EXAM PAPERS PRACTICE

Waves In Air, Fluid, And Solid

These practice questions can be used by students and teachers and is

Suitable for GCSE AQA Physics Topic Question 8463

Level: GSCE AQA 8463

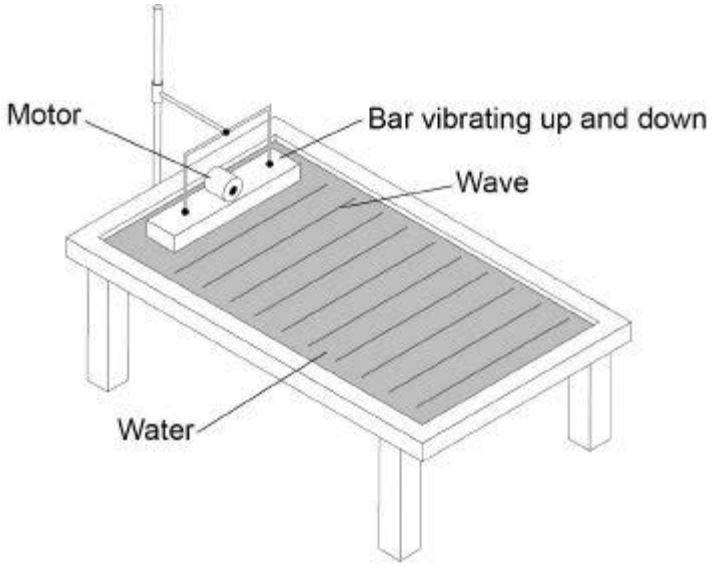
Subject: Physics

Exam Board: GCSE AQA

Topic: Waves In Air, Fluid, And Solid

Q1.

The diagram below shows a ripple tank that a student used to investigate water waves.



(a) The student adjusted the speed of the motor so that the bar hit the water more times each second.

What happened to the frequency of the waves produced?

Tick **one** box.

Decreased ☐

Did not change ☐

Increased ☐

(1)

(b) Describe how the frequency of the water waves in the ripple tank can be measured.

_____

_____

_____

_____

(2)

(c) The student measured the frequency of the water waves as 5 hertz.

Calculate the period of the water waves.

Use the equation:

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

Choose the unit.

metres	metres / second	seconds

_____

_____

_____

_____

Period = _____ Unit = _____

(3)

(Total 6 marks)

Q2.

P-waves and S-waves are two types of seismic wave caused by earthquakes.

(a) Which **one** of the statements about P-waves and S-waves is correct?

Tick **one** box.

P-waves and S-waves are transverse. ☐

P-waves and S-waves are longitudinal. ☐

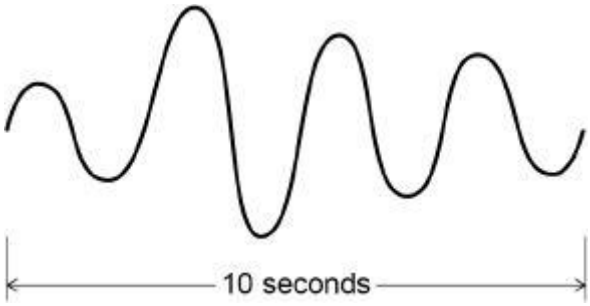
P-waves are transverse and S-waves are longitudinal. ☐

P-waves are longitudinal and S-waves are transverse. ☐

(1)

Seismometers on the Earth's surface record the vibrations caused by seismic waves.

The diagram below shows the vibration recorded by a seismometer for one P-wave.



(b) Calculate the frequency of the P-wave shown in the diagram above.

Frequency = _____ Hz

(1)

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

(1)

(d) The P-wave shown in the diagram above is travelling at 7200 m/s.

Calculate the wavelength of the P-wave.

Wavelength = _____ m

(3)

(e) Explain why the study of seismic waves provides evidence for the structure of the Earth's core.

(2)

(Total 8 marks)

Q3.

P-waves and S-waves are two types of seismic wave caused by earthquakes.

(a) Which **one** of the statements about P-waves and S-waves is correct?

Tick **one** box.

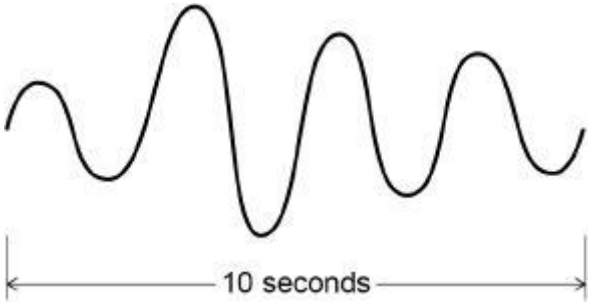
P-waves and S-waves are transverse.	☐
P-waves and S-waves are longitudinal.	☐
P-waves are transverse and S-waves are longitudinal.	☐
P-waves are longitudinal and S-waves are transverse.	☐

(1)

Seismometers on the Earth's surface record the vibrations caused by seismic waves.

Figure 1 shows the vibration recorded by a seismometer for one P-wave.

Figure 1



(b) Calculate the frequency of the P-wave shown in **Figure 1**.

_____

_____

Frequency = _____ Hz

(1)

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

_____

(1)

(d) The P-wave shown in **Figure 1** is travelling at 7200 m/s.

Calculate the wavelength of the P-wave.

Wavelength = _____ m

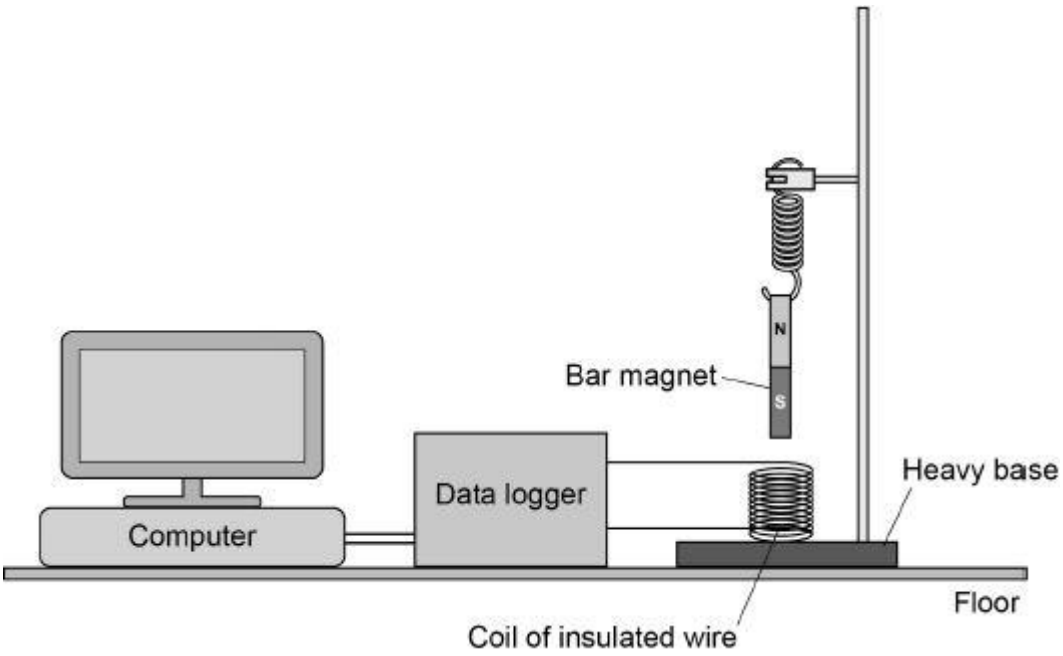
(3)

(e) Explain why the study of seismic waves provides evidence for the structure of the Earth's core.

(2)

Figure 2 shows a simple seismometer made by a student.

Figure 2



To test that the seismometer works, the student pushes the bar magnet into the coil and then releases the bar magnet.

(f) Why does the movement of the bar magnet induce a potential difference across the coil?

_____

_____

(1)

(g) Why is the induced potential difference across the coil alternating?

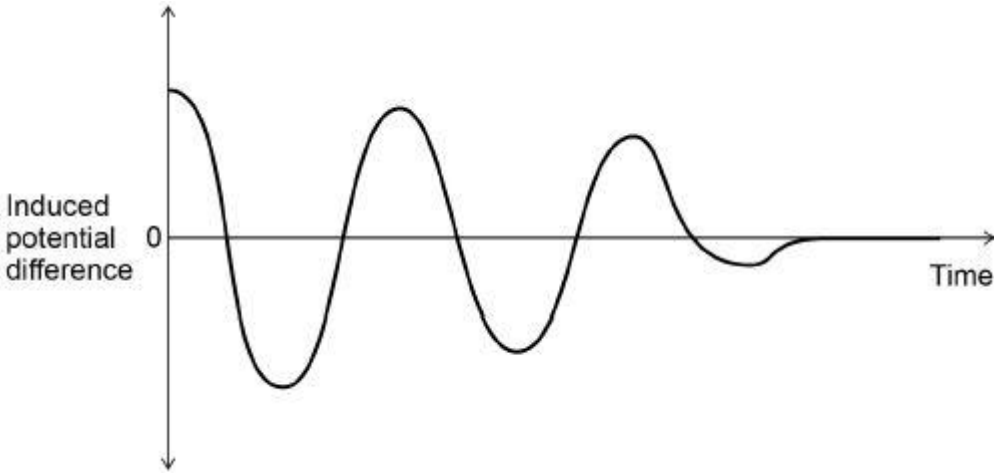
_____

_____

(1)

(h) **Figure 3** shows how the potential difference induced across the coil varies after the bar magnet has been released.

Figure 3



Which statement describes the movement of the magnet when the induced potential difference is zero?

Tick **one** box.

Accelerating upwards. ☐

Constant speed upwards. ☐

Decelerating downwards. ☐

Stationary. ☐

(1)

(i) The seismometer cannot detect small vibrations.

Suggest **two** changes to the design of the seismometer that would make it more sensitive to small vibrations.

1. _____

_____

2. _____

_____

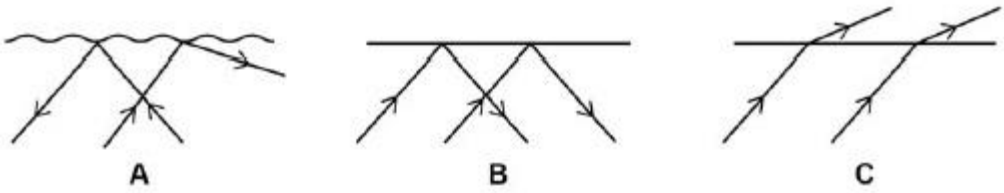
(2)

(Total 13 marks)

Q4.

(a) **Figure 1** shows what happens to rays of light incident on three different surfaces.

Figure 1



Which **one** of the diagrams shows diffuse reflection?

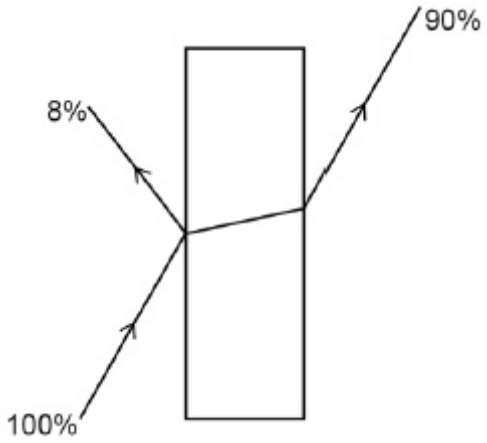
Tick **one** box.

A ☐ **B** ☐ **C** ☐

(1)

(b) **Figure 2** shows what happens to the energy transferred by a ray of light when the ray of light hits a glass block.

Figure 2



Calculate the percentage of the energy absorbed by the glass block.

_____

_____

Percentage of energy absorbed = _____ %

(1)

(c) Viewing an object through a colour filter may make the object look a different colour.

Complete the sentences.

Choose the answers from the box.

absorbs	**black**	**blue**
red	**reflects**	**transmits**

A red object viewed through a blue filter will look _____.

This is because the red object only _____ red light and the blue filter only _____ blue light.

(3)

(d) A white surface is viewed through a green filter.

What colour will the surface look?

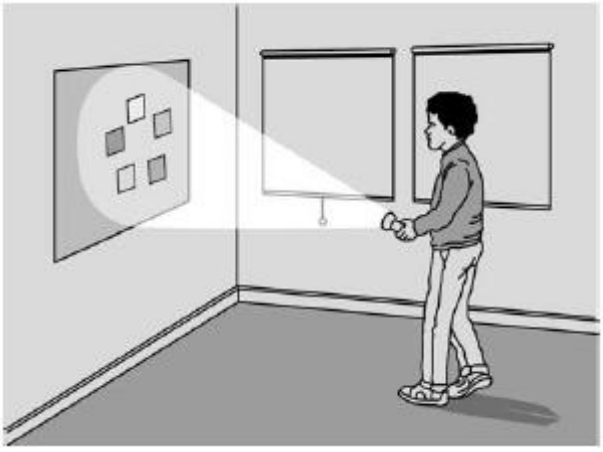
_____

(1)

Cyclists often wear clothing that reflects a lot of light.

Figure 3 shows a student investigating which colours are best at reflecting light.

Figure 3



This is the method used.

1. Small squares of different coloured material were stuck onto a piece of black paper at one end of a darkened laboratory.

2. The student switched on a torch and walked slowly towards the coloured squares.

3. The student stopped walking as soon as he could clearly see a coloured square.

4. The student measured the distance between the torch and the coloured square.

(e) Give a reason why it was important the student did the investigation in a darkened laboratory.

_____

_____

(1)

(f) Give a reason why it was important the area of each coloured square was the same.

_____

_____

(1)

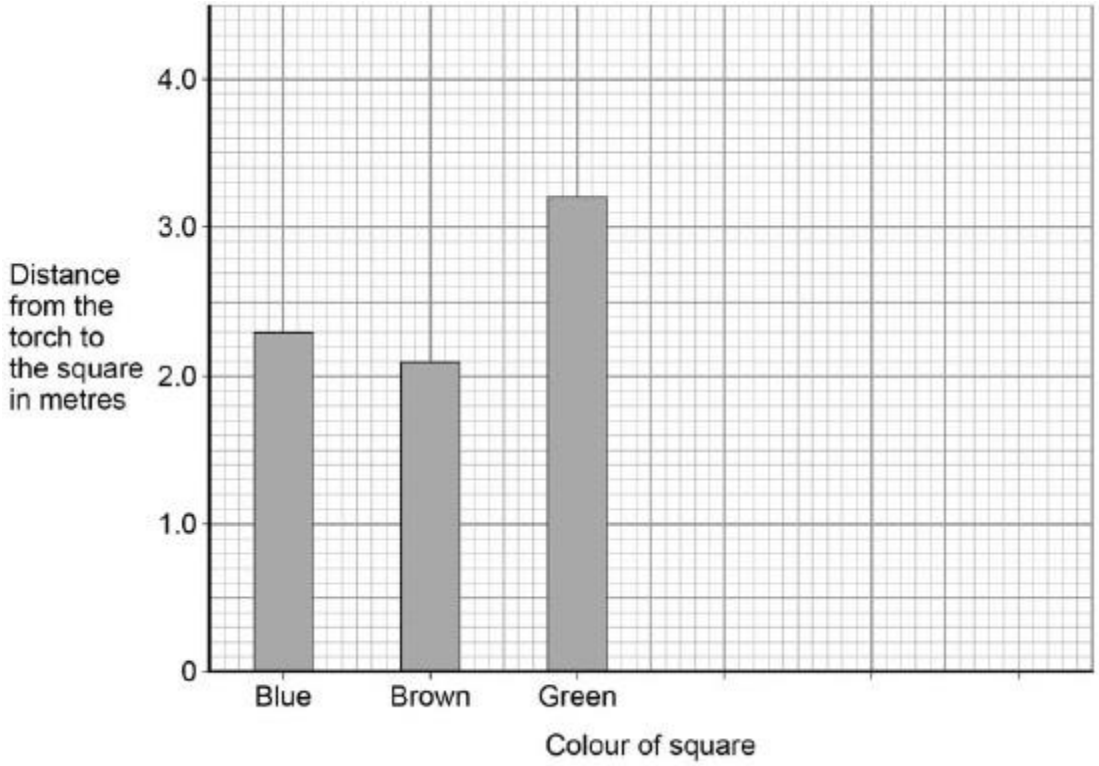
The table shows the student's results.

Colour of square	**Distance from the torch to the square in metres**
Blue	2.3
Brown	2.1
Green	3.2
Orange	3.4

Red	2.6

Figure 4 shows a bar chart with only three of the student's results.

Figure 4



(g) Complete the bar chart to show all of the results.

(3)

(h) Which colour clothing would be best for a cyclist to wear?

Use the data from the table.

Tick **one** box.

Blue ☐ Brown ☐ Green ☐ Orange ☐ Red ☐

Give a reason for your answer.

_____

_____

_____

(2)

(i) The student did the investigation again to obtain a second set of results.

The second set of results showed the same pattern as the first set.

