks together.

The sound wave produced is reflected from the wall and travels back to the students.

Describe how they can determine the speed of sound.

(4)

(Total 8 marks)

Q2.

A car aerial receives radio waves from a radio transmitter.

Radio waves are transverse waves.

Sound waves are longitudinal waves.

- (a) Describe the difference between transverse waves and longitudinal waves.

(2)

- (b) The radio waves have a frequency of 4.8×10^9 Hz

Wave speed of electromagnetic waves = 3.0×10^8 m/s

Calculate the wavelength of the radio waves.

Give your answer to 2 significant figures.

Wavelength = _____ m

(3)

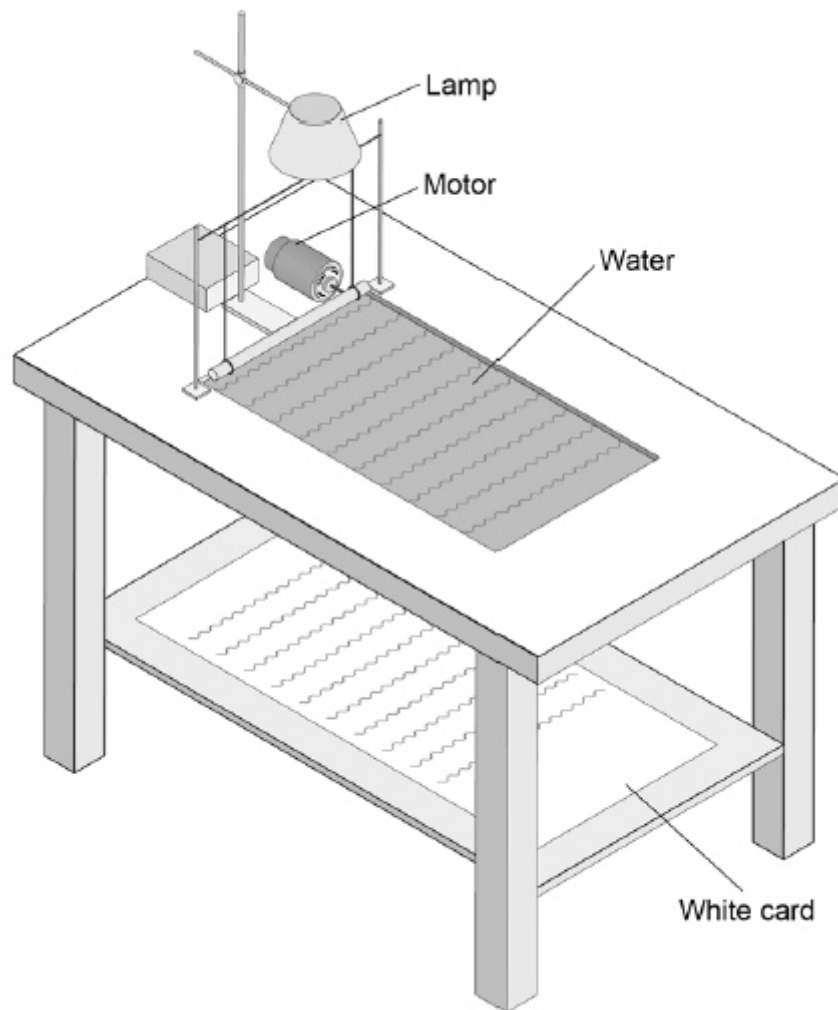
- (c) Describe how the radio waves reaching the car aerial produce signals in the electrical circuit of the car radio.

(3)

(Total 8 marks)

Q3.

The diagram shows a ripple tank.



- (a) The motor makes a noise when it is turned on.

Describe the differences between the properties of the sound waves produced by the motor and the water waves in the ripple tank.

(4)

- (b) The period of the sound waves produced by the motor is 8.3 milliseconds.

Calculate the frequency of the sound waves.

Use the Physics Equations Sheet.

Frequency = _____ Hz

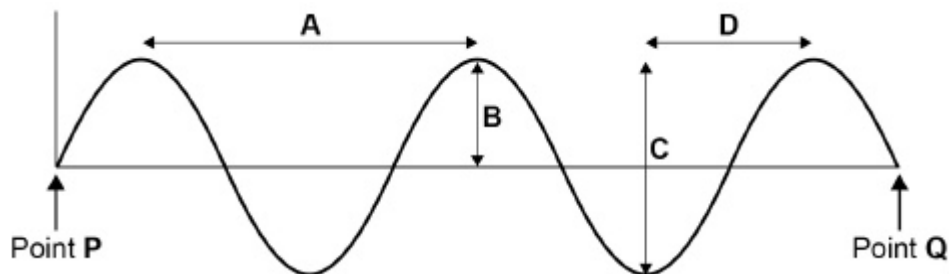
(3)

- (c) Explain how a student could make appropriate measurements and use them to determine the wavelength of the waves in the ripple tank.

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Q4.

The diagram shows a wave.



- (a) Which arrow shows the amplitude of the wave?

Tick **one** box.

A ☐ B ☐ C ☐ D ☐

(1)

- (b) Which arrow shows the wavelength of the wave?

Tick **one** box.

A ☐ B ☐ C ☐ D ☐

(1)

- (c) It takes 0.5 seconds for a wave in the diagram to travel from point **P** to point **Q**.

Calculate the frequency of the waves shown in the diagram.

Frequency = _____ Hz

(2)

- (d) What type of wave is sound?

Tick **one** box.

Electromagnetic

☐

Longitudinal

☐

Transverse



(1)

Two students carried out an experiment to determine the speed of sound.

This is the method used.

1. Student A stands 100 m away from Student B.
2. Student A bangs two blocks of wood together making a loud sound.
3. Student B starts a stopclock when he sees the blocks of wood bang together.
4. Student B stops the stopclock when he hears the sound and records the time.
5. The students repeat steps 2–4 several times.

The students calculated the speed of sound from their results.

- (e) Suggest the most likely source of error in the experiment.

(1)

- (f) The speed of sound calculated was lower than the true speed of sound in air.

Suggest **one** improvement to the students' method that would give a more accurate value for the speed of sound.

(1)

- (g) A student compares the properties of visible light waves and radio waves.

Which **two** properties are the same for both visible light waves **and** radio waves?

Tick **two** boxes.

Both are transverse waves

☐

Both can travel through a vacuum

☐

Both have the same amplitude

☐

Both have the same frequency

☐

Both have the same wavelength

☐

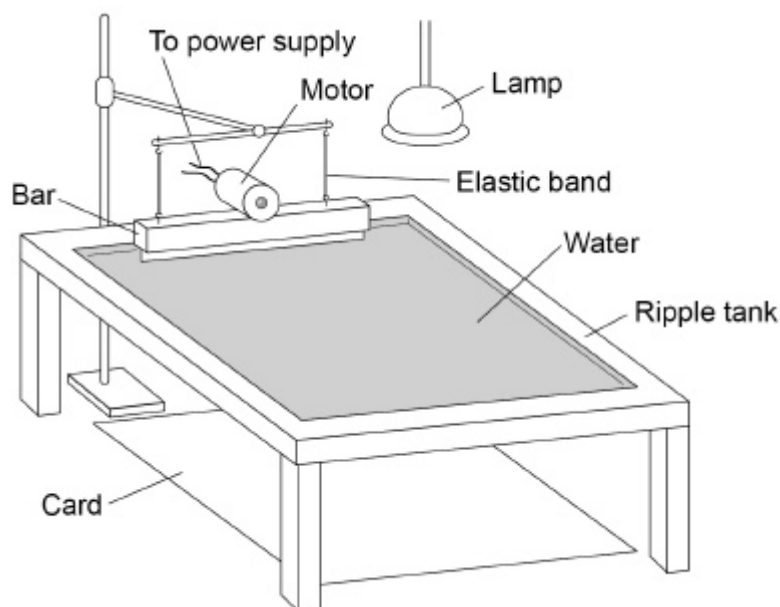
(2)

Q5.

A group of students investigate the features of waves.

Figure 1 shows some of the equipment they use.

Figure 1



- (a) Write the equation which links frequency, wavelength and wave speed.

(1)

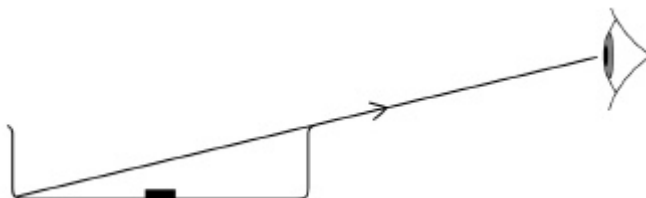
- (b) The students want to determine the wave speed of water waves in the ripple tank.

Describe a method the students could use.

Figure 2 and **Figure 3** show the 'magic coin' trick.

A coin is glued to the bottom of a bowl and an observer stands where they cannot see the coin (**Figure 2**).

Figure 2

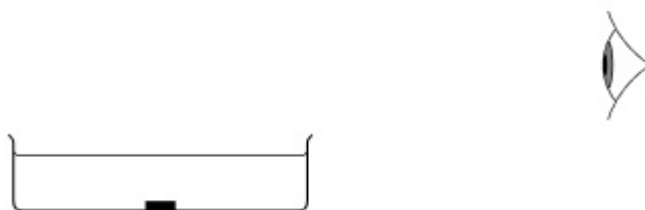


Another person fills the bowl with water.

The observer and the coin do not move.

After the water is added the observer can see the coin (**Figure 3**).

Figure 3



- (c) Explain why the observer can now see the coin in **Figure 3**.

(3)

- (d) Some types of wave are longitudinal and some types of wave are transverse.

Describe the difference between longitudinal waves and transverse waves.

(2)
(Total 10 marks)

Q6.

A baby monitor has a sensor unit that transmits an image of the baby and the noises the baby makes to a monitor unit.

The monitor unit then displays an image of the baby and emits the noises the baby makes.

- (a) Compare the properties of the waves that transmit images and noises from the monitor unit.

(4)

- (b) The sensor unit can detect infrared and visible light.

Suggest **one** advantage of being able to detect infrared.

(1)

- (c) Write down the equation that links frequency, wave speed and wavelength.

Equation _____

(1)

- (d) The signals for the monitor unit are transmitted as electromagnetic waves with a wavelength of 0.125 m.

