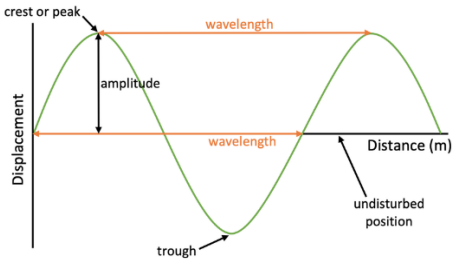
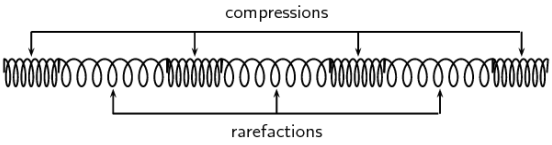
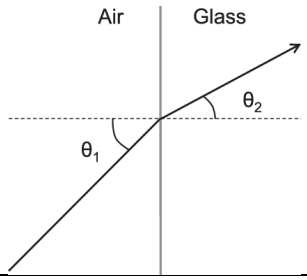
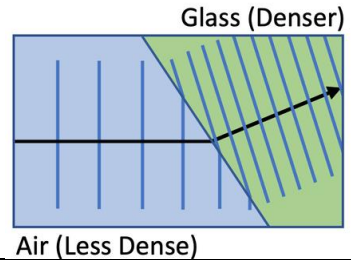
# P6 Waves Part 1

## Answer Key

| | | |
|---|---|---|
| 1 | **What is the amplitude of a wave?** | **The maximum displacement of a point on a wave from its undisturbed position (measured in metres)** |
| 2 | **What is the wavelength of a wave?** | **The distance from a point on one wave to the equivalent point on the adjacent wave e.g. distance from peak to peak (measured in metres)** |
| 3 | **What is the time period of a wave?** | **The time for one complete wave cycle to pass a point (measured in seconds)** |
| 4 | **What is the frequency of a wave?** | **The number of wave cycles to pass a point each second (measured in Hertz, Hz)** |
| 5 | **What is the definition of a transverse wave?** | **Vibrations oscillate at right angles (perpendicular) to the direction of wave travel.** |
| 6 | **What is the definition of a longitudinal wave?** | **The particles oscillate parallel to the direction of wave travel.** |
| 7 | Give an example of **transverse** waves | Surface water wave, Secondary Earthquake waves, Electromagnetic waves |
| 8 | Give an example of **longitudinal** waves | Sound waves, Primary Earthquakes |
| 9 | Define a **wave** | Waves **transfer energy** without the transfer of matter |
| 10 | What is the **unit** of **frequency**? | Hertz (Hz) |
| 11 | What is the **unit** for **wavelength**? | m (metres) |
| 12 | **Describe the features of a transverse wave.** |  <br>**-Peak/crest at maximum positive displacement**<br>**-Trough at minimum negative displacement** |
| 13 | Describe the features of a **longitudinal** wave |  <br>Area of **compression** (high pressure)<br>Areas of **rarefaction** (low pressure) |

Answer Key

| | | |
|---|---|---|
| 1 | **Name the 7 groups in the electromagnetic spectrum in order.** | **Radio, microwaves, infra-red, visible, ultraviolet, X-rays, gamma rays** |
| 2 | Which part of the **electromagnetic spectrum** can our eyes detect? | Visible (light) |
| 3 | Which part of the **electromagnetic** spectrum has the **longest wavelength**/lowest frequency? | Radio |
| 4 | Which part of the **electromagnetic** spectrum has the **shortest wavelength**/highest frequency? | Gamma |
| 5 | (HT) What 4 things can happen when a wave hits a **boundary**? | **Absorption** (energy taken in), **transmission** (wave passes through), **reflection** (wave bounces off), **refraction** (wave changes direction in the material) |
| 6 | **What is refraction?** | **When a wave changes direction when it passes from one material to another**   |
| 7 | (HT) What causes **refraction**? | Changes to a wave's velocity in different materials. |
| 8 | (HT) What happens to **wave fronts** when a wave travels from a less dense (e.g.. air) to a more dense medium? (e.g. glass) | They get closer together   |
| 9 | What is the name given to the line drawn **perpendicular** (90°) to the boundary where a wave hits it? | The normal line |
| 10 | (HT) How are **radio waves** produced by a circuit in a **transmitter?** | Alternating p.d. causes electrons in the circuit to **oscillate**, **emitting radio** waves with the **same frequency** as the **alternating current** |
| 11 | (HT) What happens when radio waves are absorbed by a wire in a circuit? | **Electrons** in the circuit **absorb** the waves and **oscillate**, producing an **alternating current** with the **same frequency** as the radio wave |
| 12 | Describe how gamma rays are produced | **Emitted** by the **nucleus** of an unstable atom |