Complete the sentence.

Choose the answer from the box.

accurate	**precise**	**repeatable**	**reproducible**

The measurements taken by the student were _____ .

(1)

(Total 14 marks)

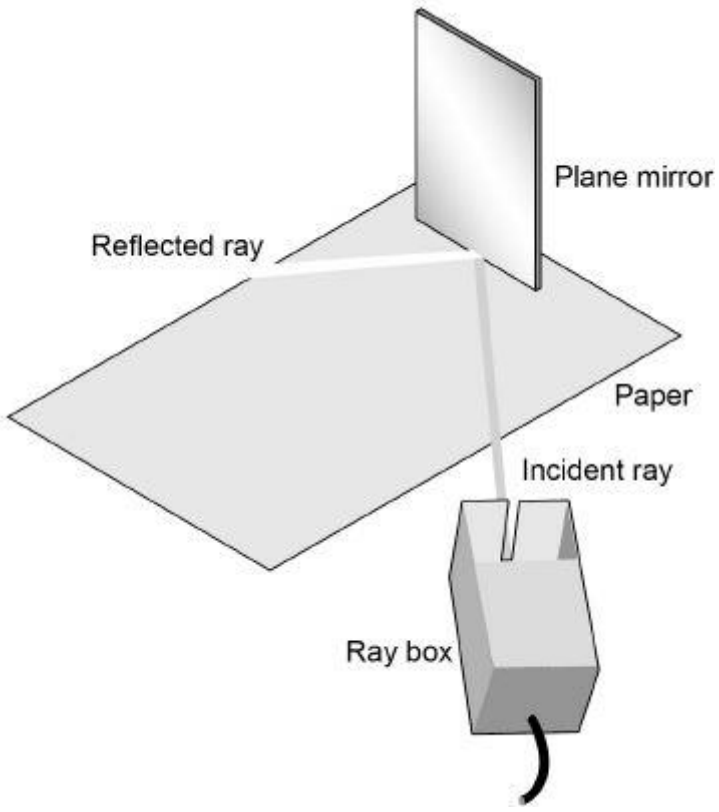
Q5.

The diagram below shows the apparatus a student used to investigate the reflection of light by a plane mirror.

The student drew four ray diagrams for each angle of incidence.

The student measured the angle of reflection from each diagram.

The table below gives the student's results.



	Angle of reflection			
Angle of incidence	**Test 1**	**Test 2**	**Test 3**	**Test 4**
20°	19°	22°	20°	19°

30°	31°	28°	32°	30°
40°	42°	40°	43°	41°
50°	56°	49°	53°	46°

(a) For each angle of incidence, the angle of reflection has a range of values.

This is caused by an error.

What type of error will have caused each angle of reflection to have a range of values?

_____

(1)

(b) Suggest what the student may have done during the investigation to cause each angle of reflection to have a range of values.

_____

_____

(1)

(c) Estimate the uncertainty in the angle of reflection when the angle of incidence is 50°.

Show how you determine your estimate.

_____

_____

_____

_____

Uncertainty = ± _____ °

(2)

(d) The student concluded that for a plane mirror, the angle of incidence is equal to the angle of reflection.

Explain whether you agree with this conclusion.

Use examples from the results in the table below in your answer.

_____

_____

_____

_____

(2)

(e) What extra evidence could be collected to support the student's conclusion?

_____

_____

(1)

(f) State **one** change the student should make to the apparatus if he wants to use the same method to investigate diffuse reflection.

_____

_____

(1)

(Total 8 marks)

Q6.

(a) Which one of the following is not an electromagnetic wave?

Tick **one** box.

Gamma rays ☐

Sound ☐

Ultraviolet ☐

X-rays ☐

(1)

(b) What type of electromagnetic wave do our eyes detect?

_____

(1)

(c) What is a practical use for infrared waves?

Tick **one** box.

Cooking food ☐

Energy efficient lamps ☐

Medical imaging ☐

Satellite communications ☐

(1)

Scientists have detected radio waves emitted from a distant galaxy.

Some of the radio waves from the distant galaxy have a frequency of 1 200 000 000 hertz.

(d) Which is the same as 1 200 000 000 hertz?

Tick **one** box.

1.2 gigahertz ☐

1.2 kilohertz ☐

1.2 megahertz ☐

1.2 millihertz ☐

(1)

(e) Radio waves travel through space at 300 000 kilometres per second (km/s).

How is 300 000 km/s converted to metres per second (m/s)?

Tick **one** box.

300 000 ÷ 1000 = 300 m/s ☐

300 000 × 1000 = 300 000 000 m/s ☐

300 000 + 1000 = 301 000 m/s ☐

300 000 – 1000 = 299 000 m/s ☐

(1)

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

_____

(1)

(g) Calculate the wavelength of the radio waves emitted from the distant galaxy.

Give your answer in metres.

_____

_____

_____

wavelength = _____ m

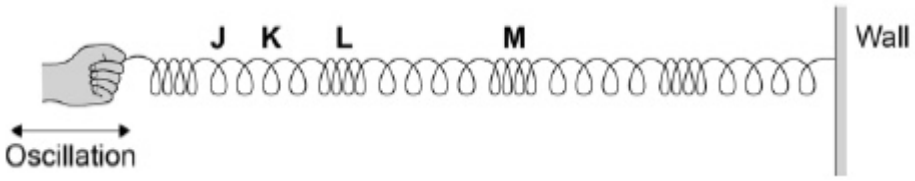
(3)

(Total 9 marks)

Q7.

Figure 1 shows a longitudinal wave being produced in a stretched spring.

Figure 1



(a) Which of the letters on **Figure 1** shows the centre of a rarefaction?

Tick **one** box.

J ☐ **K** ☐ **L** ☐ **M** ☐

(1)

(b) Which two letters in **Figure 1** have a distance of one wavelength between them?

Tick **one** box.

J and **K** ☐ **K** and **L** ☐ **L** and **M** ☐ **J** and **M** ☐

(1)

(c) Describe how the end of the stretched spring should be moved in order to produce a transverse wave.

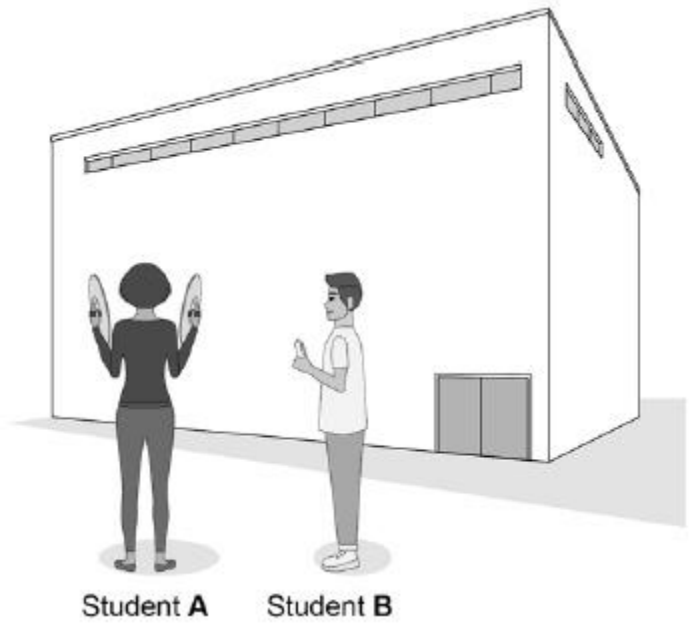
_____

_____

(1)

Figure 2 shows how two students used the sound reflected off a building (an echo) to measure the speed of sound.

Figure 2



This is the method used.

1. Student **A** hit two cymbals together and student **B** started a stopwatch.
2. When student **A** heard an echo she hit the cymbals together again.
3. Student **B** stopped the stopwatch after timing 5 echoes.

The table shows the student's results.

Time for 5 echoes in seconds
3.1
2.7
2.2
3.2

(d) The students decided that the time of 2.2 s was an anomalous result.

What was the most likely cause for this anomalous result?

Tick **one** box.

Not resetting the stopwatch to zero. ☐

Starting the stopwatch too soon. ☐

Timing less than five echoes. ☐

Timing more than five echoes. ☐

(1)

(e) Calculate the mean value of the time for 5 echoes.

Ignore the anomalous result.

_____

_____

mean time = _____ s

(1)

(f) The distance between student A and the building is 75 metres.

Calculate the distance the sound travels in going from student A to the building and back again five times.

_____

_____

distance = _____ m

(1)

(g) Calculate the speed of sound.

Use your answers to Questions (e) and (f) and the equation:

$$\text{speed} = \frac{\text{distance travelled}}{\text{time}}$$

_____

_____

_____

_____

speed of sound = _____ m/s

(2)

(h) The value for the speed of sound obtained by the students is not very accurate.

Suggest **two** changes to the method used by the students that would improve the accuracy.

1. _____

_____

2. _____

_____

(2)

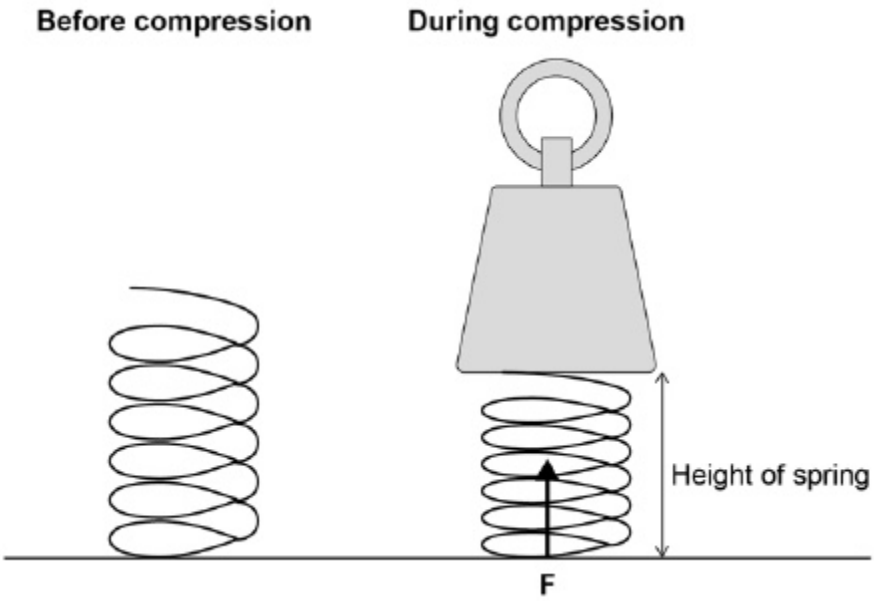
(Total 10 marks)

Q8.

Figure 1 shows a spring before and during compression.

The arrow F represents one of the two forces involved in compressing the spring.

Figure 1



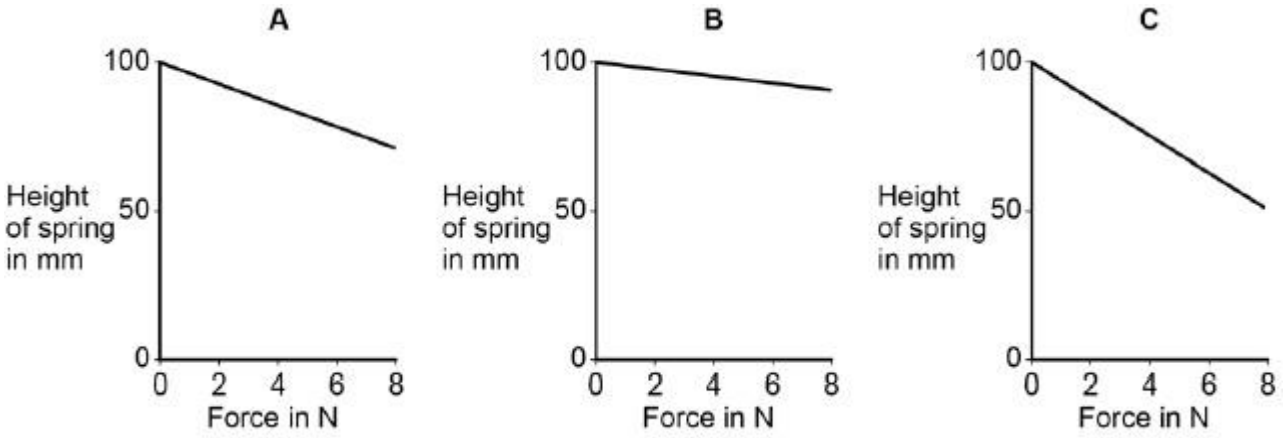
(a) Draw another arrow on **Figure 1** to represent the second force involved in compressing the spring.

(2)

A student investigated three different springs to compare the spring constants.

The results of the investigation are shown in **Figure 2**.

Figure 2



(b) Which **one** of the springs has the smallest spring constant?

Tick **one** box.

A ☐ **B** ☐ **C** ☐

Give the reason for your answer.

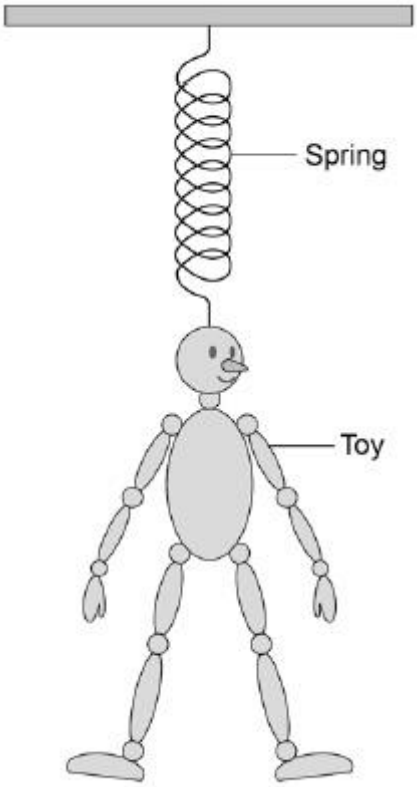
_____

_____

(2)

Figure 3 shows a child's toy. The toy hangs from a hook in the ceiling.

Figure 3



A child pulls the toy downwards and then releases it.

The toy oscillates up and down with a frequency of 1.25 Hz

(c) How many times each second will the toy oscillate up and down?

_____

(1)

(d) Calculate the period of the oscillating toy.

Use the Physics Equations Sheet.

_____

_____

_____

Period = _____ s

(2)

(e) When the toy is stationary, its weight causes the length of the spring to increase from 0.05 m to 0.25 m

The spring constant = 7.0 N/m

Calculate the elastic potential energy stored in the spring.

Elastic potential energy stored = _____ J

(3)

(Total 10 marks)

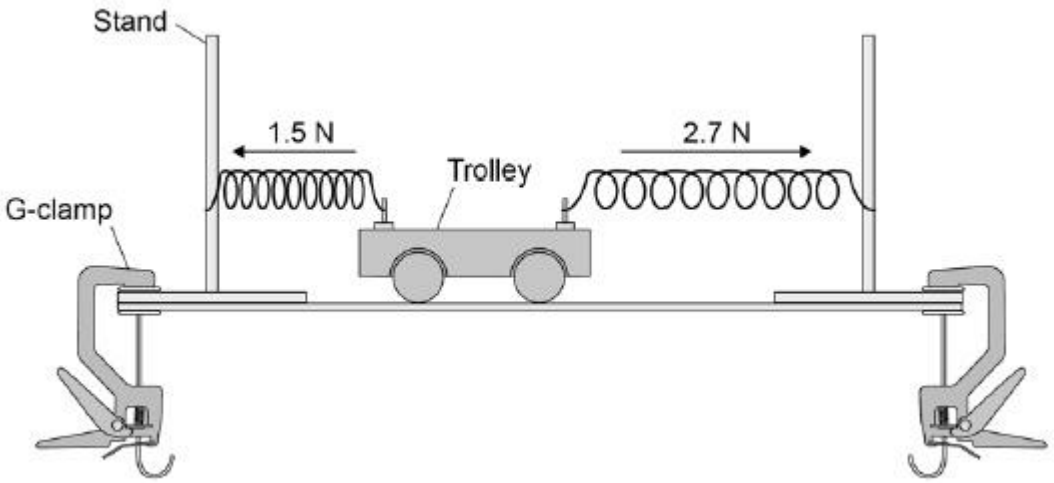
Q9.

