Waves 3

Name: _____

Class: _____

Date: _____

Time: **93 minutes**

Marks: **86 marks**

Comments:

1. X-rays and gamma rays are types of electromagnetic waves.

X-rays are used for medical imaging.

(a) Which substance will **not** absorb X-rays?

Tick (✓) **one** box.

Bone ☐ Metal ☐ Skin ☐

(1)

The table below shows the effect of exposure to different doses of radiation.

Dose in mSv	**Effect on the human body**
100	slightly increased risk of cancer
1000	5% increased risk of cancer
5000	high risk of death

(b) During one X-ray a person receives a dose of 0.100 mSv

Why is this dose unlikely to harm the person?

_____

_____

(1)

(c) A doctor takes an X-ray photograph of a person.

When taking the X-ray photograph, the doctor stands behind a screen.

Suggest why.

_____

_____

(1)

(d) Which of the following are gamma rays used for?

Tick (✓) **one** box.

Cooking food ☐

Energy-efficient lamps ☐

Sterilising medical equipment ☐

(1)

(e) Why are gamma rays and X-rays harmful to humans?

Tick (✓) **one** box.

They are ionising ☐

They are radioactive ☐

They travel at the speed of light ☐

(1)

(f) Electromagnetic waves are also used in communications.

Describe how microwaves and visible light are used in communications.

Microwaves _____

_____

_____

_____

Visible light _____

_____

_____

_____

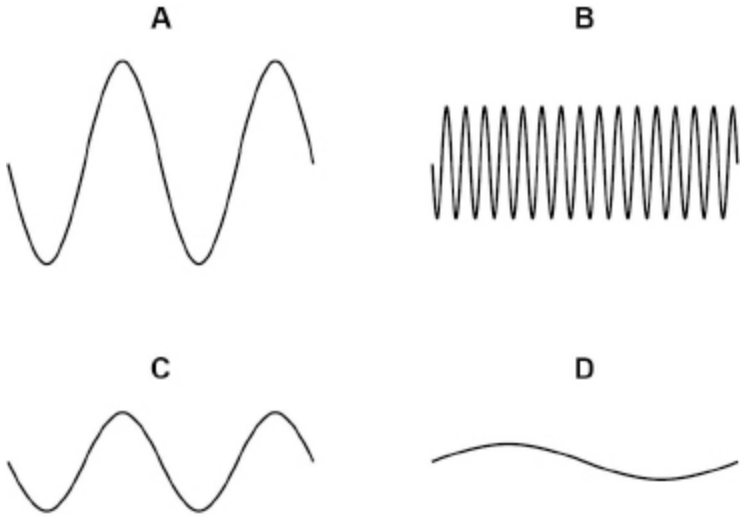
(4)

(Total 9 marks)

2. **Figure 1** shows four waves.

The waves are drawn to the same scale.

Figure 1



(a) Which wave has the greatest amplitude?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(b) Which wave has the greatest frequency?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(c) Which wave has the greatest wavelength?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(d) A wave has a frequency of 1650 Hz and a wavelength of 0.200 m

Calculate the wave speed.

Use the equation:

wave speed = frequency × wavelength

_____

_____

_____

_____

Wave speed = _____ m/s

(2)

A student uses a mobile phone app that displays sound waves.

Figure 2 shows the student holding the mobile phone close to a loudspeaker.