Wave speed of electromagnetic waves = 3×10^8 m / s

Calculate the frequency of the signal.

Frequency = _____ Hz

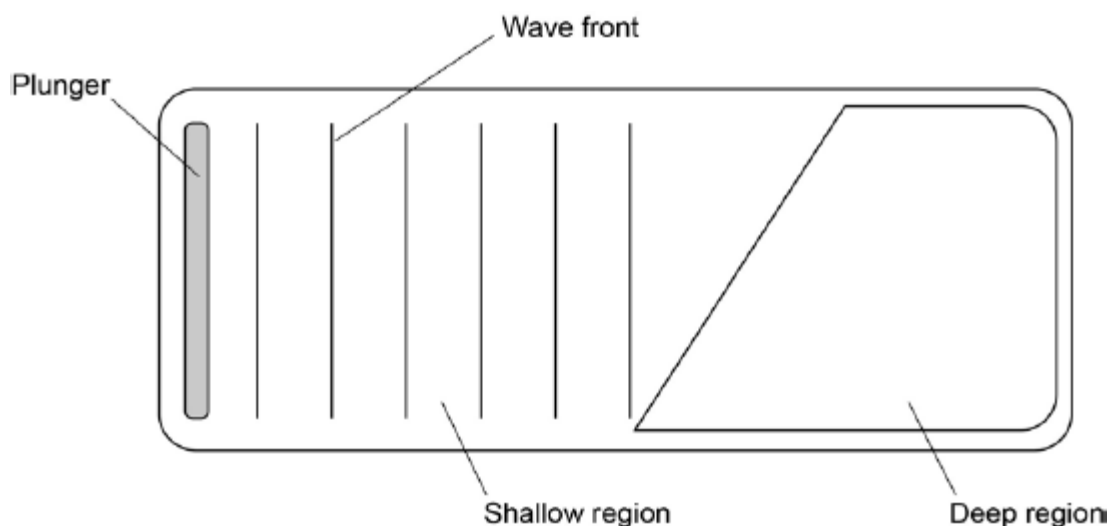
(3)

(Total 9 marks)

Q7.

Some students did an investigation to study the behaviour of waves.

The figure below shows a ripple tank that they used to model the behaviour of waves.



- (a) Complete the wave fronts on the figure above.

Show how the wave is refracted as it passes from the shallow region into the deep region.

(1)

- (b) Explain what happens to the waves as they pass into the deep region.

(2)

- (c) The waves generated on the surface of the water are transverse waves.

Describe the differences between longitudinal waves and transverse waves.

You may include labelled diagrams to help your answer.

(3)

- (d) Some students investigate the properties of the waves generated in the figure above.

Student **A** says 'the waves move water from one end of the tank to the other'.

Student **B** says 'that's wrong. Only the waves move, not the water'.

Suggest what the students could do to decide which of them is correct.

(2)

- (e) Another student uses a ripple tank where all the water is the same depth.

She measures the wavelength of each wave as 0.34 m.

The period of each wave is 0.42 s.

Calculate the speed of the wave.

Use the correct equation from the Physics Equation Sheet.

Give the unit.

Give your answer to three significant figures.

Speed = _____

Unit = _____

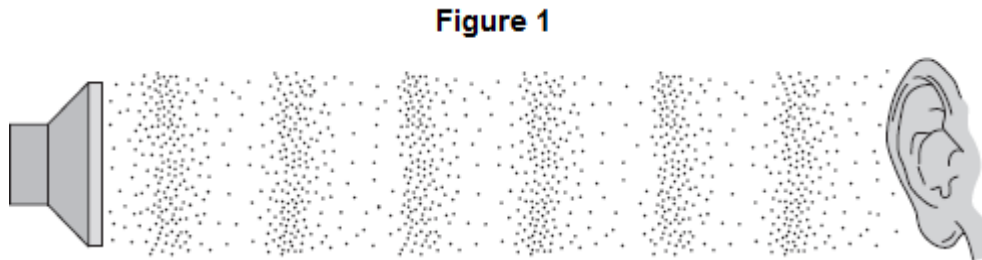
(5)

(Total 13 marks)

Q28.

A sound wave is an example of a longitudinal wave.

- (a) **Figure 1** shows the air particles in a sound wave as the wave travels from a loudspeaker to an ear.



Write a letter **R** on **Figure 1** to show an area of rarefaction.

(1)

- (b) Complete the sentence about longitudinal waves.

The vibrations of the air particles are _____ to the direction of energy transfer.

(1)

- (c) A stationary car horn emits a sound wave of frequency 400 Hz.

The wavelength of the wave is 0.85 m.

Calculate the speed of sound.

Use the correct equation from the Physics Equations Sheet.

Speed of sound = _____ m / s

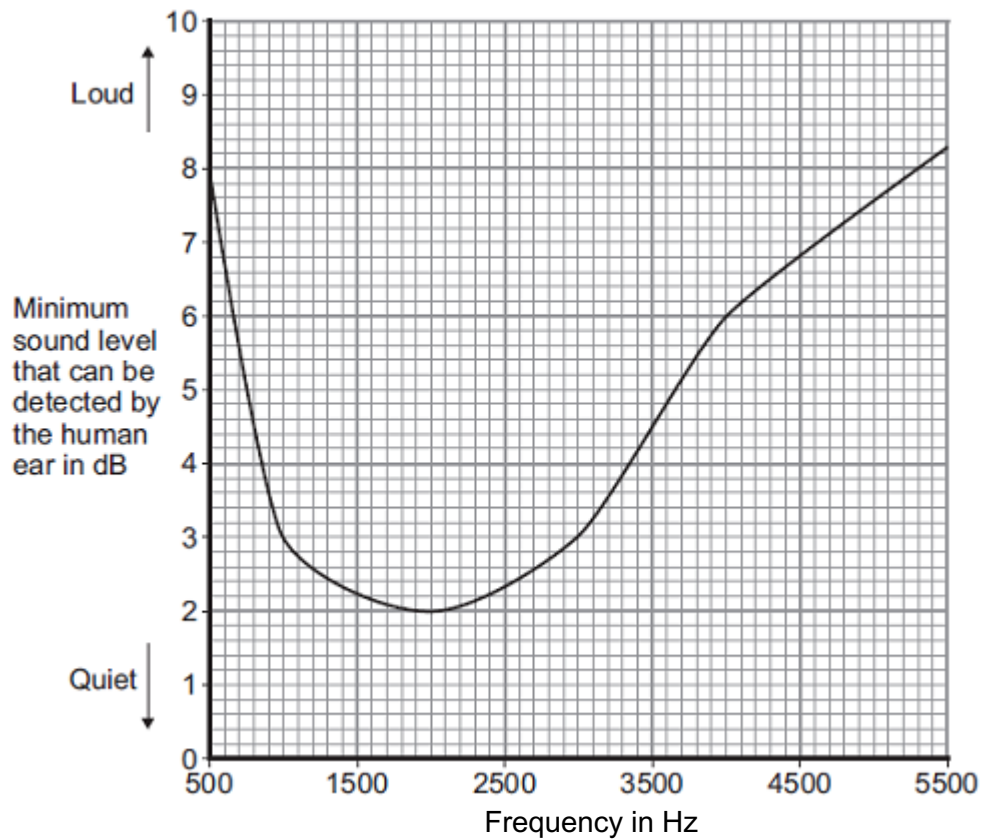
(2)

(Total 4 marks)

Q29.

The human ear can detect a range of frequencies of sound.
Sound level is measured in decibels, dB.

The figure below shows how the minimum sound level that can be detected by the human ear depends on the frequency of sound.



- (a) A sound has a frequency of 2000 Hz.

What is the minimum sound level needed to detect the sound?

Minimum sound level: _____ dB

(1)

- (b) Which frequency shown in the figure above would require the loudest sound before it could be heard?

Frequency: _____ Hz

(1)

- (c) The lowest frequency of sound the human ear can detect is 20 Hz. The wavelength of a sound wave with a frequency of 20 Hz is 17 metres.

Calculate the speed of a sound wave with a frequency of 20 Hz.

Use the correct equation from the Physics Equations Sheet.

Speed = _____ m / s

(2)

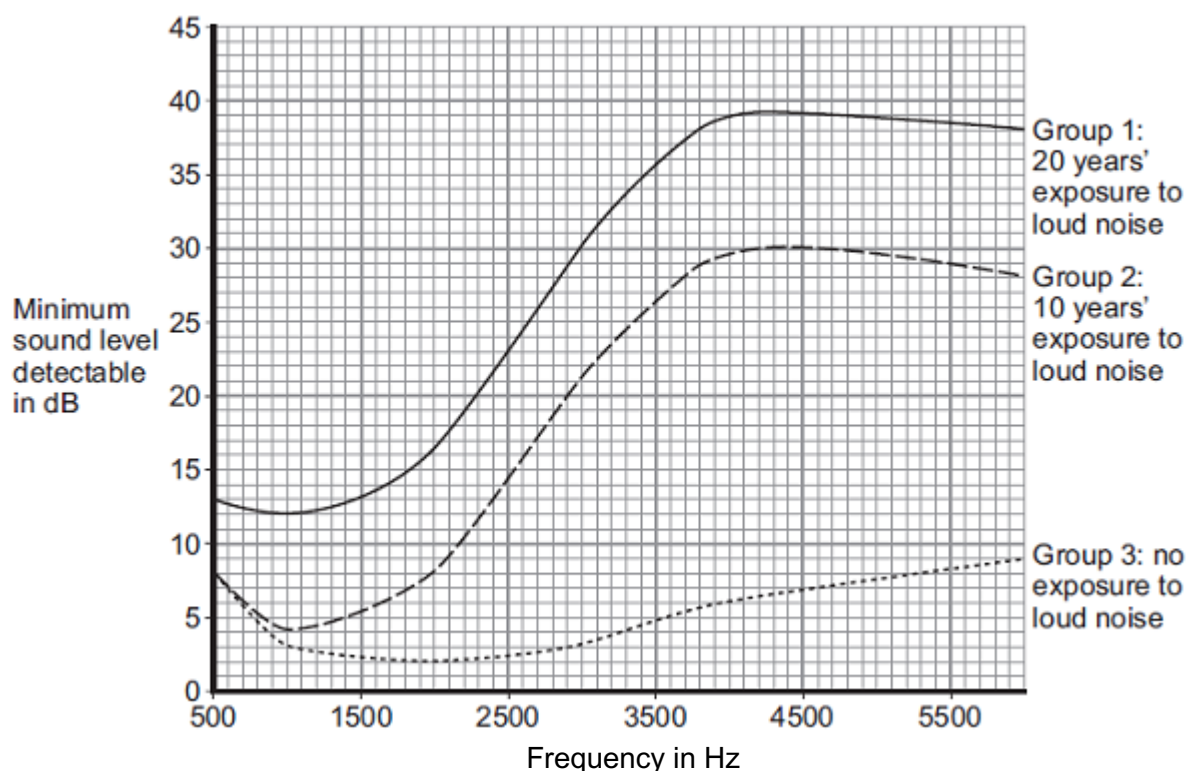
- (d) Sound waves can be reflected from a wall.