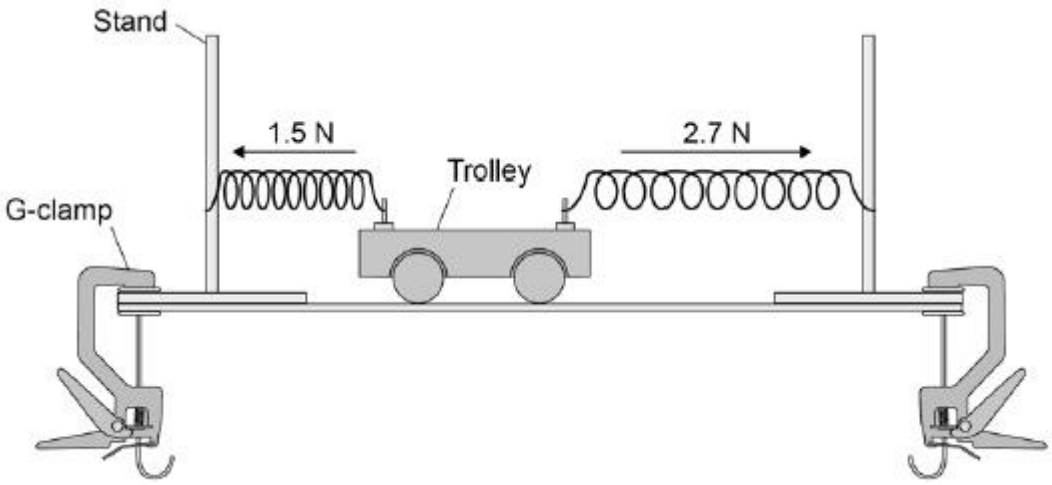
A trolley is attached to two identical springs.

The trolley is pushed to the left and then released.

Figure 1 shows the horizontal forces acting on the trolley just after it is released.

Figure 1





(a) Write the equation which links acceleration, mass and resultant force.

_____

(1)

(b) The trolley has a mass of 0.75 kg

Calculate the acceleration of the trolley just after it is released.

Give the unit.

_____

_____

_____

_____

_____

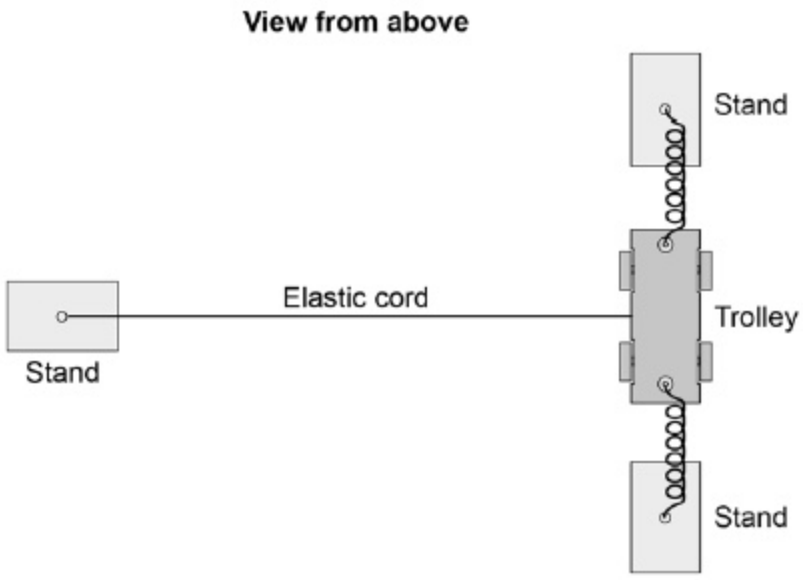
Acceleration = _____ Unit _____

(4)

An elastic cord is fixed to the trolley.

Figure 2 shows the arrangement viewed from above.

Figure 2



When the trolley is pushed and released a wave travels along the cord.

(c) What type of wave travels along the cord?

_____

Give the reason for your answer.

_____

_____

(2)

(d) Suggest one change that could be made to the apparatus shown in **Figure 2** to produce a wave with a lower frequency.

_____

_____

(1)

(Total 8 marks)

Q10.

(a) Which one of the following types of electromagnetic wave has the highest frequency?

Tick **one** box.

Gamma rays ☐

Infrared ☐

Microwaves ☐

Ultraviolet ☐

(1)

(b) What makes microwaves suitable for sending communications to a satellite in space?

_____

_____

(1)

(c) Scientists have detected short bursts of radio waves emitted from a distant galaxy.

The scientists think that the radio waves may have been emitted from a neutron star.

What event leads to a neutron star forming?

_____

_____

(1)

(d) Some of the radio waves from the distant galaxy have a frequency of 1.2 gigahertz (GHz).

Which of the following is the same as 1.2 GHz?

Tick **one** box.

1.2×10^3 Hz ☐

1.2×10^6 Hz ☐

1.2×10^9 Hz ☐

1.2×10^{12} Hz ☐

(1)

(e) Radio waves travel through space at a speed of 3.0×10^8 m/s

Calculate the wavelength of the 1.2 GHz radio waves emitted from the distant galaxy.

_____

Wavelength = _____ m

(3)

(f) When radio waves are absorbed by an aerial they may create an alternating current in an electrical circuit.

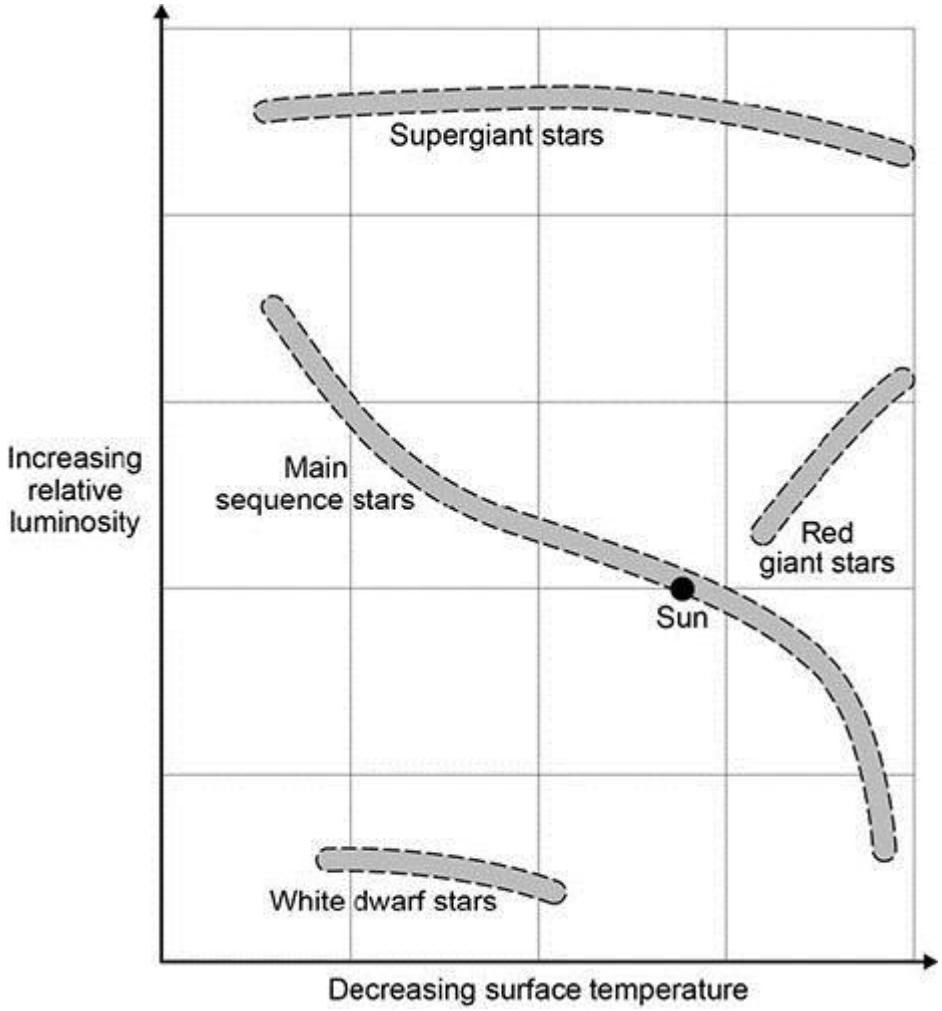
If an alternating current is created what frequency would it have?

(1)

The diagram shows four groups of stars.

The surface temperature and relative luminosity determine which group a star is in.

A star with a relative luminosity of 1 emits the same amount of energy every second as the Sun.



(g) The Sun is in the group of main sequence stars. These stars are stable.

Explain why a star remains stable.

_____

_____

_____

_____

(2)

(h) At different points in their lifecycle stars change from one group to another.

Describe what will happen to the Sun between it leaving the main sequence group and becoming a white dwarf.

Use information from the diagram.

_____

_____

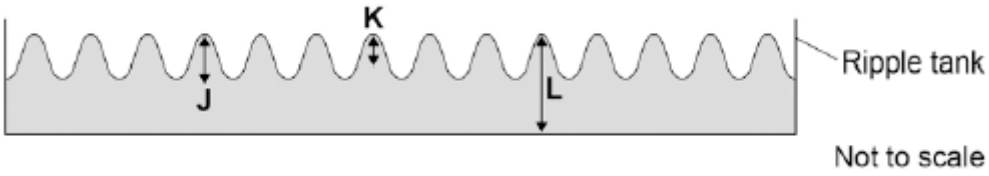
(4)

(Total 8 marks)

Q11.

Small water waves are created in a ripple tank by a wooden bar. The wooden bar vibrates up and down hitting the surface of the water.

The figure below shows a cross-section of the ripple tank and water.



(a) Which letter shows the amplitude of a water wave?

Tick **one** box.

J ☐

K ☐

L ☐

(1)

(b) The speed of the wooden bar is changed so that the bar hits the water fewer times each second.

What happens to the frequency of the waves produced?

Tick **one** box.

Increases ☐

Does not change ☐

Decreases ☐

(1)

(c) Describe how the wavelength of the water waves in a ripple tank can be measured accurately.

_____

_____

_____

_____

_____

(2)

(d) The speed of a wave is calculated using the following equation.

wave speed = frequency × wavelength

The water waves in a ripple tank have a wavelength of 1.2 cm and a frequency of 18.5 Hz.

How does the speed of these water waves compare to the typical speed of a person walking?

_____

_____

_____

_____

_____

_____

(4)

(Total 8 marks)

Q12.

Waves may be either longitudinal or transverse.

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

_____

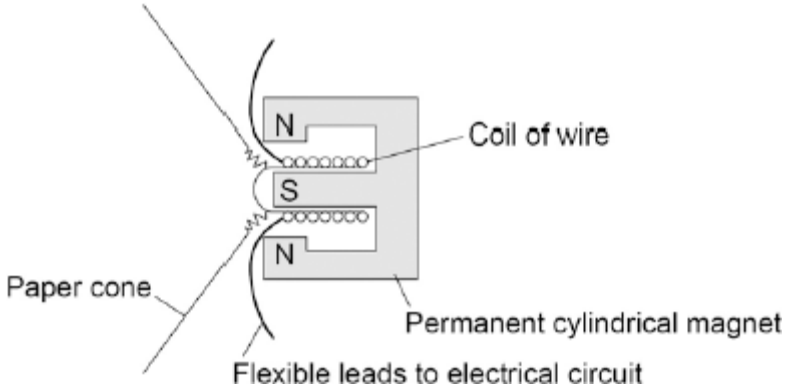
(2)

(b) Describe **one** piece of evidence that shows when a sound wave travels through the air it is the wave and not the air itself that travels.

(1)

(c) The figure below shows the parts of a moving-coil loudspeaker.

A coil of wire is positioned in the gap between the north and south poles of the cylindrical magnet.

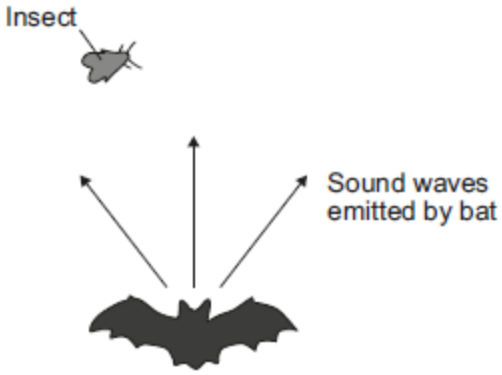


Explain how the loudspeaker converts current in an electrical circuit to a sound wave.

(6)
(Total 9 marks)

Q13.

Bats use the reflection of high pitched sound waves to determine the position of objects. The image below shows a bat and an insect flying in front of the bat.



(a) What determines the pitch of a sound wave?

Tick (✔) **one** box.

	Tick (✔)
amplitude	
frequency	
speed	

(1)

(b) State the name given to reflected sound waves.

_____

(1)

(c) The bat emits a sound wave with a frequency of 25.0 kHz and a wavelength of 0.0136 metres.

Calculate the speed of this sound wave.

_____

_____

_____

Speed = _____ m/s

(2)

(d) Sound waves are longitudinal. Describe a longitudinal sound wave.

_____

_____

_____

_____

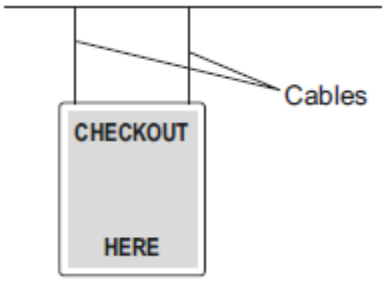
(2)

(Total 6 marks)

Q14.

A sign hangs from the ceiling using two cables, as shown in **Figure 1**.

Figure 1



(a) On **Figure 1**, mark the centre of mass of the sign using an X.

(1)

(b) Use the correct answer from the box to complete the sentence.

concentrated	**greatest**	**pivoted**

The centre of mass of an object is the point where the mass appears

to be _____ .

(1)

(c) A breeze made the sign swing forwards and backwards like a pendulum.
The frequency of oscillations of the sign was 2 hertz.

Calculate the periodic time for the sign.

_____

_____

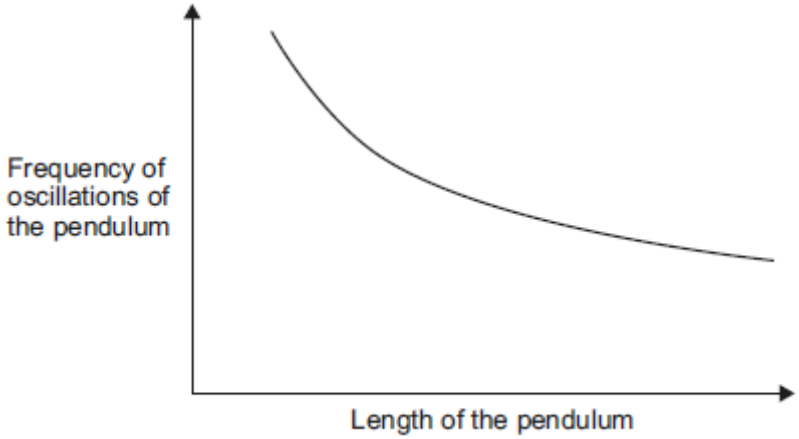
_____

Periodic time = _____ seconds

(2)

(d) **Figure 2** is a sketch graph showing how the frequency of the oscillations of a pendulum changes as the length of the pendulum is increased.

Figure 2



Give **one** way the sign could be made to swing with a lower frequency.

Use **only** the information in the sketch graph.

_____

_____

(1)

(Total 5 marks)

Q15.

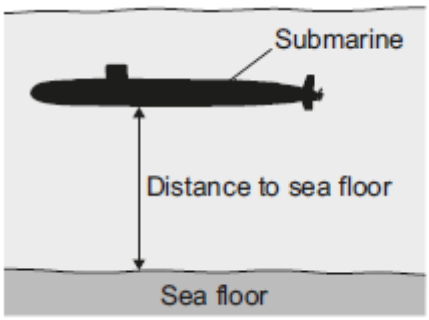
(a) Ultrasound is sound above the maximum frequency that humans can hear.

Tick (✔) **one** box.

20 Hz	☐
2000 Hz	☐
20 000 Hz	☐

(1)

(b) The image shows a submerged submarine.



Not to scale

The submarine sends a pulse of ultrasound to the sea floor.
The pulse takes 0.25 seconds to travel from the submarine to the sea floor.

The speed of sound in water is 1600 m/s.

Calculate the distance from the submarine to the sea floor.

_____

_____

_____

_____

Distance = _____ m

(2)

(c) The ultrasound is reflected from the sea floor back to the submarine.
Use the correct answer from the box to complete the sentence.

half	**the same as**	**twice**

The total distance the ultrasound pulse travelled is _____ the distance to the sea floor.

(1)

(d) The submarine moves through the sea and every few seconds sends a pulse of ultrasound to check the distance to the sea floor.

The table shows the time taken for five ultrasound pulses to travel from the submarine to the sea floor and back to the submarine.

Pulse number	**Time for pulse to return in seconds**
1	0.50
2	0.45
3	0.38
4	0.40

5	0.48

Describe how the distance from the submarine to the sea floor changed over these five pulses.

_____

_____

_____

_____

(2)

(Total 6 marks)

Q16.

X-rays and ultrasound can both be used for scanning internal organs.

(a) Ultrasound is used to scan unborn babies but X-rays are **not** used to scan unborn babies.

Explain why.

_____

_____

_____

_____

_____

_____

(3)

(b) The behaviour of ultrasound waves when they meet a boundary between two different materials is used to produce an image.

Describe how.