Figure 2

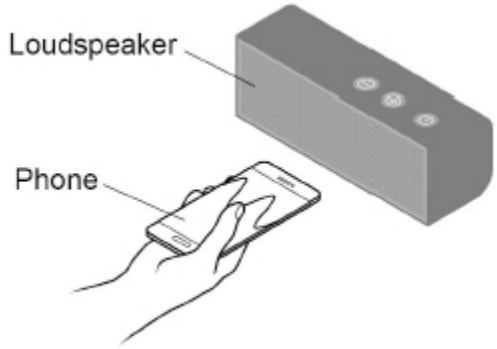
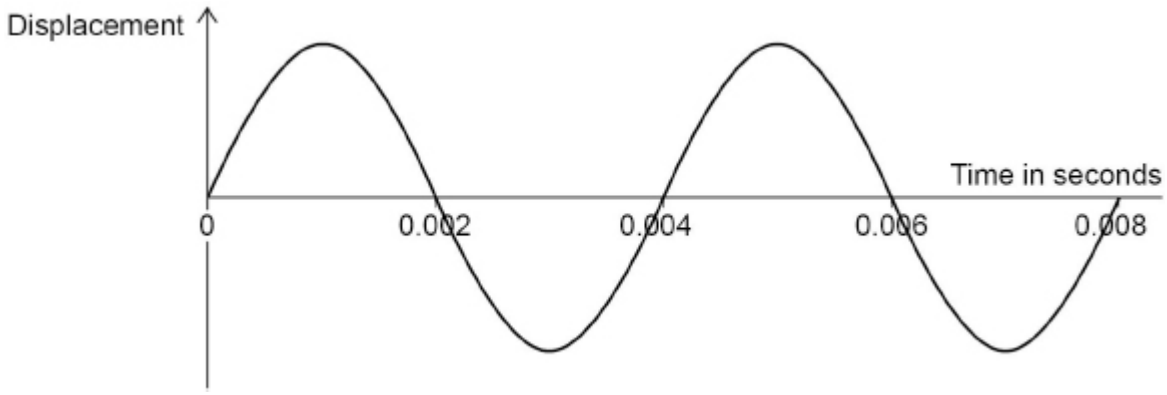


Figure 3 shows the wave pattern seen on the phone screen.

Figure 3



(e) What is the period of the wave shown in **Figure 3**?

Tick (✓) **one** box.

0.002 s ☐ 0.004 s ☐ 0.006 s ☐ 0.008 s ☐

(1)

(f) Determine the frequency of the wave shown in **Figure 3**.

Use the Physics Equations Sheet.

Frequency = _____ Hz

(3)

(Total 9 marks)

3. X-rays form part of the electromagnetic spectrum.

Radiographers use X-rays to produce images of bones inside the body.

(a) Explain why X-rays can be used to produce images of the bones inside the body.

(2)

(b) The table below shows the effect of exposure to different doses of radiation.

Dose in mSv	Effect on the human body
100	slightly increased risk of cancer
1000	5% increased risk of cancer
5000	high risk of death

During an X-ray a person receives a dose of 0.5 mSv

The radiographer takes many X-ray images each day.

Explain why the radiographer stands behind a protective screen when taking an X-ray image.

_____

_____

_____

_____

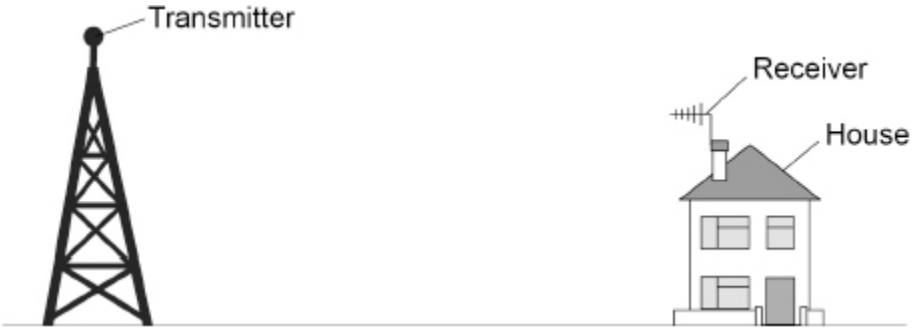
_____

_____

(3)

(c) Radio waves form part of the electromagnetic spectrum.

The diagram below shows one use of radio waves.



Explain how electrical signals in the transmitter produce a signal in the receiver.

(3)

(Total 8 marks)

4. The Sun emits all types of electromagnetic waves.

Figure 1 shows the electromagnetic spectrum.

Figure 1

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

(a) Complete the sentences.

Choose answers from the box.

frequency	**mass**	**power**
velocity	**wavelength**	

In a vacuum, all electromagnetic waves travel at the same _____ .

Gamma waves have the greatest _____ .

Radio waves have the greatest _____ .

(3)

(b) Explain why it is important that the Earth's atmosphere absorbs gamma rays emitted by the Sun.