What name is given to reflected sound waves?

Q30.

Exposure to a noisy environment can damage a person's hearing.

The figure below shows the minimum sound level that is needed to detect sounds of different frequencies for three different groups of people. Sound level is measured in decibels, dB.



- (a) Which group of people has the worst hearing?

Group: _____

Use the information from the figure above to give a reason for your answer.

(1)

- (b) Give **three** other conclusions that can be made from the figure in part (a).

(3)
(Total 4 marks)

Q31.

A Doppler probe emits high frequency sound waves.

A doctor uses a Doppler probe to measure the pulse rate of an unborn baby in its mother's womb.

The sound waves have a frequency of 5.24×10^6 Hz.

The mean speed of sound through human body tissue is 1540 m / s.

Calculate the wavelength of the sound wave emitted by this Doppler probe as it travels through human body tissue.

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

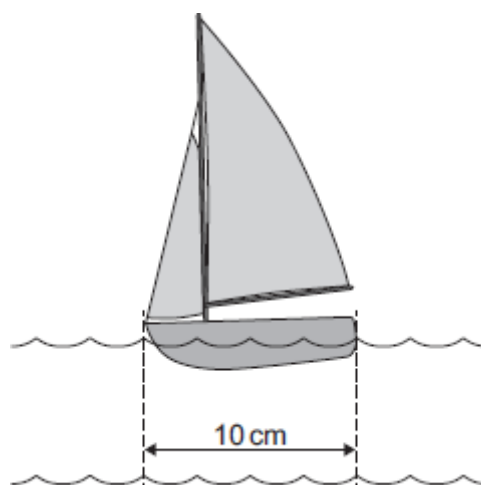
Use the correct equation from the Physics Equations Sheet.

Wavelength = _____ m

(Total 3 marks)

Q32.

A scientist tests a design for a sailing boat using a scale model in a tank of water.



- (a) Waves are produced on the surface of the water.

Use the diagram to calculate the wavelength of one wave.

Wavelength = _____ cm

(2)

(b) After testing the scale model, a full-size boat is built. This boat is tested at sea.

(i) The waves at sea have a wavelength of 6 m. The frequency of the waves is 0.5 Hz.

Calculate the speed of the water waves.

Use the correct equation from the Physics Equations Sheet.

Speed = _____ m/s

(2)

(ii) Suggest why a scale-model is tested before a full-size boat is built.

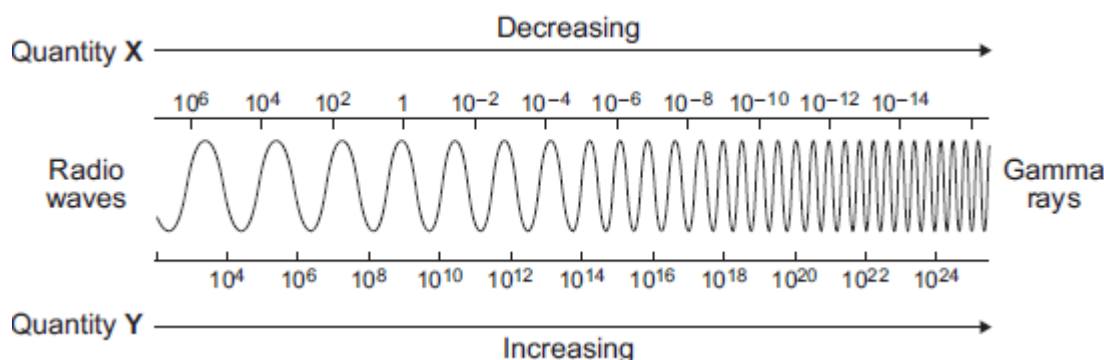
(1)

(Total 5 marks)

Q33.

The electromagnetic spectrum is shown in the diagram below.

Diagram 1



(a) Name quantities X and Y, and state the units they are measured in.

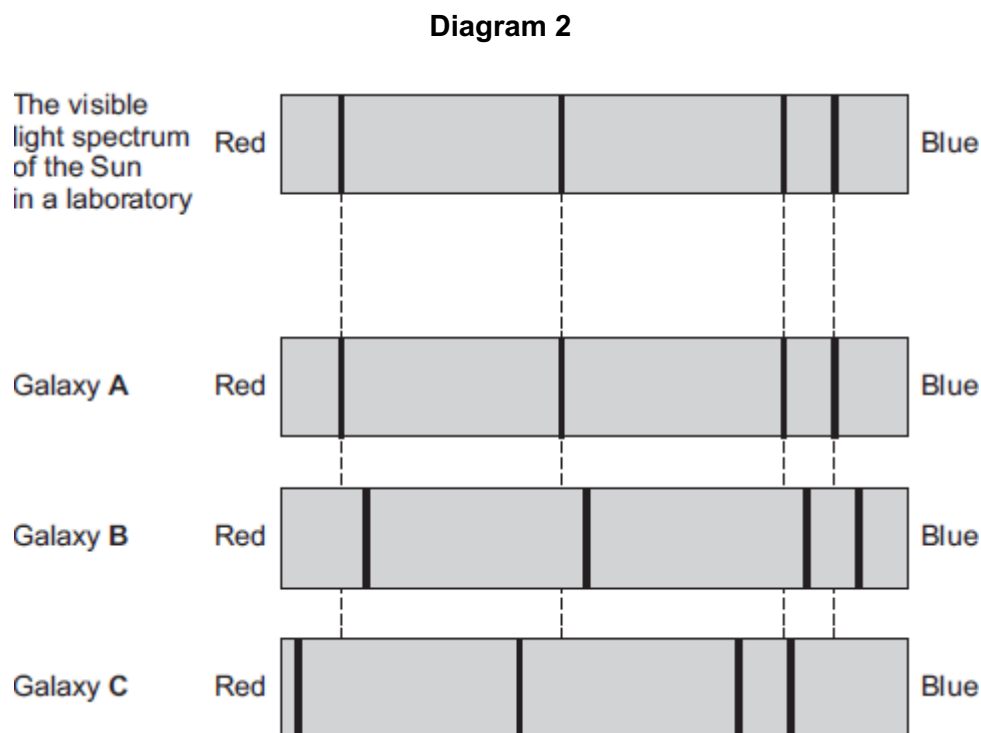
Quantity X: _____ Unit for Quantity X: _____

Quantity Y: _____ Unit for Quantity Y: _____

(3)

- (b) The visible part of the electromagnetic spectrum from stars includes dark lines. These lines are at specific wavelengths.

Diagram 2 shows the visible light spectra for three galaxies, **A**, **B** and **C**, compared to the visible light spectrum of the Sun as seen in a laboratory.



- (i) Using evidence from the spectra, what conclusions can be made about the movement of galaxies **A**, **B** and **C** relative to the Earth?

(3)

- (ii) Compare the speed of galaxy **B** with the speed of galaxy **C** relative to the observer.

(1)

- (iii) Explain why it is **not** valid to make conclusions about all galaxies in the

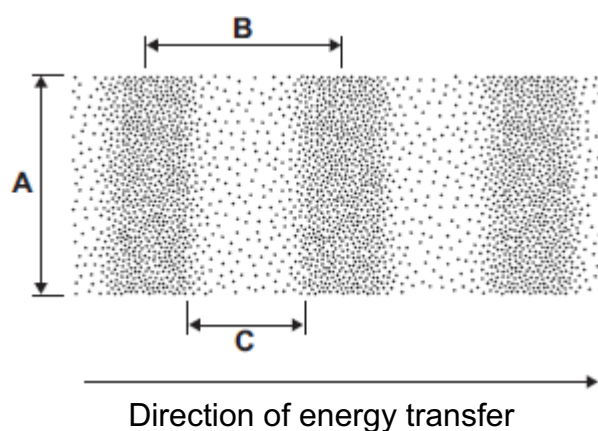
Universe from these spectra.

(2)
(Total 9 marks)

Q34.

Sound waves are mechanical waves.

The diagram shows the disturbance of air particles in the path of a sound wave at an instant in time.



- (a) (i) Which labelled arrow, **A**, **B** or **C**, correctly identifies the wavelength of the sound wave?

Arrow: _____

(1)

- (ii) What type of wave is a sound wave?

Draw a ring around the correct answer.

electromagnetic

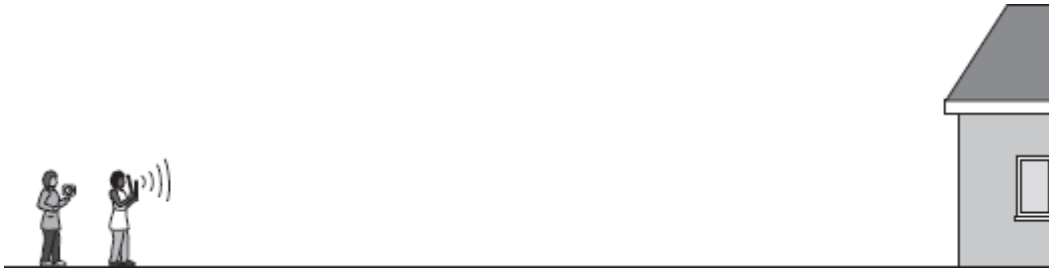
longitudinal

transverse

(1)

- (b) Two students investigate the reflection of sound waves from a building.

One student hits two metal bars together to produce a sound wave.