_____

_____

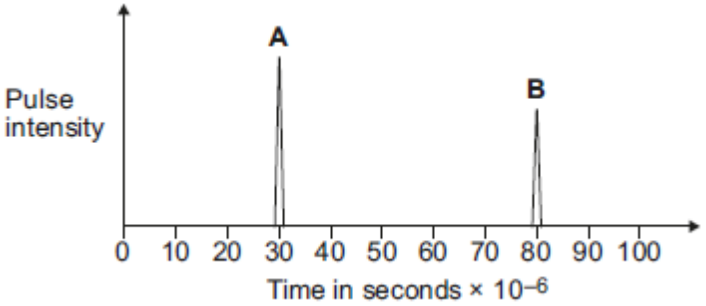
_____

_____

(2)

(c) **Figure 1** shows two pulses from a scan of an unborn baby. The emitted pulse is labelled **A**. The returning pulse picked up by the receiver is labelled **B**.

Figure 1



The closest distance between the unborn baby and the mother's skin is 4.0 cm.
Use information from **Figure 1** to calculate the average speed of the pulse.

Average speed = _____ m/s

(3)

(d) **Figure 2** shows an X-ray of an arm with a broken bone.

Figure 2

© emmy-images/iStock

(i) Describe how X-rays are able to produce an image of bones.

_____

_____

_____

(3)

(ii) Complete the following sentence.

X-rays are able to produce detailed images because their wavelength

is very _____ .

(1)

(Total 12 marks)

Q17.

Ultrasound waves can be passed through the body to produce medical images.

When ultrasound waves are directed at human skin most of the waves are reflected.

If a material called a 'coupling agent ' is placed on the skin it allows most of the ultrasound waves to pass through the skin and into the body.

(a) What is 'ultrasound'?

_____

_____

_____

(2)

(b) Two ultrasound frequencies that are used are 1.1 MHz and 3.0 MHz.

The speed of ultrasound in water is 1500 m / s.

Calculate the wavelength of the 3.0 MHz waves in water.

_____

_____

_____

Wavelength = _____ m

(3)

(c) The coupling agent used with ultrasound is usually a gel.

Water would be a good coupling agent.

Suggest why water is **not** used.

_____

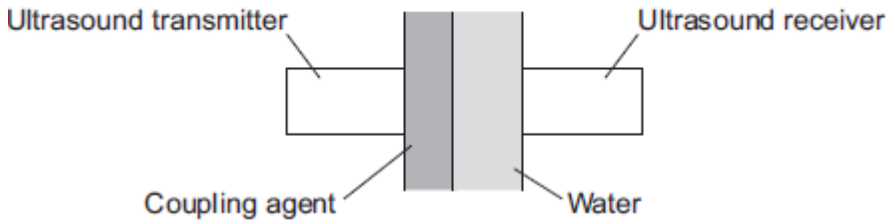
_____

(1)

(d) **Figure 1** shows a coupling agent being tested.

- An ultrasound transmitter emits waves.
- The waves pass through the coupling agent and then through the water.
- The waves are detected by the ultrasound receiver.

Figure 1



A scientist tests different coupling agents.

Suggest which variables she must control.

Tick (✓) **two** boxes.

	Tick (✓)
The amount of light in the room	
The colour of the coupling agent	
The width of the coupling agent	
The width of the water	

(2)

(e) The table shows the results for coupling agents **A**, **B**, **C**, **D**, **E**, **F** and **G**.

They were tested using the two frequencies, 1.1 MHz and 3.0 MHz.

The results show how well the waves pass through the coupling agent compared with how they pass through water. The results are shown as a percentage.

100% means that the coupling agent behaves the same as water.

Coupling agent	**Coupling agent**	**Coupling agent**

	percentage using 1.1 MHz	percentage using 3.0 MHz
A	108	100
B	105	100
C	104	98
D	100	98
E	98	98
F	95	99
G	89	88

(i) Which coupling agent allows most ultrasound to pass through at both frequencies? ☐

(1)

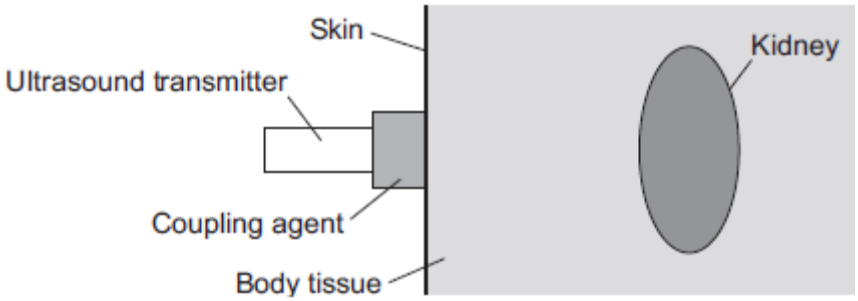
(ii) Which coupling agent performs the same for both frequencies? ☐

(1)

(f) **Figure 2** shows an ultrasound transmitter sending waves into a patient's body.

The waves enter the body and move towards a kidney.

Figure 2



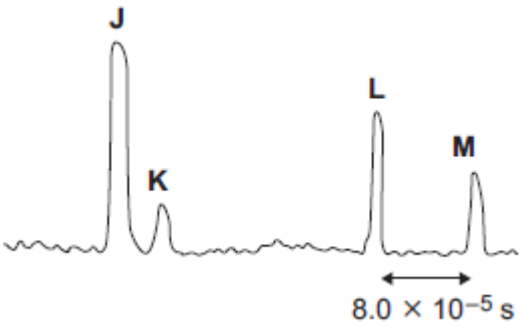
The transmitter also detects the ultrasound waves.

The transmitter is connected to an oscilloscope.

Figure 3 shows the trace on the screen of the oscilloscope.

J represents the intensity of the waves emitted by the transmitter.

Figure 3



(i) Explain the intensities at **K**, **L** and **M**.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6)

(ii) The speed of ultrasound waves in the body is 1500 m/s.

Use information from **Figure 3** to calculate the maximum width of the kidney.

_____

_____

_____

Maximum width of kidney = _____ m

(3)

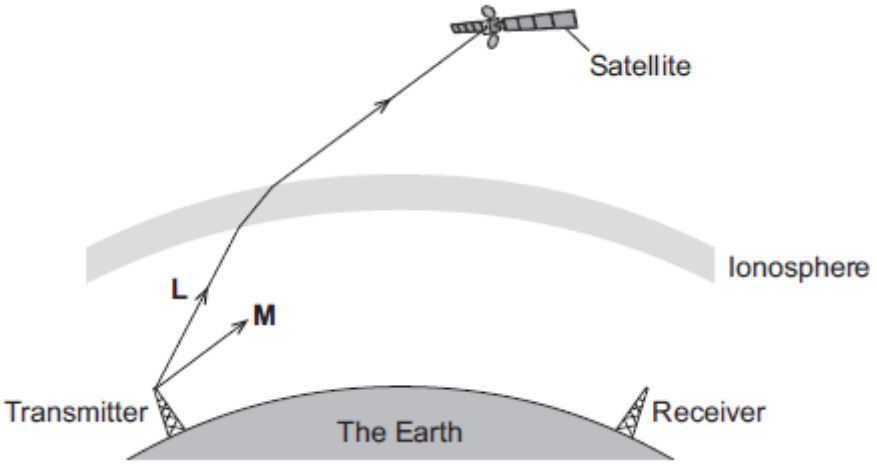
(Total 19 marks)

Q18.

Different parts of the electromagnetic spectrum are useful for different methods of

communication.

The diagram shows a transmitter emitting two electromagnetic waves, **L** and **M**.



(a) (i) Wave **L** is used to send a signal to a satellite.
Which part of the electromagnetic spectrum does wave **L** belong to?

_____

(1)

(ii) What name is given to the process that occurs as wave **L** passes into the ionosphere?

_____

(1)

(b) Wave **M** is **reflected** by the ionosphere.

(i) On the diagram above, draw the path of wave **M** until it reaches the receiver.

(2)

(ii) On the daigram above, draw a line to show the normal where wave **M** meets the ionosphere. Label the line **N**.

(1)

(c) Give **two** properties of all electromagnetic waves.

1. _____

_____

2. _____

_____

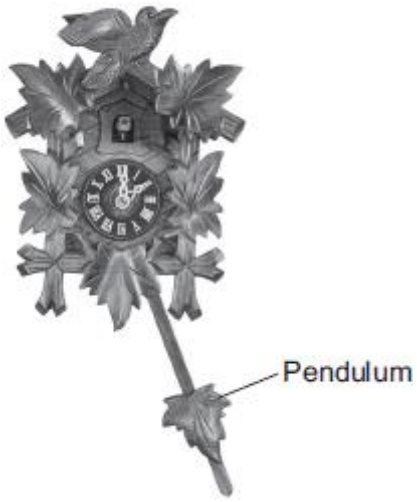
(2)

(Total 7 marks)

Q19.

The clock shown in **Figure 1** uses a pendulum to keep time.

Figure 1



(a) The pendulum has a frequency of 0.80 Hz.

Calculate the periodic time of the pendulum.

_____

_____

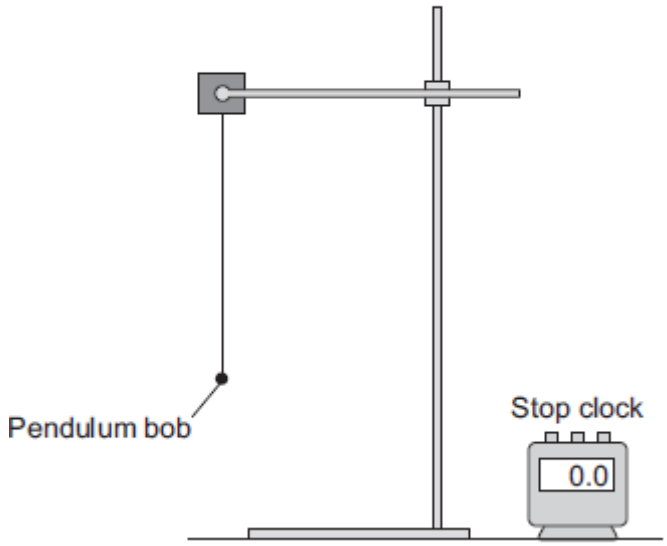
_____

Periodic time = _____ seconds

(2)

(b) A student investigated the factors affecting the oscillation of a pendulum. The student set up a pendulum as shown in **Figure 2**.

Figure 2



The student investigated how many complete oscillations the pendulum made for different lengths of the pendulum and different masses of the pendulum bob.

The results are shown in the table.

Length of the pendulum in millimetres	Mass of the pendulum bob in grams	Number of complete oscillations made by the pendulum in 20 seconds
200	100	22
200	200	22
400	100	15
400	200	15
600	50	13
600	100	13

(i) State **two** conclusions that the student should make from the results shown in the table.

1. _____

_____

2. _____

_____

(2)

(ii) The student wants to be more certain that her conclusions are correct.

Suggest **two** ways in which the investigation could be improved.

1. _____

_____

2. _____

_____

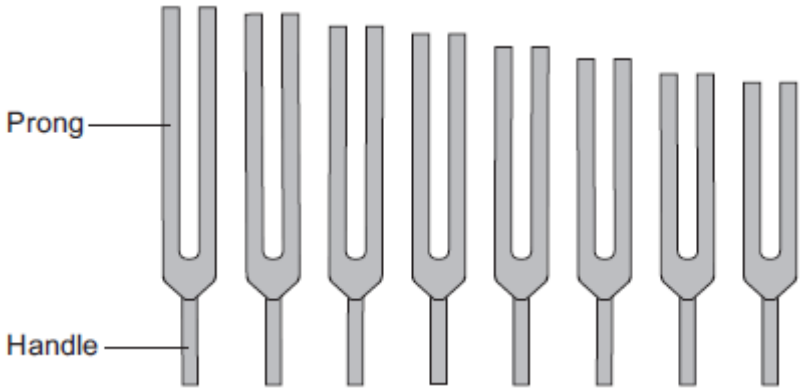
(2)

(Total 6 marks)

Q20.

Figure 1 shows a set of tuning forks.

Figure 1



A tuning fork has a handle and two prongs. It is made from metal.

When the prongs are struck on a hard object, the tuning fork makes a sound wave with a single frequency. The frequency depends on the length of the prongs.

(a) Use the correct answer from the box to complete each sentence.

direction	loudness	pitch	speed

The frequency of a sound wave determines its _____ .

The amplitude of a sound wave determines its _____ .

(2)

(b) Each tuning fork has its frequency engraved on it. A student measured the length of the prongs for each tuning fork.

Some of her data is shown in the table.

Frequency in hertz	Length of prongs in cm
320	9.5
384	8.7
480	7.8
512	7.5

(i) Describe the pattern shown in the table.

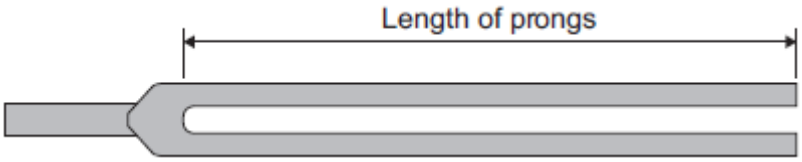
_____

_____

(1)

(ii) **Figure 2** shows a full-size drawing of a tuning fork.

Figure 2



Measure and record the length of the prongs.

Length of prongs = _____ cm

(1)

Use the data in the table above to estimate the frequency of the tuning fork in **Figure 2**.

Explain your answer.

_____

_____

_____

_____

_____

Estimated frequency = _____ Hz

(3)

(c) Ultrasound waves are used in hospitals.

(i) Use the correct answer from the box to complete the sentence.

electronic	**hydraulic**	**radioactive**

Ultrasound waves can be produced by _____ systems.

(1)

(ii) The frequency of an ultrasound wave used in a hospital is 2×10^6 Hz.

It is **not** possible to produce ultrasound waves of this frequency using a tuning fork.

Explain why.

_____

_____

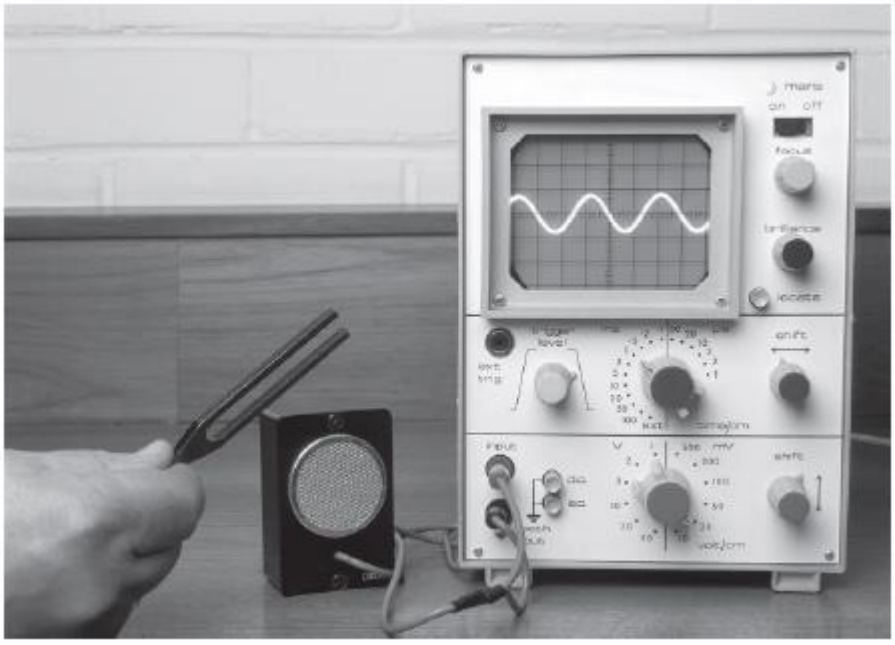
_____

_____

(2)

(d) **Figure 3** shows a tuning fork and a microphone. The microphone is connected to an oscilloscope.

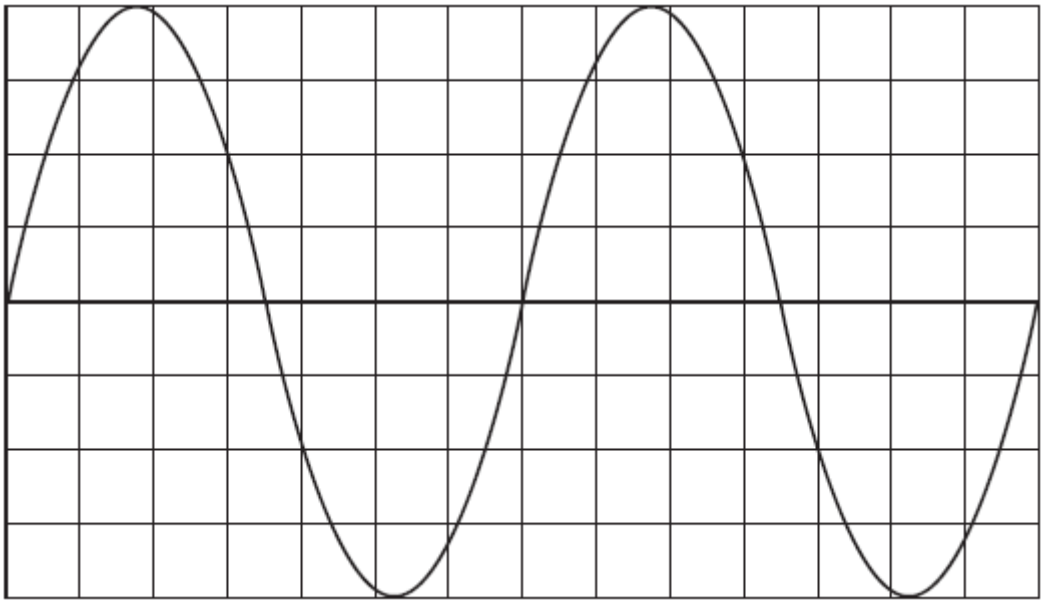
Figure 3



When the tuning fork is struck and then placed in front of the microphone, a trace appears on the oscilloscope screen.