_____

_____

_____

_____

(2)

(c) Some microwaves are **not** absorbed by the Earth's atmosphere.

Why is this useful?

_____

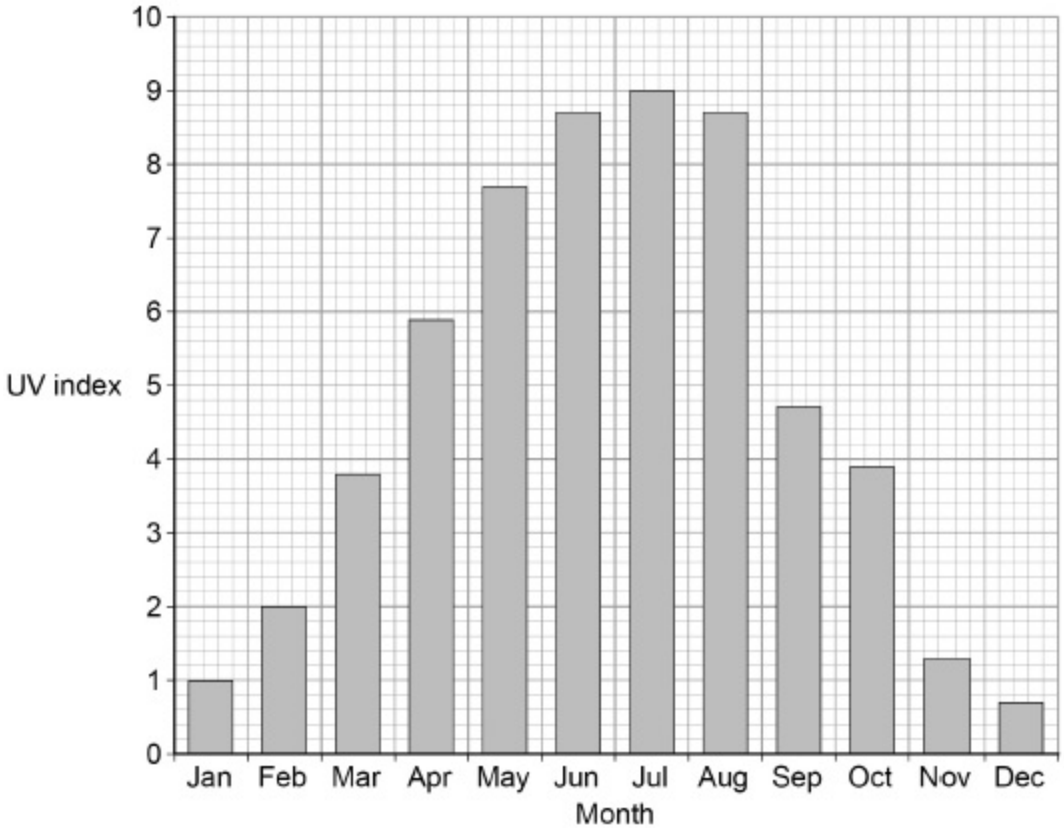
(1)

Some ultraviolet (UV) radiation from the Sun passes through the atmosphere and reaches the surface of the Earth.

The amount of UV radiation that reaches the surface of the Earth can be measured on a scale called the UV index.

Figure 2 shows the average midday UV index in the UK for 1 year.

Figure 2



(d) Why is exposure to UV radiation harmful to humans?

_____

_____

(1)

(e) Compare the risk from UV radiation at different times of year in the UK.

Use data from **Figure 2**.