The second student starts a stop clock when the metal bars are hit together and stops the stop clock when she hears the echo.

The students want to calculate the time it takes the sound wave to travel to the building.

- (i) Why must the students divide the time on the stop clock by 2 to calculate the time it takes the sound wave to travel to the building?

(1)

- (ii) The students divide each time by 2 and record their results in a table.

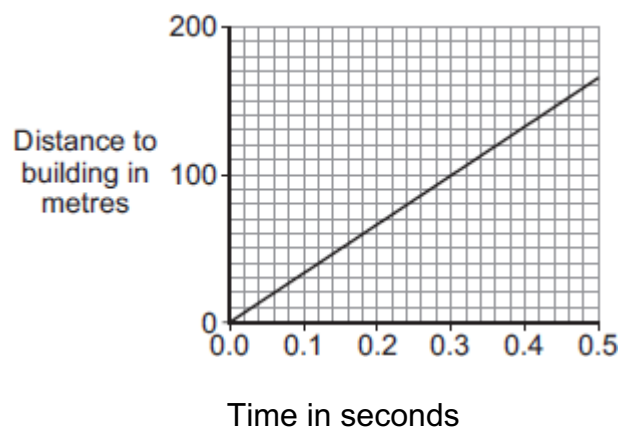
	Trial 1	Trial 2	Trial 3	Mean
Time in seconds	0.33	0.27	0.30	

Calculate the mean of the 3 results.

Write the mean in the table.

(2)

- (iii) The time taken for the sound wave to reach the building, from different distances, is shown in the graph.



Use the mean time from the table to determine the distance to the building.

Distance = _____ m

(1)

- (iv) The students see differences between the results.

Choose **one** improvement the students could make to the investigation.

Tick (✓) **one** box.

Improvement	Tick (✓)
Decrease the distance between the students and the building.	
Use a sound sensor and a datalogger to measure the time.	
Play a long note on a musical instrument instead of using metal bars.	

(1)

- (v) The students listen to the echo. The echo is quieter than the sound heard when the metal bars are hit together.

How does the amplitude of the echo compare with the amplitude of the sound wave produced by the metal bars?

(1)

(Total 8 marks)

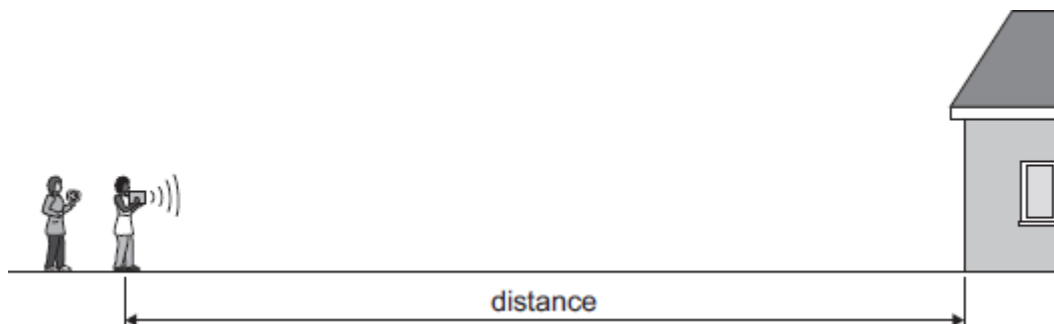
Q35.

Two students investigated the reflection of sound waves from a building.

One student used a signal generator connected to a loudspeaker to produce a short, high-pitched sound wave.

The second student used a stop clock to measure the time taken for the sound wave to return to the students.

The students repeated the experiment at different distances from the building.



- (a) Sound is a longitudinal wave.

How is a longitudinal wave different from a transverse wave?

(2)

- (b) The students' results are shown in the table.

	Trial 1	Trial 2	Trial 3
Time in seconds	0.40	0.59	0.92
Distance in metres	50.0	100.0	150.0

- (i) What was probably the biggest source of error in the students' investigation?

Give a reason for your answer.

(2)

- (ii) The signal generator was set at a frequency of 1.2 kHz.

The speed of sound in air, when the students did the investigation, was 340 m/s.

Calculate the wavelength of the sound wave generated by the speaker.

Use the correct equation from the Physics Equations Sheet.

Wavelength = _____ m

(3)

(Total 7 marks)

Q36.

Waves have many different properties.

- (a) Draw a ring around the correct answer in the boxes to complete each sentence.

Light waves

are longitudinal.
are transverse.
may be either longitudinal or transverse.

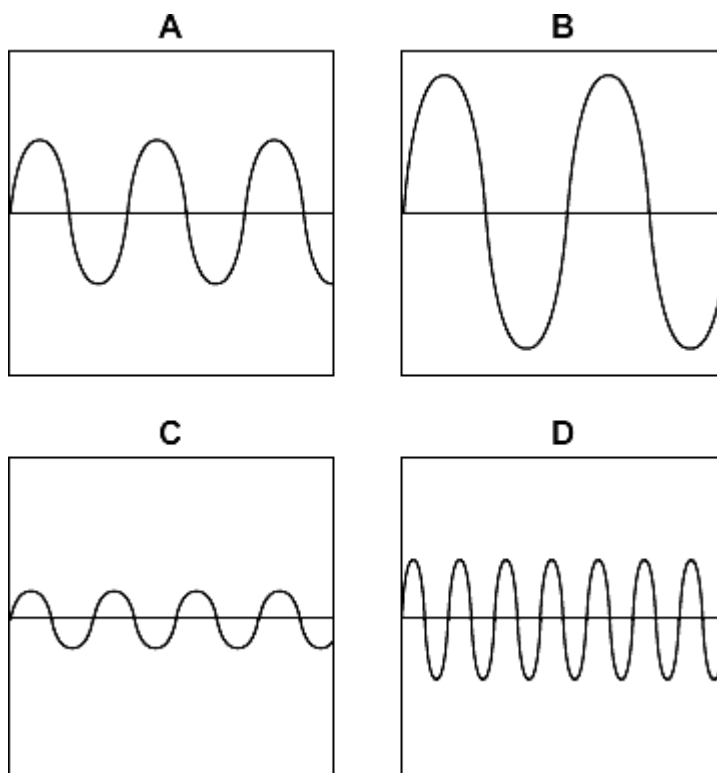
Sound waves

are longitudinal.
are transverse.
may be either longitudinal or transverse.

(2)

- (b) Diagrams **A**, **B**, **C** and **D** show oscilloscope traces of four different sound waves.

The oscilloscope settings are the same each time.



- (i) Give the letter of the loudest sound.

(1)

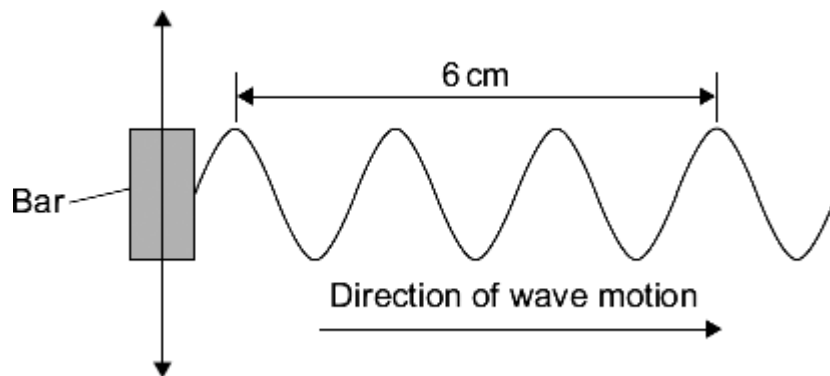
- (ii) Give the letter of the highest pitch sound.

(1)

(Total 4 marks)

Q37.

A ripple tank is used to investigate the behaviour of water waves.
A bar moves up and down to make the waves.



- (a) What is the wavelength of each wave in the diagram?

Draw a ring around the correct answer.

2 cm

3 cm

6 cm

(1)

- (b) The ripple tank produces 10 waves in 2 seconds.

What is the frequency of the waves?

Frequency = _____ hertz

(1)

- (c) The bar is made to move faster.

It now produces waves with:

- a frequency of 20 hertz
- a wavelength of 0.5 cm.

Calculate the speed of the water waves in cm/s.

Use the correct equation from the Physics Equations Sheet.

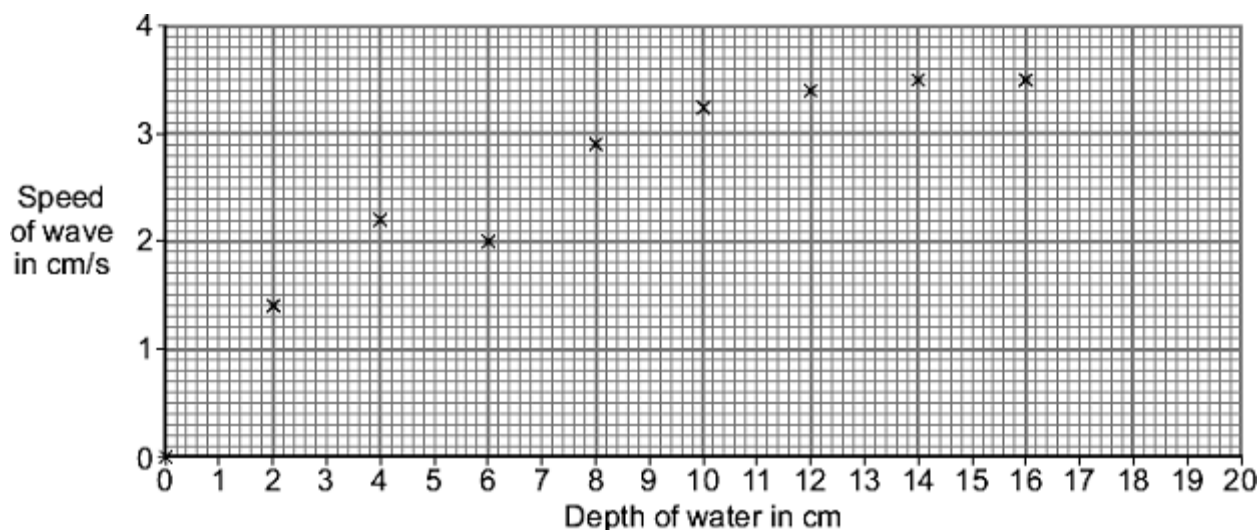
Show clearly how you work out your answer.