Figure 4 shows part of the trace on the screen.

Figure 4



Each horizontal division in **Figure 4** represents a time of 0.0005 s.

What is the frequency of the tuning fork?

_____

_____

_____

Frequency = _____ Hz

(3)

(Total 13 marks)

Q21.

A note was played on an electric keyboard.

The frequency of the note was 440 Hz.

(a) (i) What does a frequency of 440 Hz mean?

_____

_____

(1)

(ii) The sound waves produced by the keyboard travel at a speed of 340 m / s.

Calculate the wavelength of the note.

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

_____

_____

_____

Wavelength = _____ metres

(3)

(b) **Figure 1** shows a microphone connected to a cathode ray oscilloscope (CRO) being used to detect the note produced by the keyboard.

Figure 1

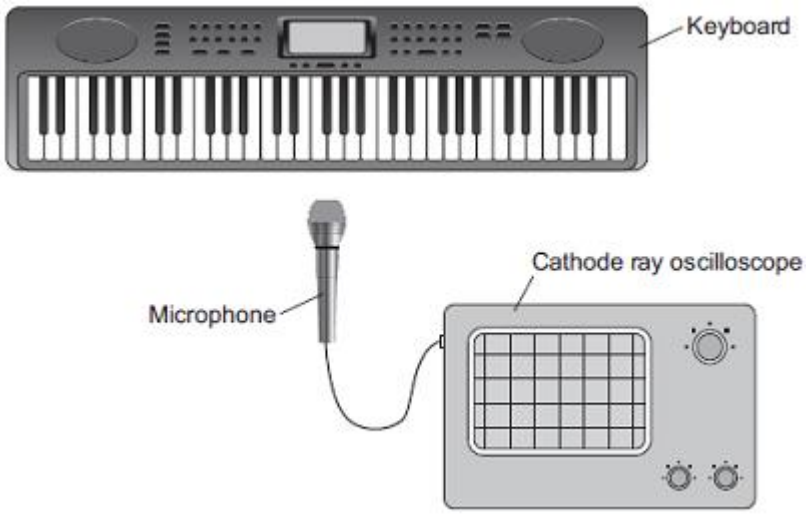
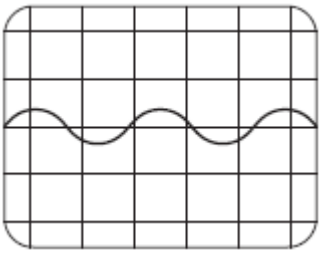


Figure 2 shows the trace produced by the sound wave on the CRO.

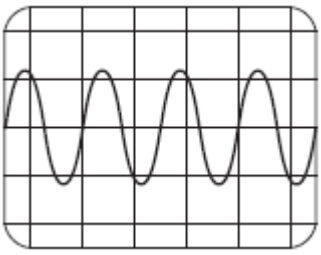
Figure 2



A second note, of different wavelength, was played on the keyboard.

Figure 3 shows the trace produced by the sound wave of the second note on the CRO.

Figure 3



The settings on the CRO were unchanged.

What **two** conclusions should be made about the **second** sound wave produced by the keyboard compared with the **first** sound wave?

Give a reason for each conclusion.

Conclusion 1 _____

_____

Reason _____

_____

Conclusion 2 _____

_____

Reason _____

_____

(4)

(Total 8 marks)

Q22.

(a) What is ultrasound?

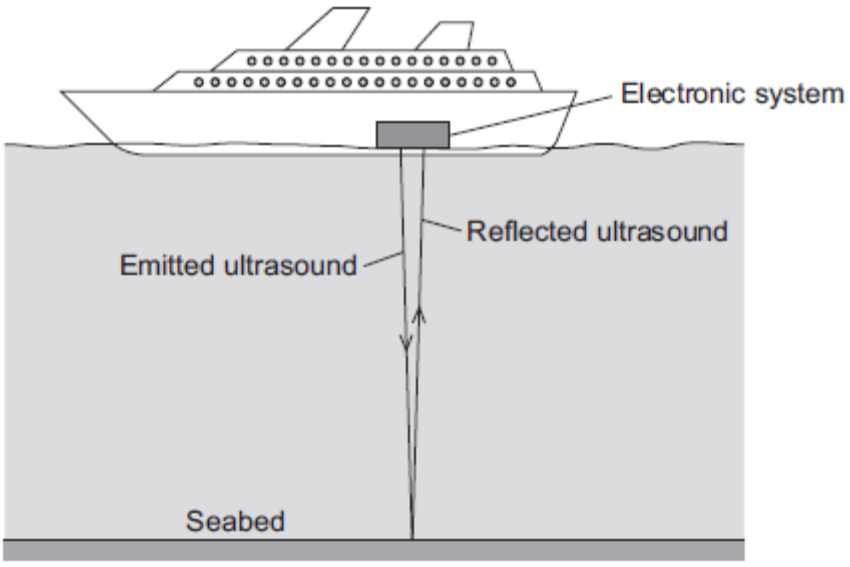
_____

_____

(1)

(b) **Figure 1** shows how ultrasound is used to measure the depth of water below a ship.

Figure 1



A pulse of ultrasound is sent out from an electronic system on-board the ship.

It takes 0.80 seconds for the emitted ultrasound to be received back at the ship.

Calculate the depth of the water.

Speed of ultrasound in water = 1600 m / s

_____

_____

_____

_____

Depth of water = _____ metres

(3)

(c) Ultrasound can be used in medicine for scanning.

State **one** medical use of ultrasound scanning.

_____

(1)

(d) Images of the inside of the human body can be made using a Computerised Tomography (CT) scanner. The CT scanner in **Figure 2** uses X-rays to produce these images.

Figure 2

monkeybusinessimages/iStock/Thinkstock

State **one** advantage and **one** disadvantage of using a CT scanner, compared with ultrasound scanning, for forming images of the inside of the human body.

Advantage of CT scanning _____

_____

_____

Disadvantage of CT scanning _____

_____

_____

(2)

(Total 7 marks)

Q23.

(a) Human ears can detect a range of sound frequencies.

(i) Use the correct answers from the box to complete the sentence.

2	**20**	**200**	**2000**	**20 000**

The range of human hearing is from about _____ Hz to _____ Hz.

(2)

(ii) What is ultrasound?

_____

_____

(1)

(iii) Ultrasound can be used to find the speed of blood flow in an artery.

State **one** other medical use of ultrasound.

_____

(1)

(b) The speed of an ultrasound wave in soft tissue in the human body is 1.5×10^3 m / s and the frequency of the wave is 2.0×10^6 Hz.

Calculate the wavelength of the ultrasound wave.

_____

_____

Wavelength = _____ m

(2)

(c) When ultrasound is used to find the speed of blood flow in an artery:

- an ultrasound transducer is placed on a person's arm
- ultrasound is emitted by the transducer
- the ultrasound is reflected from blood cells moving **away** from the transducer
- the reflected ultrasound is detected at the transducer.

Describe the differences between the ultrasound waves emitted by the transducer and the reflected waves detected at the transducer.

(2)
(Total 8 marks)

Q24.

Waves may be longitudinal or transverse.

(a) Describe the differences between longitudinal waves and transverse waves.

(3)

(b) Radio waves are electromagnetic waves.

Describe how radio waves are different from sound waves.

(4)
(Total 7 marks)

Q25.

(a) Light waves transfer energy.

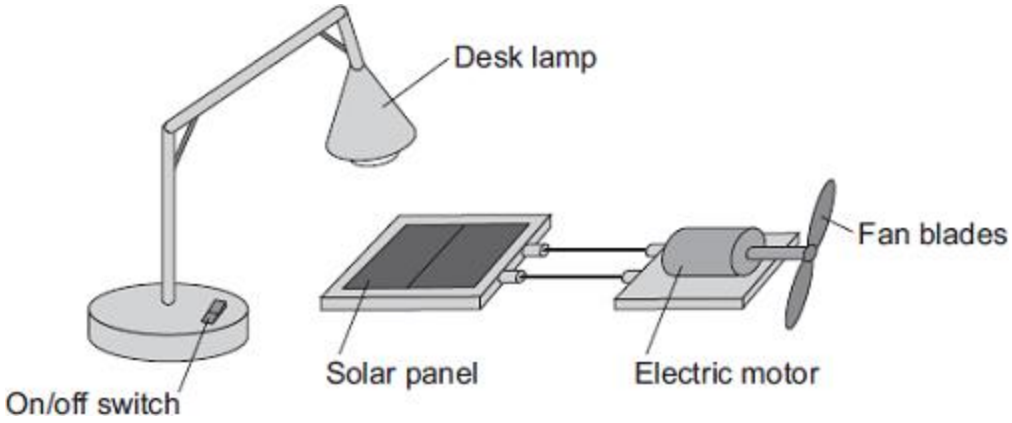
(i) Complete the following sentence.

The oscillations producing a light wave are _____

to the direction of the energy transfer by the light wave.

(1)

(ii) The apparatus in the diagram shows that light waves transfer energy.



Describe how switching the desk lamp on and off shows that light waves transfer energy.

You do **not** need to describe the energy transfers.

_____

_____

_____

_____

(2)

(b) A student holds a wrist watch in front of a plane mirror. The student can see an image of the wrist watch in the mirror.

The diagram shows the position of the wrist watch and the mirror.

Draw a ray diagram showing how the image of the wrist watch is formed.

Mark the position of the image.

(4)

(c) The image of the wrist watch seen by the student is virtual.

What is a virtual image?

_____

_____

(1)

(Total 8 marks)

Q26.

Ultrasound and X-rays are waves used in hospitals to create images of the inside of the human body. To produce the images below, the waves must enter the human body.

Ultrasound scan of an unborn child

© Isabelle Limbach/Thinkstock

X-ray of a broken bone

© itsmejust/iStock

(a) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate*.

Describe the features of ultrasound and X-rays, and what happens to each type of wave after it has entered the human body.

(6)

(b) It would **not** be safe to use X-rays to produce an image of an unborn child.

Explain why.

(2)

(c) Ultrasound can be used for medical treatments as well as for imaging.

Give **one** use of ultrasound for medical treatment.

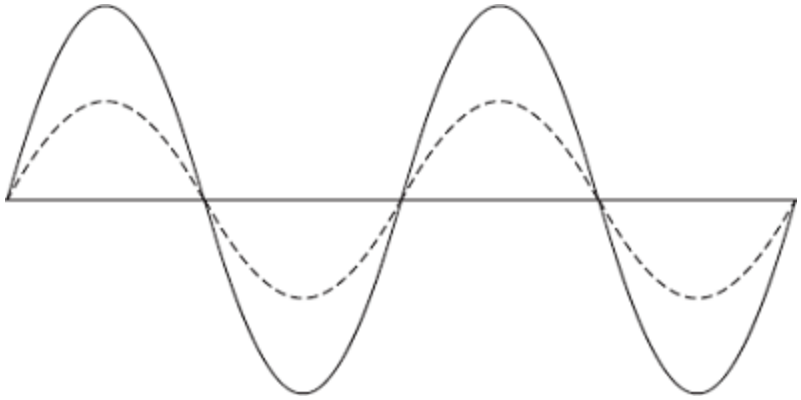
(1)

(Total 9 marks)

Q27.

(a) **Diagram 1** shows two waves.

Diagram 1



(i) Name **one** wave quantity that is the same for the two waves.

_____

(1)

(ii) Name **one** wave quantity that is different for the two waves.

_____

(1)

(iii) The waves in **Diagram 1** are transverse.

Which **one** of the following types of wave is **not** a transverse wave?

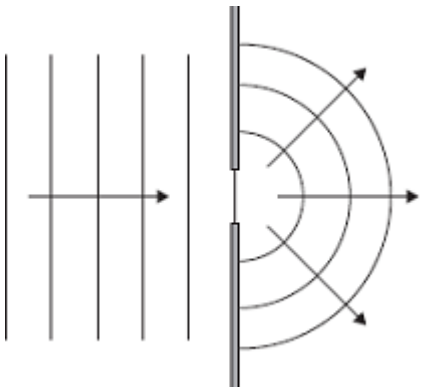
Draw a ring around the correct answer.

gamma rays **sound** **visible light**

(1)

(b) **Diagram 2** shows water waves in a ripple tank moving towards and passing through a gap in a barrier.

Diagram 2



Every second, 8 waves pass through the gap in the barrier. The waves have a wavelength of 0.015 metres.

Calculate the speed of the water waves and give the unit.

_____

_____

_____

Speed = _____

(3)

(Total 6 marks)

Q28.

(a) Explain what ultrasound is.

_____

_____

_____

_____

(2)

(b) Ultrasound is used for pre-natal scanning. This is much safer than using X-rays. However, doctors were only sure ultrasound was safe after experiments on mice.

Do you think the ultrasound experiments on mice were justified?

Explain your answer.

_____

_____

_____

_____

(2)

(c) Explain what scientists should do if they find evidence that ultrasound may be harmful to human health.

_____

_____

_____

(2)

(Total 6 marks)

Q29.

(a) The table gives information about the frequencies in the hearing ranges of six different mammals.

Name of mammal	Frequencies in hearing range
Bat	20 Hz → 160 kHz
Dog	20 Hz → 30 kHz
Dolphin	40 Hz → 110 kHz
Elephant	5 Hz → 10 kHz
Human	20 Hz → 20 kHz
Tiger	30 Hz → 50 kHz

(i) Which mammal in the table can hear the highest frequency?

_____

(1)

(ii) Give **one** example of a frequency which an elephant can hear but which a tiger **cannot** hear.

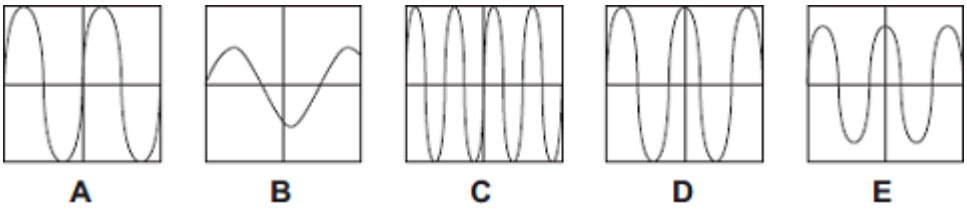
Include the unit in your answer.

Frequency _____

(1)

(b) A sound wave can be represented as a trace on the screen of an oscilloscope.

The diagrams show five traces, **A**, **B**, **C**, **D** and **E**, on the oscilloscope. All the traces are drawn to the same scale.



(i) Which **three** diagrams show traces with the same amplitude?

Diagrams _____ , _____ and _____ .

(1)

(ii) Which **two** diagrams show traces with the same frequency?

Diagrams _____ and _____

(1)

(c) There is no air in space.

Astronauts in space cannot hear sounds from outside their spacesuits.

Explain this.

_____

_____

_____

_____

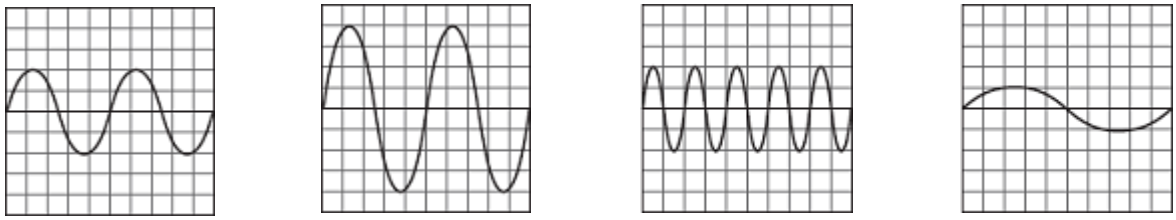
(2)

(Total 6 marks)

Q30.

(a) The diagram shows four sound waves, **J**, **K**, **L** and **M**, represented on an oscilloscope screen.

They are all drawn to the same scale.



J **K** **L** **M**

(i) Which **two** of the waves have the same amplitude?

Wave _____ and wave _____

(1)

(ii) Which of the waves would sound the loudest?

Wave _____

(1)

(iii) Only **one** of the waves is an ultrasound wave.

Which **one** is the ultrasound wave?