_____

_____

_____

_____

(2)

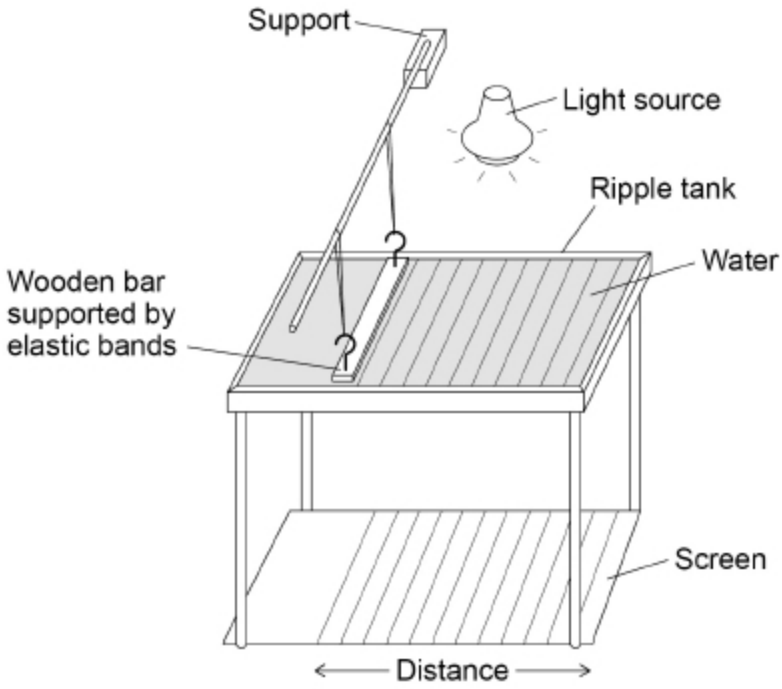
(Total 9 marks)

5. **Figure 1** below shows the equipment a teacher used to determine the speed of a water wave.

The equipment includes:

- a ripple tank filled with water
- a wooden bar that creates ripples on the surface of the water
- a light source which causes a shadow of the ripples on the screen.

Figure 1



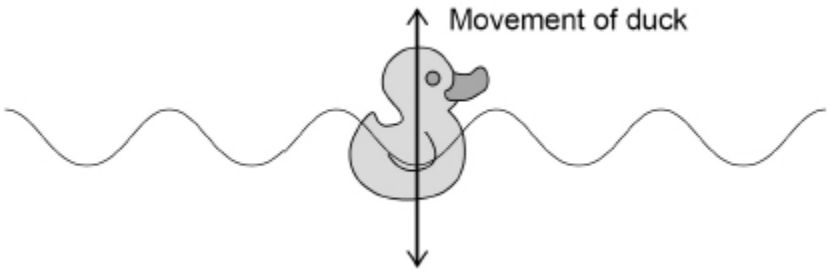
(a) Describe how equipment in **Figure 1** can be used to measure the wavelength, frequency and speed of a water wave.

(6)

The teacher put a plastic duck in the ripple tank as shown in **Figure 2**.

The plastic duck moved up and down as the waves in the water passed.

Figure 2



(b) How does the movement of the plastic duck in **Figure 2** demonstrate that water waves are transverse?

(1)

(c) The teacher measured the maximum height and the minimum height of the plastic duck above the screen as the wave passed.

The teacher repeated his measurements.

The table shows the teacher's measurements.

Maximum height in mm	509	513	511
Minimum height in mm	503	498	499

Calculate the mean amplitude of the water wave.

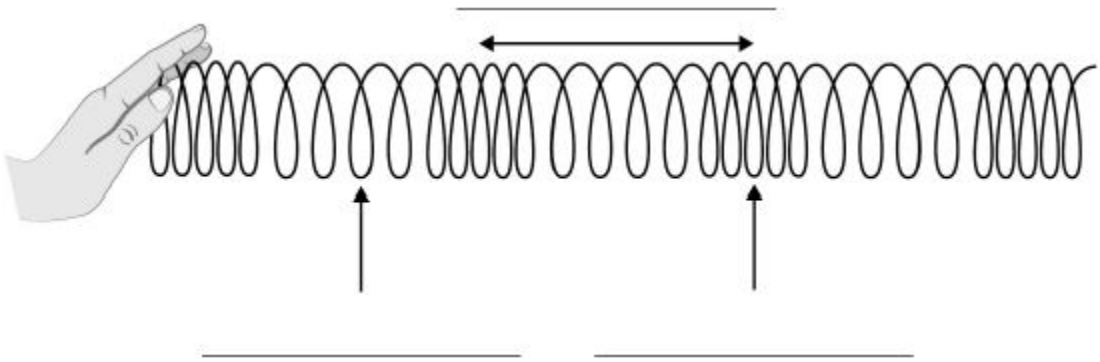
Mean amplitude = _____ mm

(3)