Speed = _____ cm/s

(2)

- (d) A student uses the ripple tank to investigate the relationship between depth of water and speed of waves.

The graph shows the student's results.



- (i) There is one anomalous result.

On the graph, draw a ring around this anomalous result.

(1)

- (ii) On the graph, draw a line of best fit

(1)

- (iii) Use your line of best fit to find the speed of the wave at a depth of 20 cm.

Wave speed = _____ cm/s

(1)

(Total 7 marks)

Q38.

Electromagnetic waves behave differently in different situations.

Electromagnetic waves travel at a speed of 3×10^8 m/s in a vacuum.

Microwave radiation has a wavelength of 2 cm.

Calculate the frequency of microwave radiation.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

Frequency = _____ hertz
(Total 2 marks)

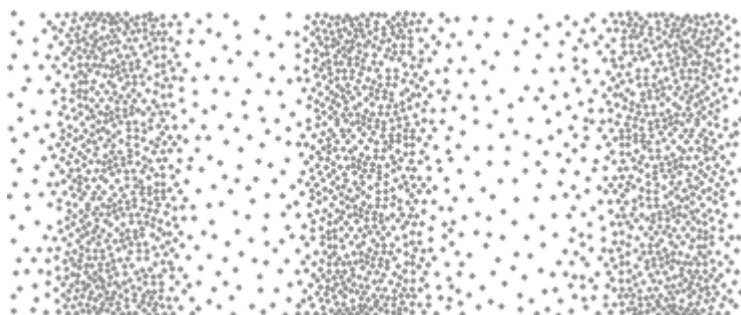
Q39.

Sound waves cause oscillations in the air. Sound waves are longitudinal.

- (a) In which direction are the oscillations of the particles compared to the direction of transfer of energy?

(1)

- (b) The diagram shows the disturbance of air molecules in the path of a sound wave at one point in time.



- (i) Label the diagram with the letter **R**, in an area of rarefaction.

(1)

- (ii) Label the diagram to show one complete wavelength.

(1)

(Total 3 marks)

Q40.

The different parts of the electromagnetic spectrum are shown below.

Gamma rays	X-rays	Ultraviolet	Visible light	Infrared	Microwaves	Radio waves
------------	--------	-------------	---------------	----------	------------	-------------

- (a) Name a part of the electromagnetic spectrum with:

- (i) a longer wavelength than microwaves: _____

(1)

- (ii) greater energy than X-rays: _____

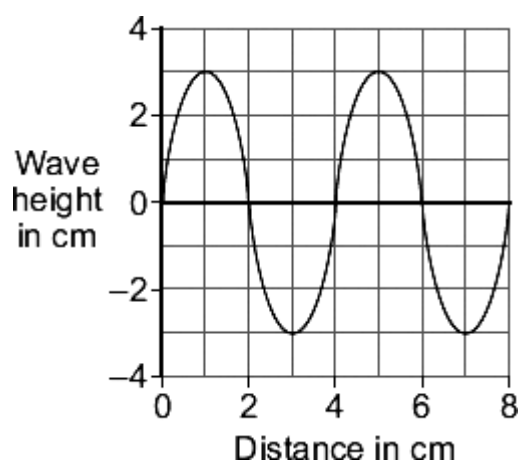
(1)

- (iii) a higher frequency than ultraviolet: _____

(1)

- (b) The properties of water waves can be measured easily in a school lab.

The diagram shows information about waves.



- (i) How many complete waves are shown in the diagram?

_____ (1)

- (ii) What is the wavelength of each wave in the diagram?

_____ cm (1)

- (iii) What is the amplitude of the waves?

_____ cm (1)

- (iv) Complete the sentence below.

The oscillations of the waves in the diagram are perpendicular to the direction of energy transfer. They are called _____ waves.

(1)

(Total 7 marks)

Q41.

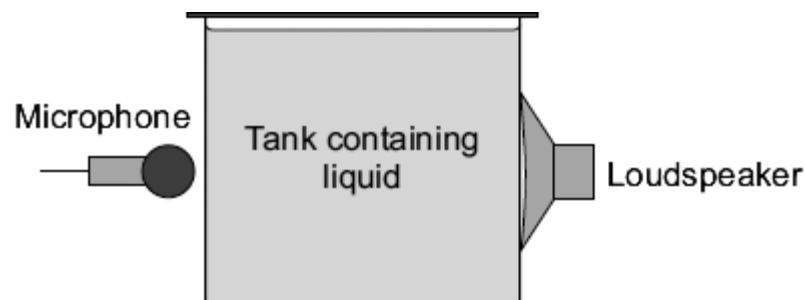
- (a) Sound and light are different types of waves.

Give **two** similarities and **two** differences between sound waves and light waves.

(4)

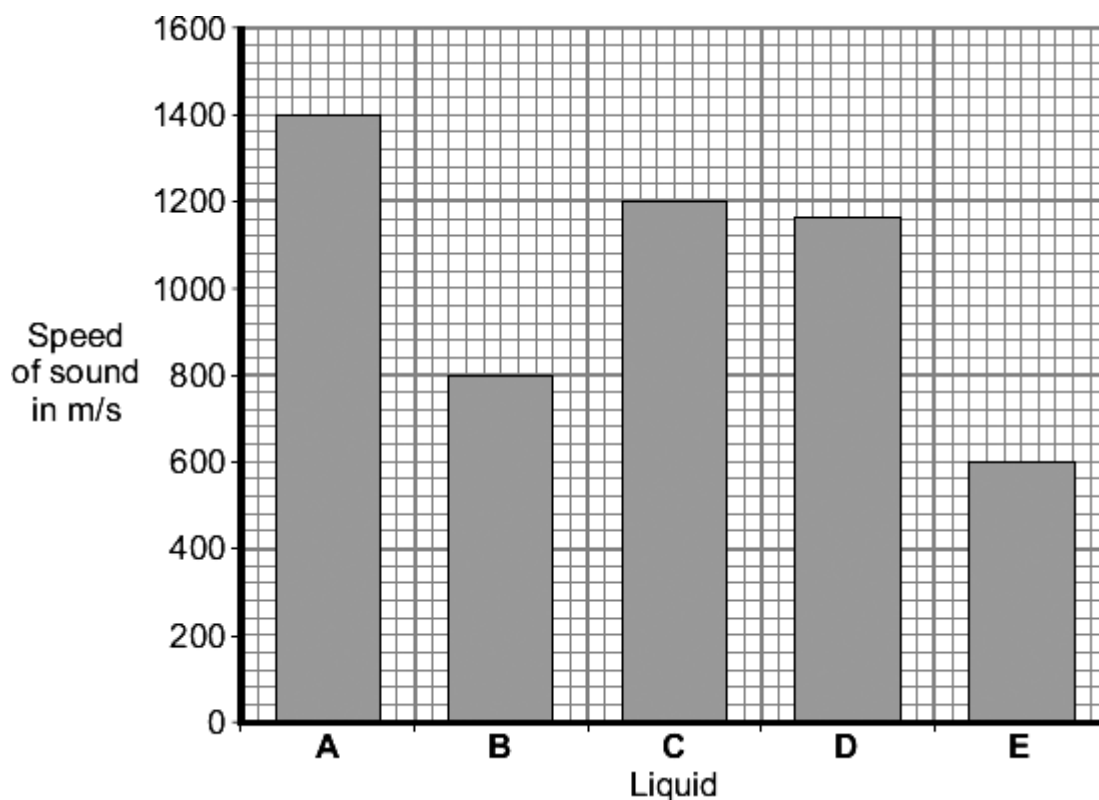
- (b) A student does an experiment to investigate the speed of sound in different liquids.

The student uses the apparatus shown.



A loudspeaker makes a sound wave. The sound wave travels through the liquid in the tank. The time it takes to travel this distance is used to calculate the speed of sound.

The bar chart shows the student's results.



- (i) When a sound wave with a frequency of 4800 hertz passes through one of the liquids, it has a wavelength of 0.25 m.

Calculate the speed of the wave and identify the liquid used.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

Speed = _____ m/s

The liquid used was _____

(3)

- (ii) The student's hypothesis was:
'There is a link between the density of a liquid and the speed of sound in the same liquid.'

Liquid	Density in g/cm ³	Speed of sound in m/s
Ethoxyethane	0.71	985
Ethanol	0.80	1150
Kerosene	0.82	1300
Water	1.00	1500
Mercury	13.50	1450

Use the information in the table to decide whether the student's hypothesis was completely correct or not.

Was the student's hypothesis completely correct?

Draw a ring around your answer. **Yes / No**

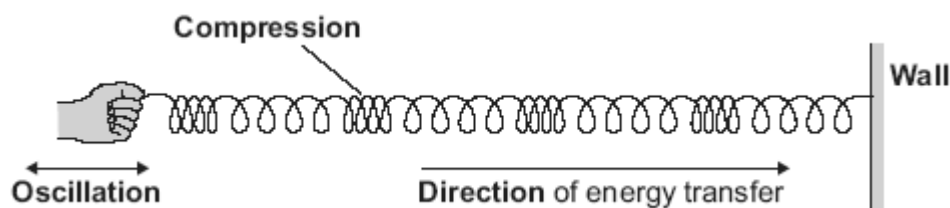
Give reasons for your answer.

(2)

(Total 9 marks)

Q42.

- (a) The diagram shows a longitudinal wave being produced in a stretched spring.



- (i) Use the bold words from the diagram to complete the following sentence.
Put only **one** word in each space.

A longitudinal wave is one in which the _____ causing
the wave is parallel to the _____ of energy transfer.

(2)

- (ii) Name the type of energy that is transferred by longitudinal waves.

(1)

- (b) The diagram shows water waves made by a wave machine in a swimming pool.



Every second, two waves go past a person standing in the swimming pool.

The waves have a wavelength of 0.8 metres.

Calculate the speed of the water waves.