Wave _____

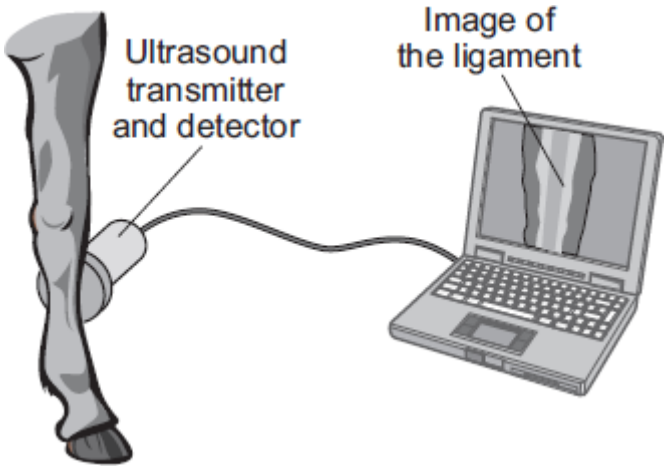
Give a reason for your answer.

_____

_____

(2)

(b) The diagram shows ultrasound being used to examine the ligament inside the leg of a horse.



Use words from the box to complete the following sentences.

computer	**detector**	**transmitter**

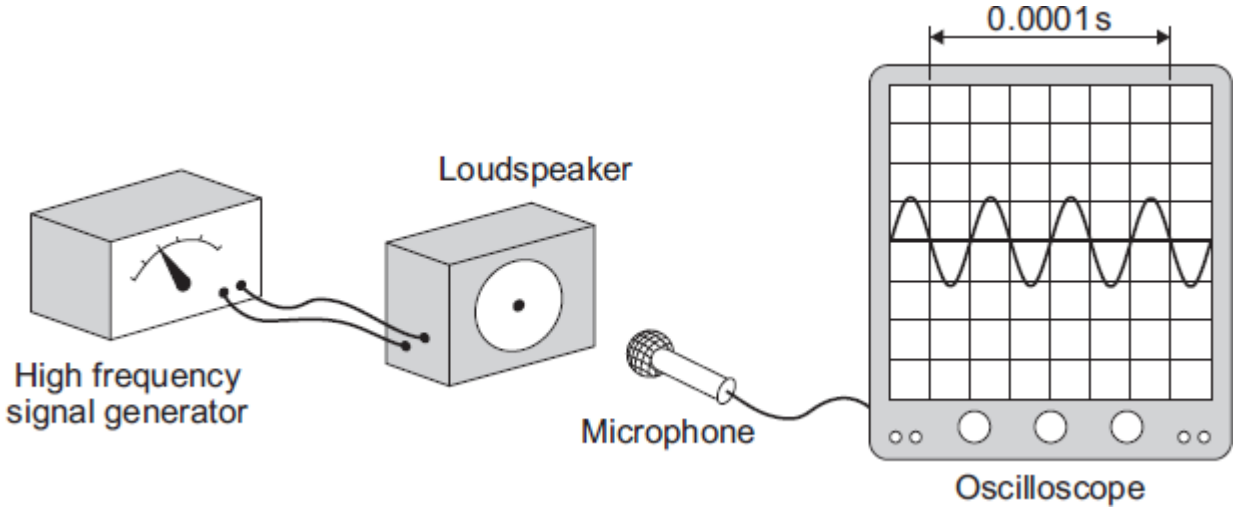
The _____ sends pulses of ultrasound into the leg. When the ultrasound meets the ligament, some is reflected back to the _____ The reflected pulses are converted by a _____ into an image that can be seen on the screen.

(2)

(Total 6 marks)

Q31.

(a) The diagram shows a microphone being used to detect the output from a loudspeaker.
The oscilloscope trace shows the wave pattern produced by the loudspeaker.



(i) How many waves are produced by the loudspeaker in 0.0001 seconds?

_____

(1)

(ii) How many waves are produced by the loudspeaker every second? Assume the input to the loudspeaker does not change.

_____

_____

(1)

(iii) A person with normal hearing cannot hear the sound produced by the loudspeaker.

Explain why.

_____

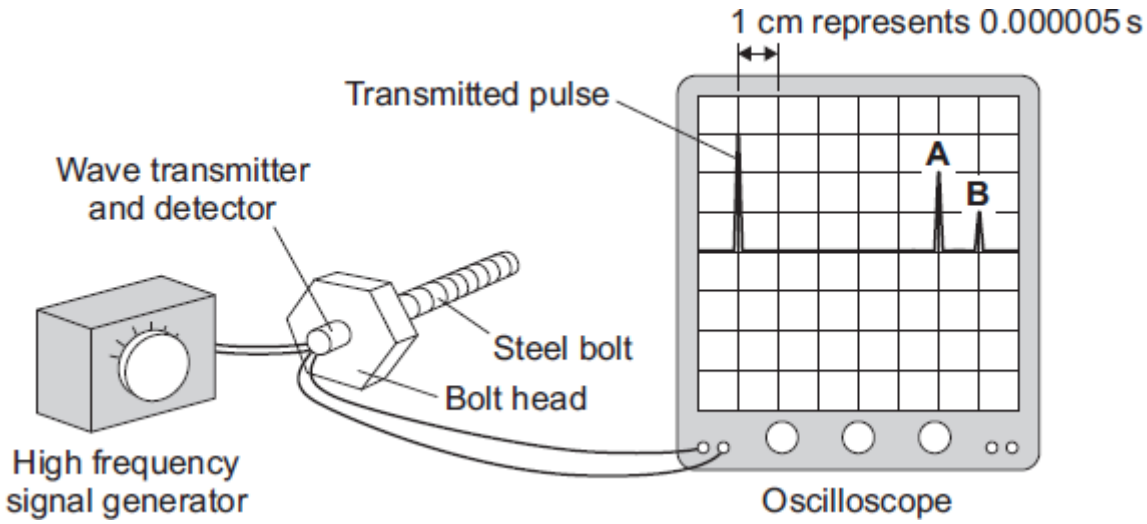
_____

_____

_____

(2)

(b) The diagram shows how a very high frequency sound wave can be used to check for internal cracks in a large steel bolt. The oscilloscope trace shows that the bolt does have an internal crack.



(i) Explain what happens to produce pulse **A** and pulse **B**.

_____

_____

_____

_____

(2)

(ii) Use the information in the diagram and the equation in the box to calculate the distance from the head of the bolt to the internal crack.

distance = speed × time

Speed of sound through steel = 6000 m/s

Show clearly how you work out your answer.

_____

_____

_____

_____

_____

_____

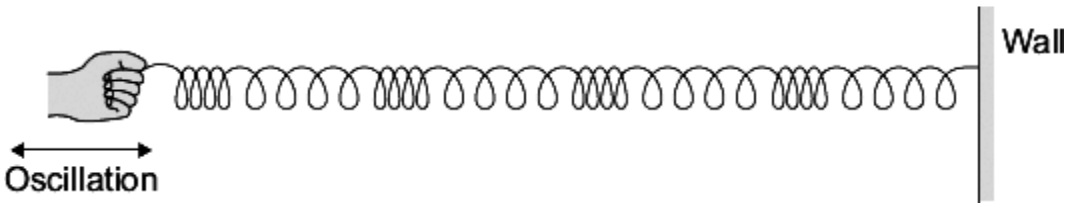
(3)

(Total 9 marks)

Q32.

Diagram 1 shows a longitudinal wave being produced in a stretched spring.

Diagram 1



(a) A longitudinal wave has areas of compression and areas of rarefaction.

Mark with the letter **C**, **one** area of compression shown in **Diagram 1.**

(1)

(b) **Diagram 2** shows the apparatus a teacher uses to demonstrate that sound can be reflected.

Diagram 2

(i) Using a ruler, draw on **Diagram 2** to show how sound from the loudspeaker is reflected by the sheet of metal to the sound sensor.

(2)

(ii) The teacher replaced the sheet of metal with a sheet of glass.

When he did this, the reading on the sound level meter went down.

Suggest why.

_____

_____

(1)

(iii) The teacher changed the output from the loudspeaker to increase the amplitude of the sound wave produced.

What effect, if any, does this increase of amplitude have on the loudness of the sound?

Draw a ring around the correct answer.

makes the sound quieter	**does not change the loudness of the sound**	**makes the sound louder**

(1)

(iv) The loudspeaker produces a sound wave at a frequency of 850 Hz. The wavelength of the sound wave is 0.4 m.

Calculate the speed of the sound wave.

Show clearly how you work out your answer.

_____

_____

_____

Speed = _____ m/s

(2)

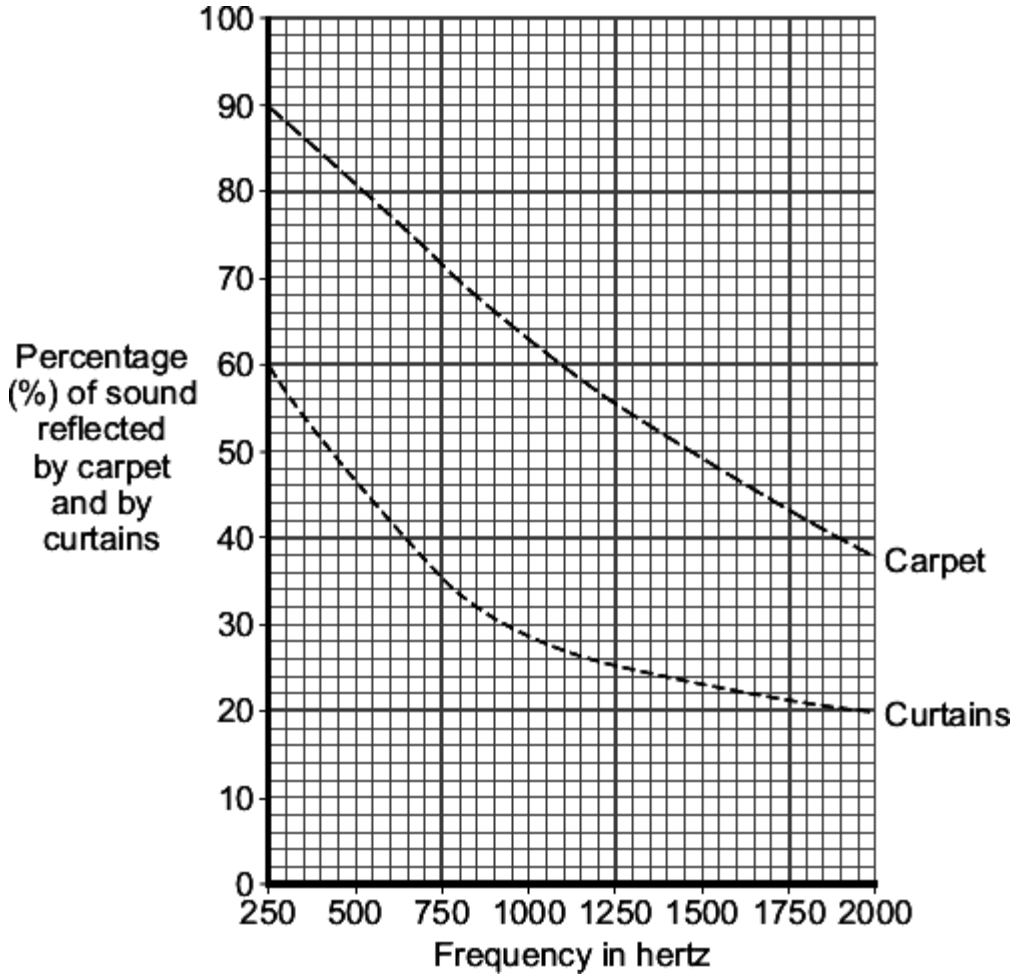
(c) Music concerts are sometimes performed in sports halls. The concerts can be spoilt because of the sound reflected from the floor and walls.

What word is used to describe a reflected sound?

_____

(1)

(d) The graph shows how the percentage of sound reflected from the floor and from the walls of a large room can be reduced by carpets and by curtains.



(i) Over which range of frequencies do curtains reduce the percentage of sound reflected the most?

Tick (✓) **two** boxes.

from 250 Hz to 750 Hz ☐

from 750 Hz to 1250 Hz ☐

from 1250 Hz to 1750 Hz ☐

(1)

(ii) The manager of a sports hall plans to use the hall for regular music concerts. He has enough money to buy either carpet or curtains, but not both.

To improve the sound an audience hears, it would be better to hang curtains on the walls rather than laying a carpet over the floor.

Use the data in the graph to explain why.

_____

_____

_____

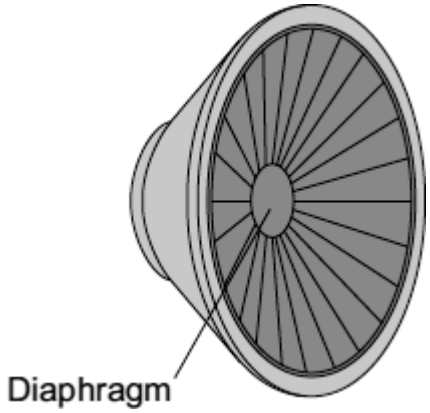
_____

(2)

(Total 11 marks)

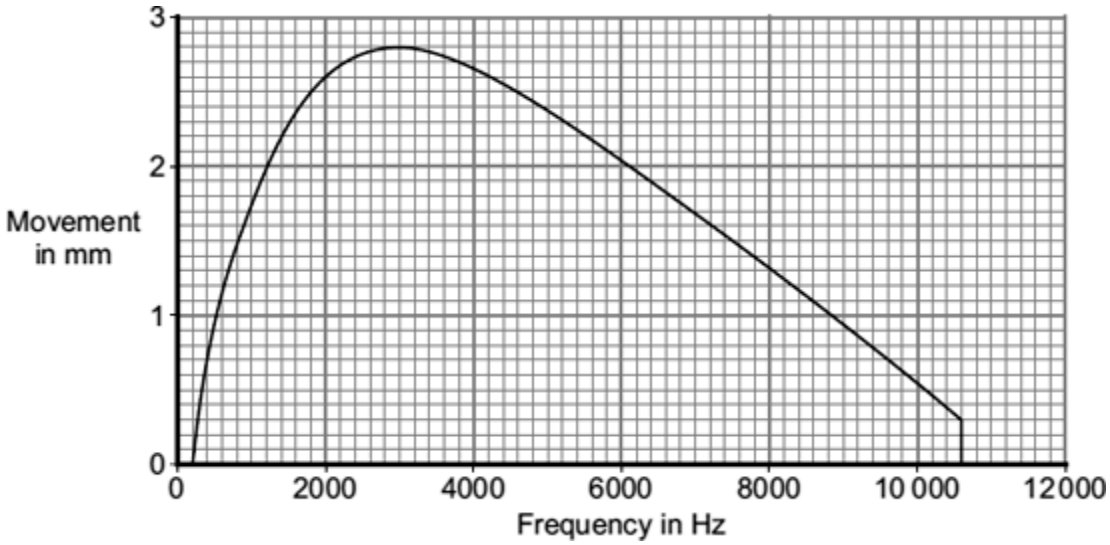
Q33.

The diaphragm of a loudspeaker moves in and out.



A team of scientists investigated loudspeakers.

The scientists measured the size of the movement of the diaphragm for signals of different frequencies.
They kept all the other variables constant.
The graph shows the average results for a large number of tests on one of the loudspeakers.



(a) What is the frequency of the highest pitched sound which this loudspeaker produces?

Frequency = _____ Hz

(1)

(b) The greater the movement of the diaphragm, the greater the amplitude of the sound produced.

What is the frequency of the loudest sound which this loudspeaker produces?

Show clearly on the graph how you get to your answer and then complete this answer space.

Frequency = _____ Hz

(2)

(c) Can this loudspeaker produce the full range of sound which most people can hear?

Put a tick (✓) in the box next to your answer.

Yes ☐ No ☐

Explain the reason for your answer.

_____

_____

_____

_____

(2)

(d) Use **one** word to complete the sentence.

Repeating tests a large number of times and taking the average of the results

improves the _____ .

(1)

(e) Why did the scientists keep all the other variables constant?

_____

_____

(1)

(Total 7 marks)

Q34.

Ultrasound waves are very high frequency sound waves. They cannot be heard by humans.

(a) Ultrasound waves can be used to clean jewellery.

The jewellery is put into a container of cleaning fluid.

Complete each sentence to explain how ultrasound can clean jewellery.

The ultrasound generator makes the molecules of the cleaning fluid

_____ . The molecules knock particles of _____

from the surface of the jewellery.

(2)

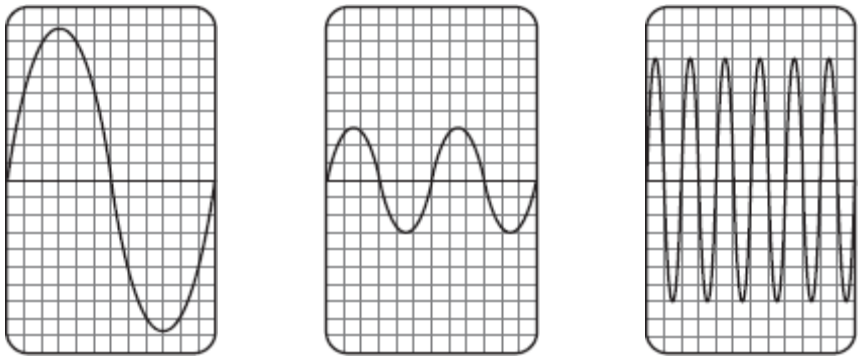
(b) Give a medical use for ultrasound.