(Total 10 marks)

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

Figure 1



(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 ☐

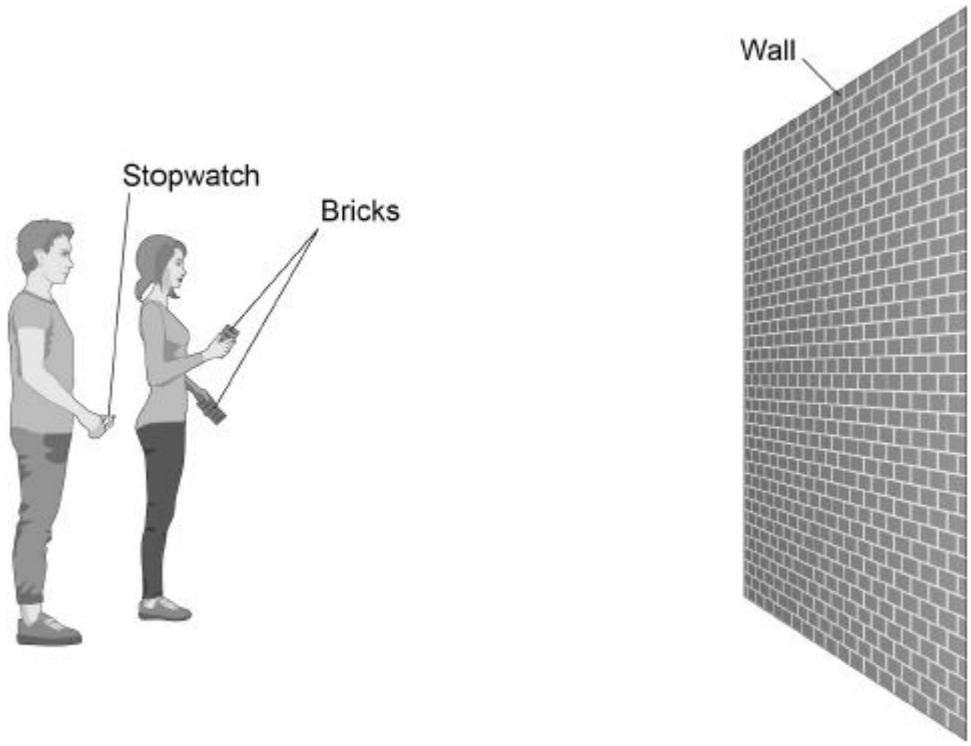
longitudinal ☐

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)

7. The diagram below shows types of waves within the electromagnetic spectrum.

Some of the types of waves are represented by letters.

P	**microwaves**	**Q**	**visible light**	**R**		**S**	**gamma rays**

(a) Which letter shows the position of ultraviolet (UV) radiation within the electromagnetic spectrum?

Tick **one** box.

P ☐ **Q** ☐ **R** ☐ **S** ☐

(1)

(b) A special lamp can produce UV radiation.

Which **two** statements describe the electromagnetic waves emitted by a UV lamp?

Tick **two** boxes.

They have a higher frequency than X-rays. ☐

They have the same wave speed as visible light. ☐

They have a longer wavelength than microwaves. ☐

They have a lower frequency than gamma rays. ☐

They have a greater wave speed than radio waves. ☐

(2)

(c) UV radiation is used to treat a vitamin D deficiency.

People should **not** use a UV lamp for long periods of time.

State **two** risks of exposure to high levels of UV radiation.

1. _____

_____

2. _____

_____

(2)

(d) Ionising radiation is used for some medical imaging.

Name **two** types of electromagnetic waves that are used.