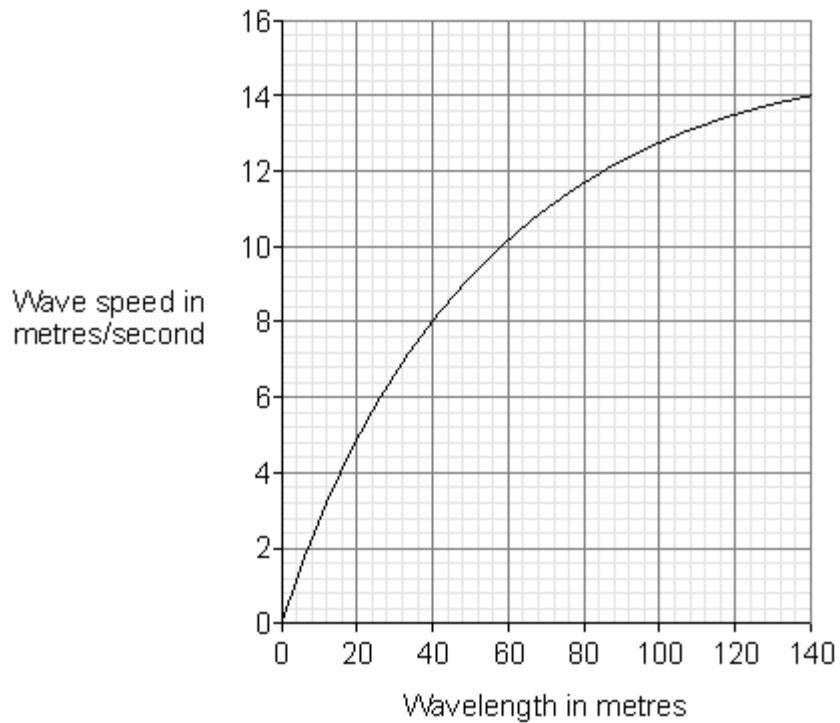
Write down the equation you use, and then show clearly how you work out your answer.

Give the correct unit in your answer.

Wave speed = _____

(3)

- (c) The graph shows how the speed of deep ocean waves depends on the wavelength of the waves.



What can you conclude from the graph?

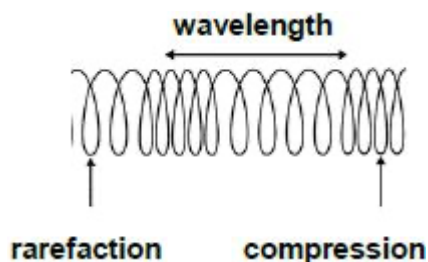
(2)

(Total 8 marks)

Mark schemes

Q1.

(a)



3

(b) longitudinal

1

(c) **Level 2:** The method would lead to the production of a valid outcome. Key steps are identified and logically sequenced.

3-4

Level 1: The method would not necessarily lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1-2

No relevant content

0

Indicative content

- measure the distance between the student with the bricks and the wall
- trundle wheel or tape measure
- measure the time taken from banging the bricks to the echo
- double the measured distance to give the distance travelled or half the time
- use:

$$\text{speed} = \frac{\text{distance travelled}}{\text{time}}$$
- repeat timings
- remove anomalies
- calculate a mean

[8]

Q2.

(a) in a longitudinal wave, the oscillations / vibrations are parallel to the direction of energy transfer

allow direction of travel for energy transfer

1

in a transverse wave, the oscillations / vibrations are perpendicular to the direction of energy transfer

allow direction of travel for energy transfer

if no other mark scored allow 1 mark for (oscillations / vibrations of) longitudinal waves

are parallel **and** (oscillations / vibrations of)
 transverse waves are perpendicular
 if no other mark scored allow **1** mark for
 transverse waves have peaks and troughs **and**
 longitudinal waves have compressions and
 rarefactions

1

(b) $3.0 \times 10^8 = 4.8 \times 10^9 \times \lambda$

allow $\lambda = \frac{3.0 \times 10^8}{4.8 \times 10^9}$

this mark may be awarded if the standard form
 values are incorrectly converted

1

$\lambda = 0.0625 \text{ (m)}$

1

$\lambda = 0.063 \text{ (m)}$

or

$\lambda = 6.3 \times 10^{-2} \text{ (m)}$

allow an answer to 2 sig figs that is consistent
 with their calculated value of λ and has required
 rounding

1

an answer of 0.063 (m) scores **3** marks

(c) any **three** from:

- (the car aerial) absorbs radio waves or energy
- electrons are made to vibrate (in the aerial)
- creating an alternating current (in the aerial circuit)
- the (signal) frequency is the same (as the radio wave)

3

[8]

Q3.

(a) sound waves are longitudinal

1

in longitudinal waves, the oscillations / vibrations are parallel to the direction of
 energy transfer

allow direction that the wave is travelling for direction of
 energy transfer

1

water waves are transverse

1

in transverse waves, the oscillations / vibrations are at 90 degrees to the direction of
 energy transfer

ignore references to wave speed, wavelength or frequency

an answer stating that sound waves travel in all directions but water waves don't is insufficient.

1

(b)
$$0.0083 = \frac{1}{\text{frequency}}$$

1

$$\text{frequency} = \frac{1}{0.0083}$$

1

frequency = 120 (Hz)

an answer of 120(.481...) scores 3 marks

an answer of 0.12 scores 2 marks

1

(c)

Level 3: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5-6
Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.	3-4
Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical thinking.	1-2
No relevant content	0
Indicative content equipment - a stopclock / stopwatch should be used to time the waves - a metre rule should be used to measure distance determining the frequency of the waves - the frequency could be determined by finding the time for several waves to pass a point - the frequency could be determined by finding the how many waves pass a point in a fixed time - frequency is the average time for one wave to pass a point - frequency = $\frac{\text{no. of waves}}{\text{total time for waves to pass}}$	

determining the speed of the waves - the speed can be determined by measuring the distance travelled by a wave and the time taken to travel that distance - the distance used to determine speed should be as long as possible - speed = distance/time determining the wavelength of the wave - the wavelength can be calculated using the speed and frequency of the wave - wavespeed = frequency × wavelength $\text{wavelength} = \frac{\text{wavespeed}}{\text{frequency}}$ $\text{wavelength} = \frac{\left(\frac{\text{distance}}{\text{time}}\right)}{\left(\frac{\text{no. of waves}}{\text{second}}\right)}$	
--	--

6

[13]

Q4.

- | | | |
|-----|---|---|
| (a) | B | 1 |
| (b) | A | 1 |
| (c) | $\frac{2.5 \text{ (waves)}}{0.5 \text{ (s)}}$ | 1 |
| | 5(.0)(Hz) | 1 |
| (d) | longitudinal | 1 |
| (e) | timing (from seeing the blocks bang together and hearing the sound)
or
risk of cancelling the timer
<i>ignore human error unqualified</i>
<i>allow reaction time (of student B)</i> | 1 |
| (f) | student to stand further away (so there is a greater time lag to measure)
<i>allow other correct methods, eg using echoes</i> | 1 |
| (g) | both are transverse waves | |

1

both can travel through a vacuum

1

[9]

Q5.

- (a) wave speed = frequency $\times$ wavelength

$$\text{allow } v = f\lambda$$

1

- (b)

Level 2: The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	3-4
Level 1: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.	1-2
No relevant content	0
Indicative content - adjust the bar so that it just touches the surface of the water - adjust motor to produce low frequency wave - adjust the lamp until the pattern is seen clearly on the card underneath - place a metre rule at right angles to the waves - measure the length of a number of waves (minimum 3 waves) - divide the length by the number of waves to give wavelength - count the number of waves passing a point in a given time - divide the number of waves counted by the time to give the frequency	

4

- (c) light is reflected off the coin (and travels through the water)

allow correct ray on diagram

1

as the light leaves the water its speed increases

allow correct ray on diagram

1

(this causes) the light to refract in the direction of the eye

1

(d) in longitudinal waves oscillations are parallel to the direction of energy transfer

1

in transverse waves the oscillations are perpendicular to the direction of energy transfer

1

[10]

Q6.

(a) any **four** from:

- light waves are transverse whereas sound waves are longitudinal
- light waves travel faster than sound waves
- light waves have a higher frequency than sound waves
- light waves have a shorter wavelength than sound waves
- light waves have oscillations perpendicular (to the direction of energy transfer) whereas sound waves are parallel (to the direction of energy transfer)

4

(b) the baby can be seen in the dark

1

(c) wave speed = frequency $\times$ wavelength

accept $v = f \lambda$

1

(d) $3 \times 10^8 = f \times 0.125$

1

$$f = 3 \times 10^8 / 0.125$$

1

$$f = 2.4 \times 10^9 \text{ (Hz)}$$

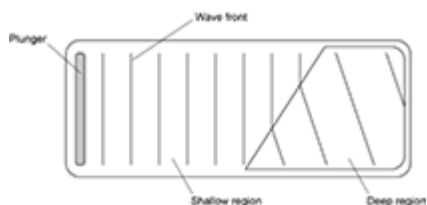
allow 2.4×10^9 with no working for 3 marks

1

[9]

Q7.

(a)



lines should be further apart with the bottom of the wave fronts further to the right than the top

1

(b) they will speed up

1

so wave (fronts) move further apart

	1
(c) longitudinal waves:	
• the oscillations are parallel to the direction of energy transfer	1
• show areas of compression and rarefaction	1
transverse waves:	
• the oscillations / movement are perpendicular to the direction of energy transfer.	1
(d) place a floating object / plastic duck on the surface of the water	1
it will stay in the same place or only bob up and down if the water doesn't move	1
(e) $0.42 = 1 / f$	1
$f = 2.38$	1
$v = 2.38 \times 0.34$	1
$= 0.809$	
<i>allow 0.809 with no working shown for 4 marks</i>	1
<i>incorrect sig. figs max 3 marks</i>	
m / s	
<i>correct unit</i>	1
	[13]

Q28.

(a) one of the areas where particles are spread out labelled R	1
(b) parallel	1
(c) 340 (m / s)	
<i>allow 1 mark for correct substitution</i>	
<i>i.e. speed = 400×0.85 provided that no subsequent steps are shown</i>	2
	[4]

Q29.

(a) 2(dB)	1
-----------	---

- (b) 5500(Hz) 1
- (c) 340(m / s)
allow 1 mark for correct substitution (20 x 17) provided no subsequent step 2
- (d) echo(es) 1
- [5]

Q30.