_____

(1)

(c) Ultrasound waves can be represented on the screen of a cathode ray oscilloscope (CRO).

The diagrams show three ultrasound waves.
Each wave is represented on an identical CRO screen, **A**, **B** and **C**.



Screen **A** Screen **B** Screen **C**

(i) How many complete waves are shown on screen **B**? _____

(1)

(ii) Which screen shows the waves with the highest frequency?

Screen _____

(1)

(Total 5 marks)

Q35.

(a) Explain what an ultrasound wave is.

_____

_____

_____

_____

(2)

(b) Ultrasound waves can be used to clean jewellery.

One method is to put the jewellery in a bath of cleaning fluid which contains an electronic oscillator. The electronic oscillator generates ultrasound waves in the cleaning fluid.

Suggest how these waves clean the jewellery.

_____

_____

_____

_____

(2)

(c) Ultrasound is used for pre-natal scanning. This is much safer than using X-rays.

However, doctors were only sure it was safe after experiments on mice.

Explain whether or not you think that these experiments were justified.

_____

_____

_____

_____

(2)

(Total 6 marks)

Mark schemes

Q1.

(a) increased

1

(b) (count) how many waves pass a point

1

in one second

this is dependent on the first mark point being awarded

1

or

(count) number of waves that pass a point in a given time

allow a specific time for a given time

or

(count) number of waves that are produced in a given time (1)

and divide by that time in seconds

this is dependent on the first mark point being awarded

allow an answer in terms of measuring the frequency of the vibrating bar

(c) $\text{period} = \frac{1}{5}$

1

period = 0.2

1

seconds / s

1

[6]

Q2.

(a) Regrettably, this part of the question assessed content that we had stipulated would only be assessed on the Higher tier. All students were awarded full marks for this part of the question.

1

(b) 0.4

1

(c) wave speed = frequency × wavelength

allow $v = f\lambda$

1

(d) 7200 = 0.4 × wavelength

1

$$\text{wavelength} = \frac{7200}{0.4}$$

1

wavelength = 18 000 (m)

*allow up to full marks for ecf using their answer to part **(b)***

a method shown as
7200 × 2.5 = 18 000
*scores **0** marks*

1

*an answer 18 000 scores **3** marks*

(e) Regrettably, this part of the question assessed content that we had stipulated would only be assessed on the Higher tier. All students were awarded full marks for this part of the question.

2

[8]

Q3.

(a) P-waves are longitudinal and
S-waves are transverse

1

(b) 0.4

1

(c) wave speed = frequency × wavelength

allow $v = f\lambda$

1

(d) 7200 = 0.4 × wavelength

1

$$\text{wavelength} = \frac{7200}{0.4}$$

1

wavelength = 18 000 (m)

*allow up to full marks for ecf using their answer to part **(b)***

a method shown as
7200 × 2.5 = 18 000
*scores **0** marks*

1

*an answer 18 000 scores **3** marks*

(e) because S-waves cannot travel through a liquid

1

and S-waves do not travel through the (outer) core

allow some (seismic) waves cannot travel through

*a liquid and do not go through the core for **1** mark*

1

(f) magnetic field around the coil changes
or
the magnetic field (lines) cut by the coil

allow the generator effect

1

(g) because the magnet changes direction

1

(h) stationary

1

(i) any **two** from:

- stronger magnetic field

  allow stronger magnet
  allow heavier magnet
  bigger magnet is insufficient

- more turns on the coil

  bigger coil is insufficient
  *do **not** accept more coils of wire*

- turns pushed closer together

- spring with a lower spring constant

  allow less stiff spring
  allow weaker spring
  *do **not** accept add an iron core*

2

[13]

Q4.

(a) **A**

1

(b) 2 (%)

1

(c) black

correct order only

1

reflects

1

transmits

1

(d) green

1

(e) without a darkened laboratory would not be able to see reflected light

allow would see all squares all of the time

1

(f) so same 'amount' of light is incident on each square

a fair test is insufficient

control variable is insufficient

1

(g) two bars drawn at the correct height

*allow **1** mark for 1 correct bar*

2

both bars correctly labelled

1

(h) orange

reason only scores if orange chosen

1

can be seen from the furthest away

allow it reflects the most light

1

(i) repeatable

1

[14]

Q5.

(a) random

human error is insufficient

1

(b) accept any practical suggestion that could cause a range of values
e.g. misjudging the centre of the ray
e.g. not replacing mirror / ray box in the same position

measuring the angle incorrectly is insufficient
moving the mirror / ray box is insufficient

1

(c) range = 10
or
mean of 51 calculated

1

5(°)

*an answer of 5(°) scores **2** marks*

1

(d) within experimental accuracy the angle of incidence and the angle of reflection are the same

allow the angle of incidence is nearly the same as

the angle of reflection

or

the angle of reflection is usually different to the angle of incidence

allow only a few of the values are the same / similar
allow the idea of a range of values

1

relevant use of data
e.g.
at 20° / 30° / 40° there is at least one measurement of angle of reflection that is exactly the same
or
at 50° there are big differences

allow 50° includes anomalous results
an answer in terms of calculated mean(s) may score both marks
e.g.
mean calculated for one or more angle of reflection (1)
conclusion correctly stating angle i = / ≠ angle r (1)

1

(e) results could be collected for angles (of incidence) not yet measured

allow a stated angle of incidence e.g. 10° or 60°
changing the mirror is insufficient
ignore repeat the measurements

1

(f) replace the mirror with an irregular reflecting surface

allow use an irregular reflecting surface
replace mirror with paper is insufficient
*do **not** accept use a glass block*

1

[8]

Q6.

(a) sound

1

(b) (visible) light

1

(c) cooking food

1

(d) 1.2 gigahertz

1

(e) 300 000 × 1000 = 300 000 000 m/s

1

(f) wave speed = frequency × wavelength

allow $v = f\lambda$

1

(g) 300 000 000 = 1200 000 000 × λ

*an answer of 0.25 scores **3** marks*

1

$$\lambda = \frac{300\,000\,000}{1\,200\,000\,000}$$

*allow ecf from **(e)***

1

λ = 0.25 (m)

1

[10]

Q7.

(a) **K**

1

(b) **L** and **M**

1

(c) the oscillation should be perpendicular to the direction of the stretched spring

allow up and down

1

(d) timing less than five echoes

1

(e) 3 (.0)

1

(f) 750 (m)

1

(g) speed = $\frac{750}{3}$

*an answer of 250 (m/s) scores **2** marks*

2

speed = 250 (m/s)

allow ecf from parts (e) and (f)

1

(h) any **two** from:

- time more than 5 echoes
- students stand further from the building
- have 2 or more students (independently) measuring the time taken

use a stopwatch with a higher resolution is insufficient

2

[10]

Q8.

(a) arrow drawn vertically downwards from the weight

1

same length as given arrow

1

(b) **C**

*reason only scores if **C** is chosen*

1

smallest force required for the same compression

steepest gradient is insufficient

1

(c) 1.25

1

(d) $\text{period} = \frac{1}{25}$

*an answer of 0.8 (s) scores **2** marks*

1

period = 0.8 (s)

1

(e) extension = 0.20 m

1

$E_e = 0.5 \times 7.0 \times (0.20)^2$

1

$E_e = 0.14$ (J)

*an answer of 0.14 scores **3** marks*

1

[10]

Q9.

(a) (resultant) force = mass × acceleration

allow F = ma

symbols must be correct

1

(b) (2.7 – 1.5) = 0.75 × a

*an answer of 1.6 scores **3** marks*

1

$a = \frac{1.2}{0.75}$

allow compensation marks for correct use of incorrect resultant force

1

a = 1.6

1

m/s^2

1

(c) transverse

1

the oscillation / vibration is perpendicular to the direction of energy transfer

allow wave travel for energy transfer

1

(d) use springs with a smaller spring constant

allow use weaker springs

or

use a trolley with greater mass

allow use a heavier trolley

do not accept use a larger trolley

allow add a mass / weight to the trolley

1

(Total 8 marks)

Q10.

(a) gamma rays

1

(b) can travel through the atmosphere

1

(c) explosion of a red super giant

or

a supernova

1

(d) 1.2×10^9 Hz

1

(e) $3.0 \times 10^8 = 1.2 \times 10^9 \times \lambda$

*an answer of 0.25 (m) scores **3** marks*

*allow ecf from **(d)***

1

$$\lambda = \frac{3.0 \times 10^8}{1.2 \times 10^9}$$

1

$\lambda = 0.25$ (m)

1

(g) same as the radio wave

1

(f) expansion due to fusion energy

1

in equilibrium with gravitational collapse

*forces acting inwards equal forces acting outwards gains **1** mark*

1

(h)

Level 2: Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.	3-4
Level 1: Facts, events or processes are identified and simply stated but their relevance is not clear.	1-2
No relevant content	0
Indicative content • Sun goes from main sequence to red giant • then from red giant to white dwarf • when the Sun changes to a red giant the surface temperature will decrease • and the relative luminosity will increase • when changing from a red giant to a white dwarf the surface temperature increases • and the relative luminosity decreases	

4

[14]

Q11.

(a) K

1

(b) Decreases

1

(c) use a metre rule / 30 cm ruler to measure across 10 (projected) waves

accept any practical number of waves number for 10

1

and then divide by 10

1

(d) 1.2 cm = 0.012 m

1

18.5 × 0.012 = 0.22(2) (m / s)

1

*allow 0.22(2) with no working shown for **2** marks*

typical walking speed = 1.5m / s

accept any value e.g. in the range 0.7 to 2.0 m / s

1

so the water waves are slower (than a typical walking speed)

this cannot score on its own

1

[8]

Q12.

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

accept wave travel for energy transfer throughout

1

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

1

(b) accept any sensible suggestion eg a vibrating drum skin does not move the air away to create a vacuum (around the drum)

1

(c) **Level 3 (5–6 marks):**
A detailed explanation linking variations in current to the pressure variations of a sound wave, with a logical sequence.

Level 2 (3–4 marks):
A number of relevant points made, but not precisely. A link between the loudspeaker and
a sound wave is made.

Level 1 (1–2 marks):
Some relevant points but fragmented with no logical structure.

0 marks:
No relevant content.

Indicative content

the current in the electrical circuit is varying

the current passes through the coil

the coil experiences a force (inwards or outwards)

reversing the current reverses the force

the size of the current affects the size of the force

the varying current causes the coil to vibrate

the (vibrating) coil causes the cone to vibrate

the vibrating cone causes the air molecules to move

the movement of the air molecules produces the pressure variations in the air needed for
a sound wave

the air molecules bunch together forming compressions and spread apart forming rarefactions

6

[9]

Q13.

(a) frequency

1

(b) echo(es)

1

(c) 340 (m/s)

*allow **1** mark for correct substitution ie 25 000 × 0.0136 provided no subsequent step*

or

*allow **1** mark for a correct calculation showing an incorrect value from conversion to hertz × 0.0136*

*an answer of 0.34 gains **1** mark*

2

(d) (a wave where the) oscillations are parallel to the direction of energy transfer

both marking points may appear as labels on a diagram

accept vibrations for oscillations
accept in same direction as for parallel to
allow direction of wave (motion) for direction of energy transfer

*allow **1** mark for a correct calculation showing an incorrect value from conversion to hertz × 0.0136*

1

causing (areas of) compression and rarefaction

accept correct description in terms of particles

mechanical wave is insufficient
needs a medium to travel through is insufficient

1

[6]

Q14.

(a) X marked in the centre of the sign

Check position by eye

1

(b) concentrated

1

(c) 0.5 (s)

*allow **1** mark for correct substitution, ie*

$\frac{1}{2}$

provided no subsequent step

2

(d) make the cables longer

accept pendulum / sign for cables

1

[5]

Q15.

(a) 20 000 Hz

1

(b) 400 (m)

*allow **1** mark for correct substitution ie 1600 × 0.25*
provided no subsequent steps shown
*an answer of 200 (m) gains **1** mark*

2

(c) twice

1

(d) From pulse 1 to pulse 3 the distance (to the sea floor) decreased

accept the sea got shallower
or
the submarine went deeper for the distance decreased

1

then (after pulse 3) the distance (to the sea floor) increased

accept the sea got deeper

or

the submarine rose for the distance increased

*An answer of the distance decreased then increased gains **1** mark*

1

[6]

Q16.

(a) ultrasound is not ionising

allow ultrasound does not harm the (unborn) baby

1

but X-rays are ionising

1

so X-rays increase the health risk to the (unborn) baby

accept specific examples of health risks, eg cancer, stunted growth, impaired brain function etc

X-rays are dangerous is insufficient

1

(b) ultrasound/waves are partially <u>reflected</u>

(when they meet a boundary) (between two different media / substances / tissues)

must be clear that not all of the wave is reflected

1

the time taken is measured (and is used to determine distances)

1

(c) 1600 (m/s)

*800 (m/s) gains **2** marks*

*160 000 (m/s) gains **2** marks*

*0.0016 (m/s) gains **2** marks*

*allow **2** marks for*

$$\frac{0.04}{25 \times 10^{-6}}$$

or

$$\frac{0.08}{50 \times 10^{-6}}$$

*80 000 (m/s) gains **1** mark*

*0.0008 (m/s) gains **1** mark*

*allow **1** mark for*

$$\frac{0.04}{25}$$

or

$$\frac{0.08}{50}$$

*allow **1** mark for evidence of doubling the distance or halving the time*

3

(d) (i) they are absorbed by bone

allow stopped for absorbed

X-rays are reflected negates this mark

1

they are transmitted by soft tissue

allow pass through for transmitted

allow flesh / muscle / fat

accept less (optically) dense material for soft tissue

1

(the transmitted) X-rays are detected

1

(ii) short

accept small

1

[12]

Q17.

(a) high frequency sound (waves)

1

with a frequency above limit of human hearing
or with a frequency greater than 20 000 Hz

above limit of human hearing

***or** greater than 20 000 Hz gains maximum **1** mark*

1

(b) $5(.0) \times 10^{-4}$ (m)
or
0.0005 (m)

*$1500 = 3 \times 10^{6}\ \lambda$ gains **2** marks*

*answer of 500 gains **2** marks*

*$1500 = 3.0\ \lambda$ gains **1** mark*

3

(c) it will run off the surface of the skin
or
water is not a gel

accept water would evaporate

1

(d) The width of the coupling agent

1

The width of the water

1

(e) (i) A

1

(ii) E

1

(f) (i) **K**
reflection from skin
maximum 5 marks if no mention of reflection

1

very little reflection, so small peak

1

L
reflection from front of kidney

1

large amount of reflection, so large peak

1

M
reflection from back of kidney

1

smaller peak due to absorption of ultrasound in kidney
or
smaller peak as further from source
or
front of the kidney already reflected a lot, so there is now less to be reflected
reflection from a boundary gains 1 mark if no other mark given

1

(ii) 0.06 (m)
or
$6(.0) \times 10^{-2}$
*0.12 (m) gains **2** marks*
*distance = $1500 \times 8 \times 10^{-5} \times 0.5$ gains **2** marks*
*distance = $1500 \times 8 \times 10^{-5}$ gains **1** mark*

3

[19]

Q18.

(a) (i) microwave

1

(ii) refraction

1

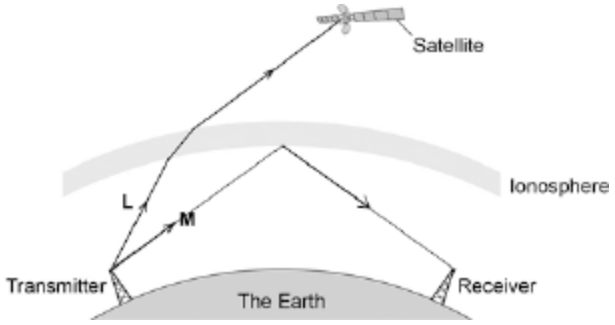
(b) (i) wave M continues as a straight line to the ionosphere and shown reflected

accept reflection at or within the ionosphere

1

correctly reflected wave shown as a straight line reaching the top of the receiver

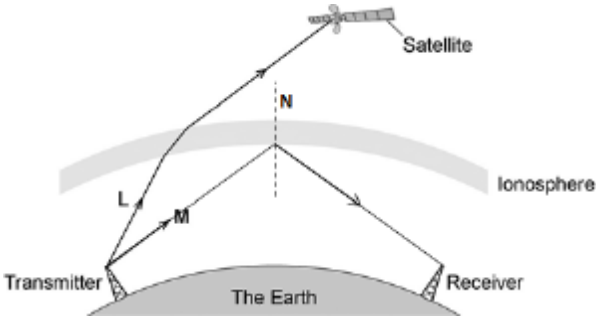
if more than 2 rays shown 1 mark maximum



ignore arrows

1

(ii) normal drawn at point where their **M** meets the ionosphere



1

(c) any **two** from:

- transverse
- same speed (through air)

  *accept speed of light **or** 3 × 10^8 m / s*
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed
- transfer energy
- can travel through a vacuum

  *an answer travel at the same speed though a vacuum scores **2** marks*
- can be polarised

- show interference.

travel in straight lines is insufficient

2

[7]

Q19.