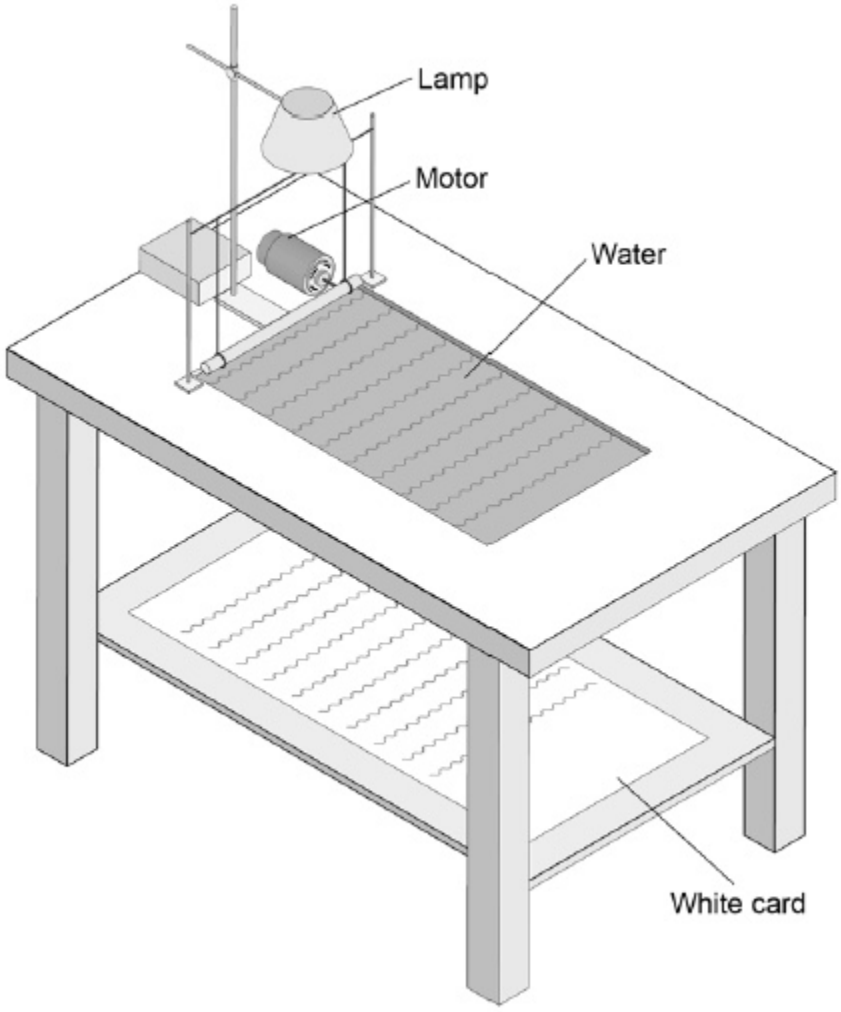
1. _____

2. _____

(2)

(Total 7 marks)

8. 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)

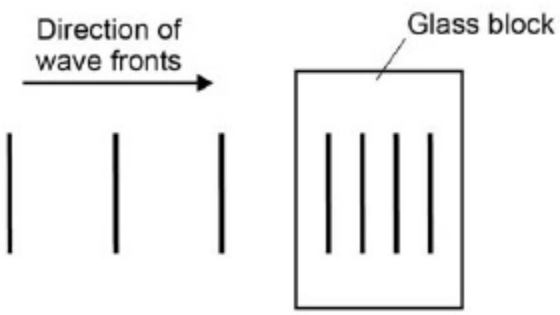
(c) Explain how a student could make appropriate measurements and use them to determine the wavelength of the waves in the ripple tank.

(6)

(Total 13 marks)

9. **Figure 1** is a wave front diagram showing light travelling through the air and into a glass block.