- (a) Group 1
ignore figures
reason only scores if group correct
Reason: Loudest sound needed for person to notice it.
allow louder sound
allow exposed to loud noise for longest / longer 1
- (b) any **three** from:
ignore Group 1 has the worst hearing
ignore figures unqualified
- the *longer* the exposure (to loud sounds) the greater the hearing loss
 - no exposure / Group 3 has the best hearing
allow better
 - hearing worsens (significantly) for frequencies above 1000Hz (or converse).
ignore hearing is worse at high frequencies
 - the first 10 years exposure has more of an effect than the next 10 years
allow 10 years exposure to loud noise has no effect on hearing at 500 Hz 3
- [4]

Q31.

- 0.000294 or 2.94×10^{-4} (m)
a correct answer given to an incorrect number of significant figures gains **2** marks
eg 2.939×10^{-4} (m) **or** 2.93×10^{-4} (m)
or 0.0002939 (m) **or** 0.000293 (m)
or 2.9×10^{-4} (m) **or** 0.00029 (m)
or 3×10^{-4} (m) **or** 0.0003 (m)
allow **1** mark for correct substitution
 $1540 = 5\,2400\,000 \times \lambda$
or $1540 = 5.24 \times 10^6 \times \lambda$
provided no subsequent step
or allow **1** mark for correct substitution and rearrangement

$$\lambda = \frac{1540}{5\,240\,000}$$

or

$$\lambda = \frac{1540}{5.24 \times 10^6}$$

provided no subsequent step

an answer of 2.94 gains one mark only

an answer given to an incorrect number of s.f. and including a rounding error gains one mark only

eg 2.938×10^{-4} (m)

3

[3]

Q32.

(a) 2.5(cm)

10 / 4 for 1 mark

2

(b) (i) 3 (m/s)

allow 0.5×6 for 1 mark

2

(ii) any **one** from:

- cheaper
 - (easier) to make adjustments
 - easier to handle
 - external conditions can be controlled
 - for safety
 - fit for purpose
- allow to see if it works / floats / has faults*

1

[5]

Q33.

(a) X = wavelength

1

Y = frequency

1

wavelength in metres / m and frequency in hertz / Hz

both units correct for 1 mark (independent of first two marking points)

correct units must match correctly named quantities

allow Hertz

allow multiples of the units eg kHz, km (or in words)

1

- (b) (i) galaxy A is stationary (relative to Earth / us) 1
- galaxy B is moving towards (Earth / us)
allow 1 mark for identifying galaxies B and C are moving in opposite directions 1
- galaxy C is moving away from (Earth / us)
allow 1 mark if say all moving away / towards **or** stationary 1
- (ii) galaxy C is faster (than galaxy B)
allow converse statement
do **not** accept galaxy C expanding faster 1
- (iii) sample is too small
accept three is too few
allow not enough evidence
ignore inaccurate, invalid, anomalous 1
- compared to the size of the population
accept there are a very large number of galaxies in the Universe
allow A, B and C are moving differently (from each other) for 1 mark 1
- [9]

Q34.

- (a) (i) B 1
- (ii) longitudinal 1
- (b) (i) the sound wave travels to the building and back
allow (because) it is an echo 1
- (ii) $0.30 / 0.3$
allow 1 mark for
$$\frac{0.30 + 0.27 + 0.33}{3}$$

or
$$\frac{0.9}{3}$$
 2
- (iii) 100 (m)
allow ecf from (b)(ii) with a tolerance of ± 10 (m) 1

- | | | | |
|------|---|---|--|
| (iv) | use a sound sensor and a datalogger to measure the time | 1 | |
| (v) | (amplitude of echo is) smaller
<i>ignore quieter</i>
<i>allow lower</i> | 1 | |
- [8]**

Q35.

- | | | | |
|-----|---|---|------------|
| (a) | any two from: <ul style="list-style-type: none"> • (longitudinal) oscillations are parallel to the direction of energy transfer • (transverse) oscillations are perpendicular / 90° to the direction of energy transfer
<i>allow vibrations for oscillations</i>
<i>allow correct description of particle movement for oscillation</i>
<i>allow direction of wave for direction of energy transfer</i> • (longitudinal waves) show areas of compression and rarefaction
<i>marks can be gained from correctly labelled diagrams</i>
<i>ignore references to need for a medium to travel through</i> | 2 | |
| (a) | (i) reaction time
<i>allow a description of reaction time</i>
<i>allow measuring the time</i> | 1 | |
| | (as) time measured is very small
<i>allow (as) sound travels quickly</i> | 1 | |
| | (ii) 0.28(3)
<i>an answer of 283(.3) gains 2 marks</i>
<i>allow correct substitution and unit conversion for 2 marks</i>
<i>340 = 1200 λ or 340 / 1200 = λ provided no subsequent step shown</i>
<i>allow correct substitution for 1 mark 340 = 1.2 λ or 340 / 1.2 = λ provided no subsequent step shown</i> | 3 | [7] |

Q36.

- | | | |
|-----|--------------------------------|---|
| (a) | (light waves) are transverse | 1 |
| | (sound waves) are longitudinal | 1 |
| (b) | (i) B | 1 |
| | (ii) D | |

Q37.

(a) 2 cm

1

(b) 5 (hertz)

ignore incorrect units

1

(c) $v = f \times \lambda$

10 (cm/s)

allow correct substitution for 1 mark (20×0.5) or (2×5)

2

(d) (i) point at 6 cm on x-axis should be circled

1

(ii) line of best fit drawn through points ignoring anomalous point at 6 cm

*line should be a curve through every point (including 0)
except anomalous point**tolerance ± 1 square at each cross**ignore line after 16 cm**do **not** accept straight lines joining crosses*

1

(iii) 3.5 (cm/s)

*tolerance $\pm$ half a square from students line**allow ecf from (d)(ii)**if no extrapolation accept 3.5*

1

Q38.

$$v = f \times \lambda$$

 1.5×10^{10} (hertz)**or**

15 000 000 000

*allow 1 mark for correct substitution and transformation
($3 \times 10^8 / 0.02$)**allow 1 mark for 1.5×10^8* ***or** 150 000 000*

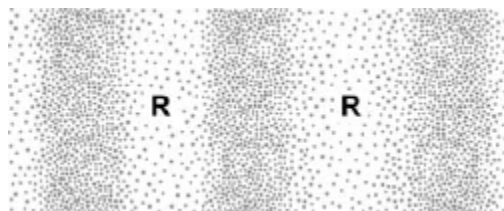
2

Q39.

(a) same / parallel to

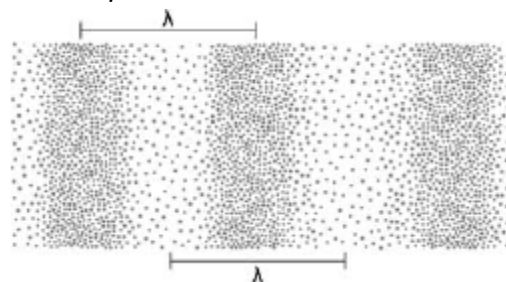
1

(b) (i) letter R where the particles are furthest apart



1

- (ii) student correctly indicates one wavelength
wavelength may be from one rarefaction to the next or from one compression to the next



1

[3]

Q40.

- (a) (i) radio (waves)
- (ii) gamma (rays)
accept γ
*do **not** accept α*
- (iii) X-rays
or
 gamma (rays)
accept γ
*do **not** accept α*
- (b) (i) 2
- (ii) 4(cm)
- (iii) 3(cm)
ignore + or – in front of 3(cm)
- (iv) transverse

1

1

1

1

1

1

1

[7]

Q41.

- (a) any **two** similarities and any **two** differences
read whole answer to ensure that there are no contradictory statements which negates that mark
ignore reference to senses in similarities and differences

similarities

- (both can be) reflected
- (both can be) refracted
allow both travel through any correctly named solid / gas / liquid
- (both can be) diffracted
- (both) interfere
- (both) transfer energy
ignore both are types of energy / waves / oscillations
- (both exhibit) Doppler effect
*do **not** accept statements like both are transverse as a similarity*

differences

- light can travel through a vacuum
or
 sound cannot travel through a vacuum
allow sound requires a medium / particles to travel through
- (different) speed / velocity
- one is longitudinal and one is transverse
accept light is faster than sound
*do **not** accept sound is transverse and light is longitudinal*
allow correct description:
(longitudinal) the oscillations / vibrations are parallel to / same direction as (the direction of energy transfer)
and
(transverse) the oscillations / vibrations are 90° to / perpendicular to (the direction of energy transfer)
- sound is a mechanical wave / caused by vibrations and light is an electromagnetic wave
accept sound waves have a longer wavelength / lower frequency
*if no other marks gained allow **1** mark for any correct difference(s) where the waves are not specified*
eg one is transverse
eg have different wavelengths / frequencies

4

- (b) (i) working must be shown for **3** marks

4800 x 0.25	1
1200(m/s)	1
(liquid) C	
<i>ignore water / named liquid</i>	1
(ii) (yes / no)	
<i>ignore yes / no, marks are for the explanation</i>	
speed increases as density increases	
<i>allow positive correlation</i>	
<i>allow the more dense the liquid the less time (for sound to travel through)</i>	
<i>ignore they both increase</i>	
<i>ignore there was no pattern</i>	1
but, mercury should have a (much) greater speed given the higher density	
<i>allow mercury does not fit the pattern / is an anomaly</i>	1

[9]

Q42.

(a) (i) oscillation	1
direction	1
<i>correct order only</i>	
(ii) sound	1
(b) 1.6	
<i>allow 1 mark for correct substitution into correct equation ie 2 × 0.8</i>	2
m/s	1
(c) as the wavelength increases so does the wave speed	1
extra information, eg wave speed increases faster between 0-40 m than between 100-140 m	1

or

not in proportion

[8]

Examiner reports

Q1.

- (a) 88% of students gained at least one mark with only 19% scoring all three. Most students were able to correctly label wavelength however many confused rarefaction and compression with amplitude and frequency.
- (b) Only 55% of students correctly identified a sound wave as being longitudinal; many of those that did not score selected transverse.
- (c) Level two required students to produce a plan that would lead to a valid outcome. Key steps are needed for this including measuring time, distance and how to calculate speed from these measurements.