(a) 1.25

*accept 1.3 for **2** marks*

*allow **1** mark for correct substitution*

ie $\frac{1}{0.8}$

provided no subsequent step shown

2

(b) (i) increasing the length (of the pendulum) decreases the number of oscillations / swings made (in 20 seconds)

accept increasing the length (of the pendulum) increases the time (of 1 oscillation / swing)

accept increasing the length (of the pendulum) decreases the speed / frequency (of 1 oscillation / swing)

answers must refer to the effect of increasing / decreasing length

ignore references to time being proportional to length

1

changing the mass (of the pendulum bob) does not change the number of oscillations / swings made (in 20 seconds)

accept changing the mass does not change the time / speed / frequency / results

accept weight for mass

1

(ii) any **two** suitable improvements:

- measure (the number of swings) over a wider range of (pendulum) lengths
- measure (the number of swings) over a wider range of (bob) masses
- measure the number of swings made over a greater period of time
- repeat each measurement & calculate mean / average (number of oscillations in 20 seconds)

  accept repeat measurements & discard anomalous measurements

  repeat measurements is insufficient
- measure (the total number of swings &) the fraction of swings made
- start the swings at the same height.

use a computer / datalogger to make measurement (of number of oscillations) is insufficient

measuring time period is insufficient

using a stop clock with greater resolution is insufficient

2

[6]

Q20.

(a) pitch

1

loudness

1

(b) (i) as length (of prongs) decreases frequency / pitch increases

accept converse

accept negative correlation

ignore inversely proportional

1

(ii) 8.3 (cm)

accept 8.3 ± 0.1 cm

1

(iii) (8.3 cm is) between 7.8 (cm) and 8.7 (cm)

*ecf from part **(ii)***

1

(so *f* must be) between 384 (Hz) and 480 (Hz)

1

410 (Hz) ≤ *f* ≤ 450 (Hz)

*if only the estimated frequency given, accept for **1** mark an answer within the range*

1

(c) (i) electronic

1

(ii) frequency is (very) high

accept frequency above

*20 000 (Hz) **or** audible range*

1

so tuning fork ***or*** length of prongs would be very small (1.2 mm)

1

(d) 285.7 (Hz)

accept any correct rounding 286, 290, 300

*allow **2** marks for 285*

*allow **2** marks for correct substitution 0.0035 = 1 / f*

*allow **1** mark for T = 0.0035 s*

*allow **1** mark for an answer of 2000*

3

[13]

Q21.

(a) (i) 440 (sound) waves produced in one second

accept vibrations / oscillations for waves

1

(ii) 0.773 (metres)

*allow **2** marks for an answer that rounds to 0.773*

*allow **2** marks for an answer of* $0.77\dot{2}$

*allow **2** marks for an answer of 0.772*

*allow **1** mark for correct substitution ie 340 = 440 × λ*

3

(b) (sound is) louder

*do **not** accept the converse*

1

as amplitude is larger

waves are taller is insufficient

1

higher pitch / frequency

1

as more waves are seen

reference to wavelengths alone is insufficient

waves are closer together is insufficient

1

[8]

Q22.

(a) (sound waves) which have a frequency higher than the upper limit of hearing for humans

or

a (sound) wave (of frequency) above 20 000 Hz

sound waves that cannot be heard is insufficient

a wave of frequency 20 000 Hz is insufficient

1

(b) 640

*an answer of 1280 gains **2** marks*

*allow **2** marks for the correct substitution*

ie 1600 × 0.40 provided no subsequent step

*allow **2** marks for the substitution* $\frac{1600 \times 0.80}{2}$

provided no subsequent step

*allow **1** mark for the substitution 1600 × 0.80 provided no subsequent step*

*allow **1** mark for the identification that time (boat to bed) is 0.4*

3

(c) any **one** from:

- pre-natal scanning / imaging
- imaging of a named organ (that is not surrounded by bone), eg stomach, bladder, testicles

  accept heart

  *do **not** allow brain **or** lungs (either of these negates a correct answer)*
- Doppler scanning blood flow

1

(d) advantage

any **one** from:

- (images are) high quality or detailed or high resolution

  clearer / better image is sufficient
- (scan) produces a slice through the body
- image can be viewed from any direction

  allow images are (always) 3D / 360°
- an image can be made of <u>any</u> part (inside the body)

  allow whole body can be scanned
- easier to diagnose **or** see a problem (on the image)

1

disadvantage

any **one** from:

- (the X-rays used **or** scans) are <u>ionising</u>

  allow a description of what ionising is
- mutate cells **or** cause mutations **or** increase chances of mutations

  allow for cells:

  DNA / genes / chromosomes / nucleus / tissue
- turn cells cancerous **or** produce abnormal growths **or** produce rapidly growing cells
- kill cells

  damage cells is insufficient
- shielding is needed

  can be dangerous (to human health) unqualified, is insufficient

1

[7]

Q23.

(a) (i) 20

1

20 000

either order

accept ringed answers in box

1

(ii) (frequency) above human range

accept pitch for frequency

or

(frequency) above 20 000 (Hz)

*do **not** accept outside human range*

*allow ecf from incorrect value in **(a)(i)***

1

(iii) any **one** from:

- pre-natal scanning

  accept any other appropriate scanning use

  *do **not** accept pregnancy testing*
- removal / destruction of kidney / gall stones
- repair of damaged tissue / muscle

  accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation

  accept physiotherapy

  accept curing prostate cancer or killing prostate cancer cells
- removing plaque from teeth

  cleaning teeth is insufficient

1

(b) 7.5×10^{-4} (m)

*$1.5 \times 10^{3} = 2.0 \times 10^{6} \times \lambda$ gains **1** mark*

2

(c) for reflected waves

must be clear whether referring to emitted or detected / reflected waves

if not specified assume it refers to reflected wave

any **two** from:

- frequency decreased
- wavelength increased
- intensity has decreased

  allow amplitude / energy has decreased

  allow the beam is weaker

2

[8]

Q24.

(a) the oscillation / vibration (causing the wave)

a movement causes the wave is insufficient

1

for a transverse wave is perpendicular to the direction of energy transfer

accept direction of wave travel

1

and for a longitudinal wave is parallel to the direction of energy transfer

accept direction of wave travel

*if no marks awarded allow **1** mark for correctly linking perpendicular with transverse and parallel with longitudinal*

the marks may be scored by the drawing of two correctly labelled diagrams

1

(b) for radio waves:

accept converse for each mark

are transverse

1

travel at speed of light / higher speed

1

have greater frequencies

1

can travel through vacuum

*accept sound waves are not electromagnetic for **1** mark*

1

[7]

Q25.

(a) (i) perpendicular

accept correct description 1

1

(ii) light off – no / slow rotation

1

light on – fast(er) rotation

accept starts rotating

ignore references to energy transfers

1

(b) one ray drawn from wrist watch and reflected by mirror

accept solid or dashed lines

1

two rays drawn from wrist watch and reflected by mirror with i = r for both rays

judge angles by eye

1

one ray traced back behind mirror

accept solid or dashed lines

1

image in correct position

judged by eye

accept image marked where two reflected rays traced back cross behind the mirror

1

(c) cannot be formed on a screen

accept image formed behind the mirror

or

rays of light seem to come from it but do not pass through it

1

[8]

Q26.

(a) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance, and apply a 'best-fit' approach to the marking.

0 marks
No relevant / correct content.

Level 1 (1-2 marks)
There is a basic description of either wave
OR
What happens to either wave when they enter the body. However there is little other detail.

Level 2 (3-4 marks)
There is either:
A clear description of BOTH waves
OR
A clear description as to what happens to BOTH waves inside the body
OR
A clear description of ONE of the waves with clear detail as to what happens to either wave inside the body.

Level 3 (5-6 marks)
There is a detailed description of BOTH of the waves
AND
A detailed description as to what happens to EITHER wave inside the body.

Examples of the points made in the response:

Description of an X-ray

- X-rays are electromagnetic waves / part of the electromagnetic spectrum

  *do **not** allow a description of a property – eg X-rays travel*

- X-rays are (very) high frequency (waves)

  through a vacuum / at the speed of light

- X-rays are (very) high energy (waves)
- X-rays have a (very) short wavelength
- Wavelength (of X-rays) is of a similar size to (the diameter of) an atom
- X-rays are a transverse wave

  correct description acceptable – oscillations / vibrations are perpendicular (at 90°) to direction of energy transfer
- X-rays are ionising radiation

Description of ultrasound

- ultrasound has a frequency above 20 000 (hertz)

  or

  ultra sound is above 20 000 hertz
- ultrasound is above / beyond the human (upper) limit (of hearing)

  accept ultrasound cannot be heard by humans
- ultrasound is a longitudinal wave

  correct description acceptable – oscillations / vibrations (of particles) are parallel (in same direction) to direction of energy transfer

Statement(s) as to what happens to X-rays inside the human body:

- X-rays are absorbed by bone
- X-rays travel through / are transmitted by tissue / skin

Statement as to what happens to ultrasound inside body:

- ultrasound is (partially) reflected at / when it meets a boundary between two different media
- travel at different speeds through different media

6

(b) (because the X-rays) are ionising

accept a description of what ionising is

1

(they will) damage cells

instead of cell, any of these words can be used:
DNA / genes / chromosomes / nucleus

or

mutate cells / cause mutations / increase chances of mutations

or

turn cells cancerous / produce abnormal growths / produce rapidly growing cells

*do **not** accept they can be dangerous (to human health)*

*do **not** accept damage to soft tissue*

or

kill cells

1

(c) any **one** from:

- removal / destruction of kidney / gall stones
- repair of damaged tissue / muscle

  accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation

  accept physiotherapy

  *accept curing prostate cancer **or** killing prostate cancer cells*
- removing plaque from teeth

  cleaning teeth is insufficient

1

[9]

Q27.

(a) (i) wavelength

accept frequency

accept speed

1

(ii) amplitude

accept energy

height is insufficient

1

(iii) sound

1

(b) 0.12

*allow **1** mark for correct substitution, ie 8 × 0.015 provided no subsequent step shown*

2

metre per second **or** m/s **or** metre/second

*do **not** accept mps*

units must be consistent with numerical answers

1

[6]

Q28.

(a) any **two** from:

- (sound with frequency) above 20 000 hertz / 20 kHz
- frequencies above (human) audible range
- (sound) cannot be heard by humans

2

(b) **either**
two appropriate points gain **1** mark each

__either__ both pro / con __or__ one of each

or
one appropriate point (and) appropriate qualification / amplification

examples
other mammals (sufficiently) similar to humans (1)
so results appropriate (1)
unethical to experiment on humans (1)
so it is better to experiment on mice (1)
knowledge / techniques will benefit humans (1)
and also other animals (1)
experiments were justified because ultrasound has proved useful (1)

2

(c) examples

allow a wide variety of appropriate responses

publish / tell doctors / the public (1)
…their evidence / results / research / data (1)

valid point (1)
appropriate example / qualification / expansion / etc (1)

carry out more research / tests (1)
…to make sure / check reliability (1)

allow just 'stop using them / ultrasonic waves' for __1__ mark only
allow using them (only) for industrial purposes for __1__ mark only

2

[6]

Q29.

(a) (i) bat(s)

1

(ii) any example in the inclusive range 5 ↔ 29 Hz / hertz

appropriate number and unit both required

1

(b) (i) A, C, D

all three required and no other

1

(ii) D, E

both required and no other

1

(c) sound cannot travel through a vacuum / (empty) space / free space

accept there is no medium (for the sound to travel through)

*do **not** accept there is no air (for the sound to travel through)*

1

(because) there is / are nothing / no particles to vibrate

accept because there is / are nothing / no particles between them and the source (of the sound)

1

[6]

Q30.

(a) (i) **J** and **L**

both required, either order

1

(ii) **K**

1

(iii) **L**

1

highest frequency

*reason does not score if **L** not chosen*

accept most waves (on screen)

*do **not** accept frequency above 20 000(Hz)*

*do **not** accept cannot hear it*

1

(b) transmitter

detector

computer

all three in correct order

*allow **1** mark for one correct*

2

[6]

Q31.

(a) (i) 3

1

(ii) 30 000 **or** 10 000 × their (a)(i) correctly calculated

1

(iii) any **two** from:

- frequency is above 20 000 (Hz)
  accept the frequency is 30 000
- frequency is above the upper limit of audible range
- upper limit of audible range equals 20 000 (Hz)
  ignore reference to lower limit
- it is ultrasound/ultrasonic

2

(b) (i) wave (partially) reflected

1

at crack to produce **A** and end of bolt to produce **B**
accept at both ends of the crack

1

(ii) 0.075 (m) allow **2** marks for time = 0.0000125
*allow **1** mark for time = 0.000025*
*answers 0.15 **or** 0.015 **or** 0.09 gain **2** marks*
*answers 0.18 **or** 0.03 gain **1** mark*
the unit is not required but if given must be consistent with numerical answer for the available marks

3

[9]

Q32.

(a) letter C clearly marking a compression
accept C at any point in a compression
if more than one letter C marked
all must be correct

1

(b) (i) straight continuous line drawn from loudspeaker to metal to sound sensor
judge by eye

1

angle I = angle R
judge by eye
ignore any arrows on lines

1

(ii) less sound reflected
accept energy for sound

or

(some) sound passes through the glass
accept (some) sound absorbed by the glass

1

(iii) makes the sound louder

1

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

340

*allow **1** mark for correct substitution*
ie 850 × 0.4
provided no subsequent step shown

2

(c) echo

1

(d) (i) from 250 Hz to 750 Hz

1

(ii) curtains reduce (percentage of) sound reflected more (than carpet)

accept curtains absorb more sound (than carpet)

1

for all frequencies (shown)

accept for both marks an answer in terms of walls having a larger (surface) area to reflect sound and curtains reducing the amount of reflected sound more (than carpet)
*answers less noisy or walls / curtains have a larger area gain **1** mark only*
*do **not** accept curtains are cheaper*

1

[11]

Q33.

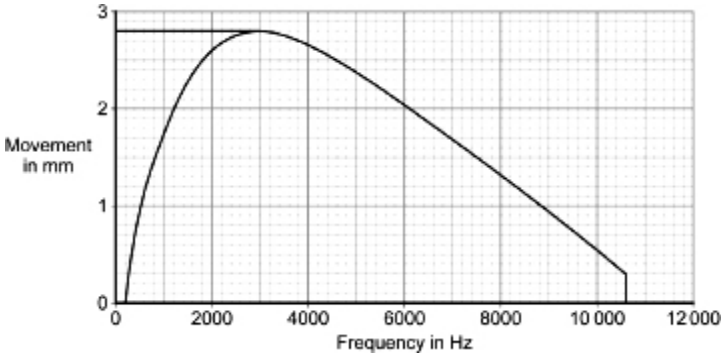
(a) 10 600 (Hz)

accept 10.6 kHz

1

(b) 3000 (Hz)

*allow **1** mark for a line drawn to show greatest movement (allow only if frequency is between 2800 and 3200)*
accept other indication of correctly using the graph



2

(c) (No)

no marks for just the ticked box
reasons can score even if yes is ticked

(human hearing) range is 20 – 20 000 (Hz)

accept (most) people hear up to 20 000 (Hz) / 20 kHz

1

any **one** from:

- range on graph is within this range
- range on graph starts after 20 Hz
- range on graph is from to 200 – 10 600 (Hz)
- range on graph finishes before 20 000 Hz

1

(d) reliability

this answer only

1

(e) only 1 variable affects dependent variable / size of movement

accept 'results' for 'size of movement'

or

there is only one independent variable

fair test is insufficient
*do **not** accept to control the experiment*

or

to be able to compare (effect of different frequencies)

1

[7]

Q34.

(a) vibrate

*allow move more (vigorously) but **not** just move*

1

dirt / muck / grit / rust / dust etc.

*do **not** accept bacteria*

1

(b) any **one** medical use eg

ignore incorrect biological detail

- scanning unborn babies
- destroying (kidney) stones

1

(c) (i) 2

1

(ii) C

1

[5]

Q35.

(a) sound / mechanical / longitudinal (wave)

1

any **one** from:

- above 20 000 hertz / 20kHz
- above (human) audible range
- cannot be heard by humans

1

(b) **either**

particles / molecules / fluid vibrate(s) (1)

(and) knock particles of dirt off the jewellery (1)

or

by the process of cavitation (1)

accept 'formation and collapse of tiny bubbles'

which breaks up / releases dirt from the surface (1)

2

(c)***either*** *both pro*
or *both con*
or *one of each*

either

two appropriate points gain **1** mark each

or

one appropriate point (and) appropriate qualification / amplification

examples

other mammals (sufficiently) similar to humans (1)

so results appropriate (1)

unethical to experiment on humans (1)

so it is better to experiment on mice (1)

knowledge / techniques will benefit humans (1)

and also other animals (1)

experiments were justified because ultrasound has proved useful (1)

2

[6]