Figure 1

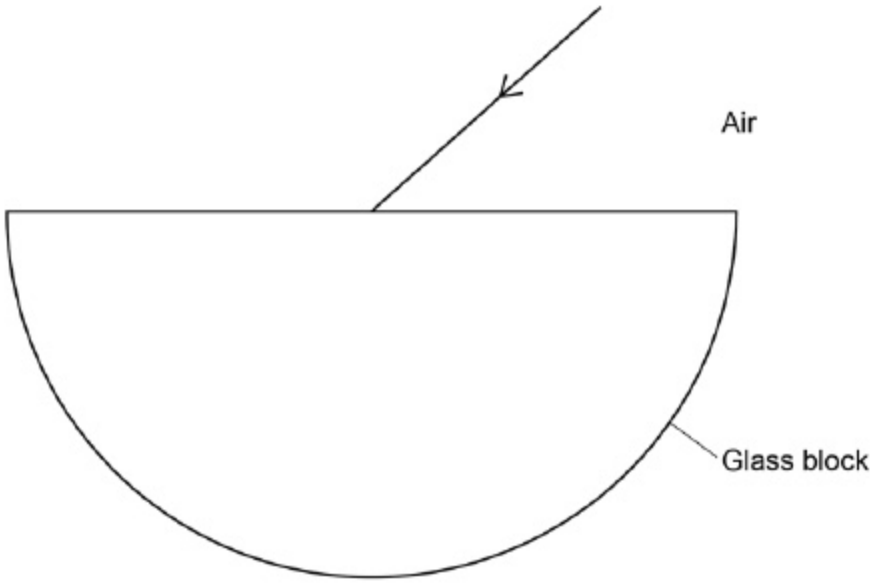


(a) Complete **Figure 1** by drawing wave fronts after they have left the glass block.

(1)

(b) **Figure 2** shows a ray of light incident on a semi-circular glass block.

Figure 2



Complete the ray diagram in **Figure 2**.

- Draw the ray of light passing through and leaving the glass block.
- Label the angle of refraction.

(4)

(c) Explain why the light is refracted.

_____

_____

_____

_____

(2)

(d) A student investigated how different coloured light was refracted by glass.

The student aimed rays of different coloured light at a glass block.

She measured the angle of refraction for each colour.

Give **two** variables that the student should control.

1. _____

2. _____

(2)

The table shows the student's results.

Colour of light	**Angle of refraction in degrees**
Red	27.94
Orange	27.90
Yellow	27.82
Green	27.78
Blue	27.70

(e) Explain why these results could **not** have been obtained with a normal protractor.

_____

_____

_____

_____

(2)

(f) What conclusion can be made about the relationship between the wavelength of light and the angle of refraction?

_____

_____

(1)

(g) Glass does **not** transmit ultraviolet radiation.

Suggest what happens to ultraviolet radiation when it is incident on glass.

_____

_____

(1)

(Total 13 marks)

1.

(a) skin

1

(b) dose is much lower than even slight increased risk of cancer dose

allow much less than 100 mSv

1

(c) to reduce the dose of radiation (they are exposed to)

allow reduce the risk

1

(d) sterilising medical equipment

1

(e) they are ionising

1

(f) **microwaves**

data is transmitted / detected

allow signal / information for data

1

by (mobile) phone / WiFi / satellite

allow bluetooth

1

visible light

example of device / system

1

description of how light is used

e.g. the internet transfers information via visible light in fibre optics

e.g. image produced / seen on a TV / mobile phone

allow any sensible suggestion for visible light, but the two marks must be linked

1

[9]

2.

(a) A

1

(b) B

1

(c) D

1

(d) v = 1650 × 0.200

1

v = 330 (m/s)

1

(e) 0.004 s

1

(f)

$0.004 = \frac{1}{\text{frequency}}$

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

1

$\text{frequency} = \frac{1}{0.004}$

1

F = 250 (Hz)

1

[9]

3. (a) X-rays are absorbed by bone

1

but can pass through flesh

ignore skin

1

(b) taking lots of X-rays would give a large dose

1

which would increase the radiographer's risk

1

the screen absorbs some of the X-rays

allow screen reduces the risk/dose received by the radiographer

1

(c) electrical current / oscillations in the transmitter producing radio waves

1

radio waves are absorbed by the receiver inducing electrical current / oscillations in the receiver

1

at the same frequency

*if no other mark is awarded, allow **1** mark for radio waves transfer information/energy through the air*

1

[8]

4. (a) velocity

1

frequency

1

wavelength

1

(b) so people are not exposed to (as much) gamma radiation

allow less gamma radiation reaches the Earth's surface

1

because gamma radiation can damage human tissue

allow increases the risk of cancer or (cell) mutation

allow gamma rays are ionising

ignore any reference to temperature / heating of the atmosphere

1

(c) (microwaves) are used in (satellite) communications

ignore any reference to temperature / heating of the atmosphere

1

(d) can cause skin cancer / premature ageing

allow sunburn

allow eye / skin damage

cancer on its own is insufficient

1

(e) risk from UV radiation is highest in July / summer

allow any sensible comparison of named months / seasons

1

two correct readings from the bar chart which support their comparison

*if no other mark scored, two correct readings from the graph scores **1** mark*

1

[9]

5. (a) **Level 3:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5–6

Level 2: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.