Only 9% of students were able to achieve level 2 with many just writing a clear account of how to measure the correct time for sound to travel to and from the wall. Many of those that did mention distance failed to give any account of what would be done with the measured values.

Nearly 27% did not gain any marks, with a significant number stating that the bricks should be thrown at the wall despite the stem of the question indicating that they would be banged together.

Q2.

- (a) Nearly 13% gave accurate answers to score both marks. A further 20% were able to score a compensation mark by vague references to parallel and perpendicular, but it was clear that many students do not realise the importance of what is oscillating and the direction of energy transfer. There were many vague incorrect descriptions of 'up and down' and 'side to side'.
- (b) 25% gained full marks, and a further 18% gained two marks, usually not giving the answer to two significant figures. There were a large number of responses using an incorrect rearrangement of the equation and generally the use of standard form was not the cause of the errors.
- (c) This was very poorly done, with just over 1% gaining full marks. There were many vague responses and a significant number of candidates wrote about transverse and longitudinal waves. There was also considerable reference to radio waves being reflected off the ionosphere.

A significant minority of students did not attempt this question which might suggest that they were unfamiliar with the material.

Q28.

- (a) The letter R was often written so that it overlapped areas of rarefaction and compression, so did not gain credit. Those who knew the answer wrote the letter R very clearly in a correct position.
- (b) Very few students gained the mark for this question. Many thought that vibrations travel.
- (c) Most students who attempted this question gained full marks for calculating the speed of sound.

Q29.

- (a) Most students interpreted the graph correctly and identified the minimum sound level needed to detect sound at 2000 Hz as 2 dB.
- (b) Many students did not fully understand what the graph was showing, and found it more difficult to take a reading from the x-axis than taking one from the y-axis, as they had done in part (a).
- (c) The question was well answered and most students gained full marks. A few gained 1 mark for showing 20×17 , but then worked this out to give an incorrect answer. Students should be informed that the first mark in a calculation is for the substitution, and so should be encouraged to show their working. A few multiplied 20 by 20, rather than by 17. Others carried out a division instead of a multiplication.
- (d) Only about a quarter of the students knew that reflected sound waves are called echoes.

Q30.

- (a) Less than half the students gained this mark. Many students correctly identified Group 1 as having the worst hearing; however, there was no mark for this; the mark was awarded for a correct reason. The reason had to include a comparative statement; "They could only hear loud noises" was therefore not creditworthy. Most gained the mark by saying they had the highest minimum sound level detectable. A few chose Group 3, because they had not understood what the graph was showing.
- (b) Many students struggled to understand the graph, so found it hard to make a sensible conclusion. The most common correct responses were that Group 3 had the best hearing, and the longer you are exposed to loud noises the worse your hearing is. Both of these ideas had to be expressed comparatively. Many students thought the graph was showing the age of people, so gave conclusions such as the older you are the worse your hearing. Some thought that the group with the longest exposure to loud sounds could hear the best because they were used to it. A lot of students did not give conclusions; instead they gave descriptions of the frequencies heard by the different groups.

Q31.

Very few students gained full marks, and only just over a third scored 1 mark or more. Students should be told that the first mark in a calculation is for the substitution, not for the rearrangement. Many students scored no marks because they did not show their working. Many students were not able to give an answer to 3 significant figures, but gained 2 marks for 2.939×10^{-4} m or an equivalent alternative. Those students who just showed a correct substitution into the equation were awarded 1 mark, even if they went on to make an error in their calculation. The most common error was to divide 5240 000 by 1540, which gave an answer of 3402.6 m.

Q32.

- (a) Many students gave the correct answer of 2.5 cm. Others made errors in counting the number of waves; 3 or 5 waves were often recorded instead of 4. Others tried to use the wave equation from the Physics Equation Sheet. If the question says use the diagram, it means that there is information in the diagram to be used.
- (b) (i) The majority of students answered the question correctly. It was pleasing to see so many students showing their working as this would gain credit even

if the final answer was incorrect. Students who answered incorrectly had attempted to rearrange the equation and calculated 6 divided by 0.5 instead of 0.5 times 6. Students should be reminded that rearranging equations will only be required on the Higher Tier paper, not the Foundation Tier. Students should be aware that only the last equation on the Physics Equation Sheet applies to SCA2 papers.

- (ii) Most responses said to see if the boat floats, or to see if it works, both of which gained credit.

Q33.

- (a) Most students did not know what quantities X and Y were, but those who did often scored the third mark for naming the correct units.
- (b)
 - (i) Many responses referred to the speed that the galaxies were travelling at, rather than their directions relative to Earth. Others gave their relative distances from Earth. Many gained 1 mark for realising that galaxies B and C were moving in opposite directions. A few gave detailed explanations for their conclusions in terms of red and blue shift.
 - (ii) The question asked for a comparison between the speed of galaxy B and the speed of galaxy C, relative to the observer. Many responses did not refer to one being faster or slower than the other, but to relative distances from the observer, or amount of red or blue shift.
 - (iii) Only a few students realised that there wasn't enough evidence, or that 3 galaxies were too few to base conclusions about all galaxies on. Even fewer mentioned that there are a very large number of galaxies in the Universe.

Q34.

- (a)
 - (i) Just under half of the students could identify the wavelength of the sound wave. All representations of waves should be taught.
 - (ii) Just over half of the students knew that a sound wave is longitudinal. Many thought it is transverse.
- (b)
 - (i) About a third of students correctly realised that the sound wave must travel to the building and back. Most incorrect answers focussed on the two metal bars or the two students as reasons to divide by two.
 - (ii) Most students correctly calculated the mean time.
 - (iii) Most students gave the correct reading from the graph. Mistakes arose when students thought they needed to do a calculation to answer the question. If they made a mistake in part **(b)(ii)** they could still gain this mark if they had correctly read the graph using their own figure for the time.
 - (iv) Three quarters of the students chose the correct improvement of using a sound sensor and data logger to measure the time.
 - (v) A lot of students misinterpreted the question thinking it was asking them for a reason why the amplitude changed, rather than the simpler question of how it changed. Many said that the echo would be quieter, but this was given in the question so was not creditworthy.

Q35.

- (a) Very few students scored on this question and struggled to give the differences between longitudinal and transverse waves. A common phrase seen was that a longitudinal wave is travelling parallel to the direction of the wave, but a reference to the direction of the vibrations or oscillations was needed.
- (b)
 - (i) Very few students gained a mark for this question. Those who did usually said that measuring the time, or stopping the stop clock would be inaccurate, but very few realised this was because the time measured would be small or that sound travels quickly.
 - (ii) Many students gained 2 marks for an answer of 283.3; their only error was that they had not converted kilohertz to hertz. A common mistake was to substitute into the equation incorrectly and divide the frequency by the speed for which no marks could be gained. Answers of 28.3 or 2.83 did not gain any marks unless there was a supporting calculation. Students should be reminded to show their working in all calculations.

Q36.

- (a) Most students scored a mark for this question. For incorrect answers, longitudinal and transverse were often given the wrong way round.
- (b) (i)+(ii) These questions were well answered with a few students putting answers B and D the wrong way round.

Q37.

- (a) A very well answered question. The most common incorrect response was 3 cm.
- (b) Less than half of students answered this question correctly. The most common incorrect response was 20 with others giving an incorrect answer of 0.2.
- (c) Most students gained full credit for this question. A number of students were able to substitute correctly into the formula but were then unable to calculate 20×0.5 . Some students selected the wrong equation.
- (d) Generally, graph skills were poor.
 - (i) Most students correctly circled the anomaly.
 - (ii) The drawing of a line of best fit was done very badly with only a tenth of students gaining one mark. Many students did not appreciate that a line of best fit can be a curve or they did not include the (0, 0) point. Sometimes a ruler was used to join the points with straight lines, or a curve that had little relationship to the points was drawn.
 - (iii) Some students did not use the line they had drawn to take the graph reading. Others had a guess without drawing any line at all. Just over a third of students gained credit for this question.

Q38.

It was apparent that most students are unfamiliar with working in standard form, a mathematical requirement for Higher Tier students on this new specification. Only one third of the students scored one mark, the majority of which for 1.5×10^8 .

Q39.

- (a) The majority of students were not familiar with the direction of oscillations of the air particles compared to the transfer of energy in a sound wave. Almost one third of the students did not attempt the question.
- (b)
 - (i) Over half of the students correctly identified an area of rarefaction, but many students 'hedged their bets' by placing the R very close to the boundary between the two areas, receiving no credit.
 - (ii) Students used a wide variety of methods to indicate wavelength, many drawing a waveform. Only a fifth of the students indicated wavelength correctly, the most common error being to include the whole of two darkly stippled areas and one lightly stippled area.

Q40.

- (a)
 - (i) Two-thirds of students identified radio waves as having a wavelength longer than microwaves.
 - (ii) Almost two-thirds of students identified gamma rays as having more energy than X-rays.
 - (iii) Despite the high number of correct responses for questions (a)(i) and (a)(ii), less than half the students could identify a part of the electromagnetic spectrum with a higher frequency than ultraviolet.
- (b)
 - (i) Just under two-thirds of students identified that two complete waves were shown on the diagram.
 - (ii) Only a quarter of students were able to work out the correct wavelength from the diagram.
 - (iii) Just over half the students gave the correct amplitude of the waves.
 - (iv) Only a quarter of students were able to identify the type of wave as transverse.

Q41.

- (a) Very few students gained three or four marks. Most students struggled to give two similarities of light and sound waves. The most common difference given was that light travels faster than sound. A few said sound waves cannot travel through a vacuum. Many got transverse and longitudinal waves mixed up. Many students said light can be seen, but sound cannot, rather than focussing on the properties of the waves themselves.

- (b) (i) Many students identified the wavelength and frequency from the question, but had trouble substituting into the equation. Although almost half the students scored full marks, a number of students attempted to guess what the liquid was; a common answer was 'water', rather than choosing a letter from the bar chart.
- (ii) Over half the students did not score any marks on this question. Many students gained one mark for either identifying the pattern (up to mercury) or by identifying the fact that mercury did not fit the pattern. The irregular intervals between values in the table confused many students and they were unfamiliar with the way that the hypothesis was stated: 'There is a link between...'. Some students attempted to find a mathematical relationship between the two quantities rather than simply identifying the trend.