3–4

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

1–2

No relevant content

0

Indicative content

- if two quantities have been determined, v = f λ can be used to find the third.

Frequency

- use a stopclock
- count the number of waves passing a point in a fixed time period
- divide the time by the number of waves to determine the time for one wave, T
- f = 1/T
- read the frequency off the oscillator

Wavelength

- use a camera to freeze the image
- use a metre rule to measure the distance between two wavefronts
- count the number of waves between the wavefronts
- divide distance by the number of waves to determine λ

Velocity

- determine a mean value of frequency
- determine a mean value of wavelength
- measure the time it takes one wavefront to travel the length of the screen
- measure the length of the screen
- speed = distance / time

To access Level 3 there must be a description of how frequency, wavelength and velocity can be determined

(b) (the duck) moves perpendicular to the direction of wave travel

duck moves up and down is insufficient

1

(c) mean maximum height = 511

and

mean minimum height = 500

1

511 − 500 = 11

allow a calculated difference from incorrect means

1

11 / 2 = 5.5 (mm)

allow their difference divided by 2

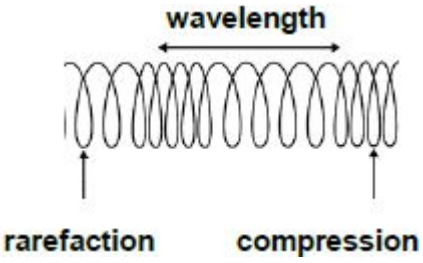
any correct method of determining the mean amplitude can score 3 marks

1

*an answer of 5.5 (mm) gains **3** marks*

[10]

6. (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]

7. (a) R

1

(b) they have the same wave speed as visible light

1

they have a lower frequency than gamma rays

1

(c) any **two** from:

- ageing of the skin

  allow sunburn
  burn unqualified is insufficient

- skin cancer

  cancer is insufficient
  allow mutation of genes in skin cells

- eye damage

  allow blindness

2

(d) any **two** from:

- gamma (rays)
- X-rays
- ultraviolet

2

[7]

8. (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

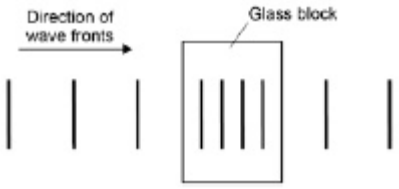
(c)

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]

9. (a) at least two wave fronts drawn to the right of the glass block, parallel to the other wave fronts and with equal spacing compared with the wave fronts to the left of the glass block



1

(b) ray of light refracts towards the normal where it is incident on the glass block

1

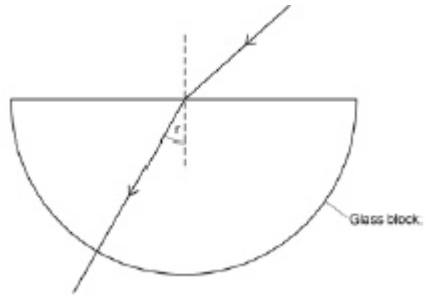
ray of light does not refract when it exits the glass block

1

a normal is drawn on where the ray is incident on the glass block

1

the angle of refraction is labelled



lines should be drawn with a ruler

1

(c) light travels more slowly (in the glass block than in the air)

1

so it changes direction

allow so it bends towards the normal

1

(d) the angle of incidence

1

the type of glass used

allow the glass block

1

(e) the <u>resolution</u> of a normal protractor is too big

1

so it could not measure the difference between results

allow so it could not read angles to 2 decimal places

1

(f) a longer wavelength gives a greater angle of refraction

1

(g) absorbed / reflected

1

[13]