Answer Key

| | | |
|---|---|---|
| 1 | **State a use of radio waves** | **Television and radio communication** |
| 2 | **State 2 uses of microwaves** | **Satellite communication (inc. mobile phones), cooking** |
| 3 | **State three uses of infra-red waves** | **Night-vision camera, remote controls, cooking/heating food** |
| 4 | **State a use of visible light** | **Fibre-optics** |
| 5 | **State 3 uses of ultra-violet light** | **Fluorescent light bulbs, tanning beds, counterfeit note detection** |
| 6 | **State 2 uses of x-rays?** | **X-ray photography for medical diagnosis, security scans for airport luggage** |
| 7 | **State 2 uses of gamma waves?** | **Radiotherapy, Killing pathogens, sterilising medical equipment** |
| 8 | Give 2 examples of electromagnetic waves **transferring energy** from emitter to absorber | Energy is transferred from the Sun (emitter) via visible light to the Earth (absorber); energy is transferred from an X-ray machine (emitter) via X-rays to bones and photographic plate4 (absorbers) |
| 9 | Which type of **electromagnetic wave** is the **most ionising?** | Gamma<br>(Highest frequency = Highest energy) |
| 10 | Describe how **X-rays** are used to produce **medical** images | X-rays are transmitted through skin and muscle. X-rays cannot penetrate bone and so the energy is absorbed – this creates a "shadow" where the bones are. |
| 11 | What are the **hazards** from **UV** waves? | Ageing of the skin, **ionisation** in skin cells can increase the risk of **skin cancer** |
| 12 | What are the **hazards** from **X-rays** and **gamma** rays? | **Ionisation** in cells can increase the risk of **cancer.** This depends on the **frequency** on the wave and the **dosage** |
| 13 | **What 3 things do all electromagnetic waves have in common?** | **They are all transverse waves, they all travel at $3x10^8$m/s in a vacuum, they all transfer energy from emitter to absorber** |

## Foundation

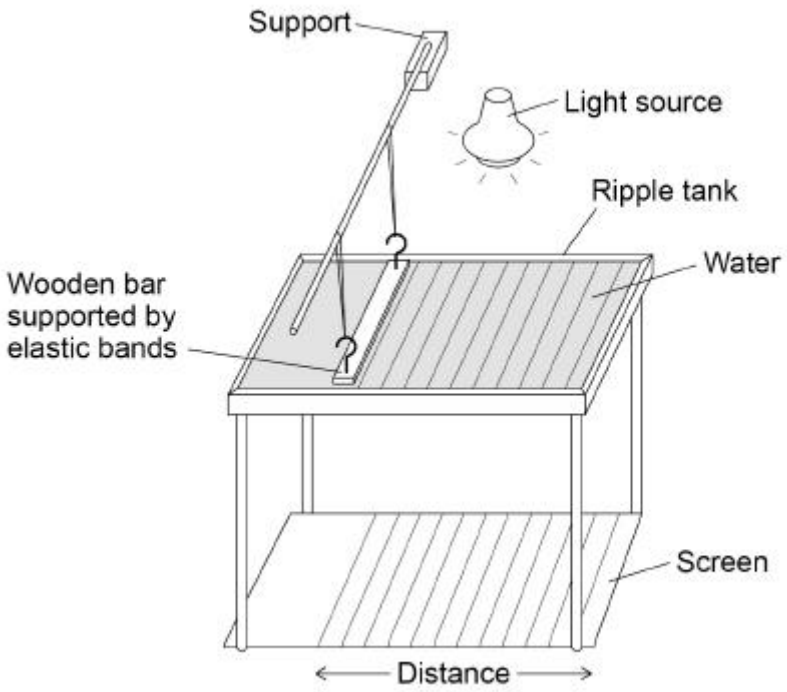
## Q1.

**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**



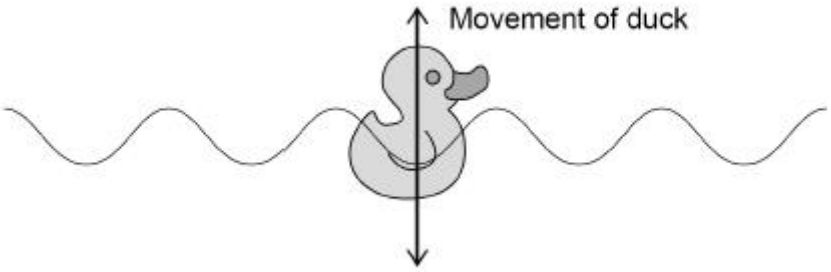

(a) Describe how equipment in **Figure 1** can be used to measure the wavelength, frequency and speed of a water wave.

**(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.

_____

_____

_____

_____

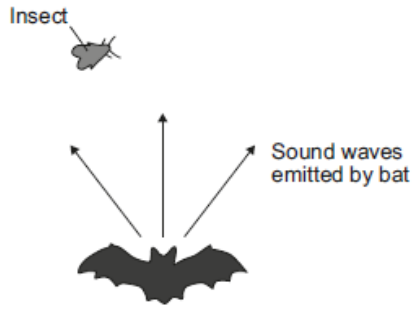
Mean amplitude = _____ mm

**(3)**

**(Total 10 marks)**

## Q2.

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)**

## Q3.

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**

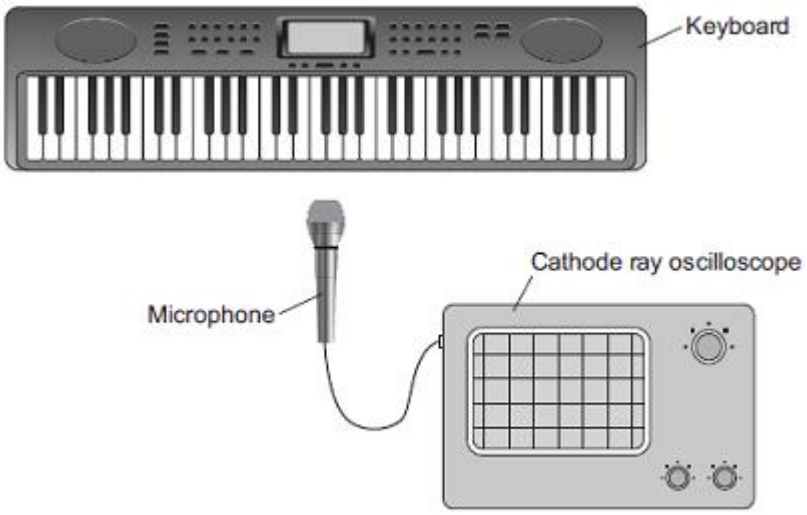
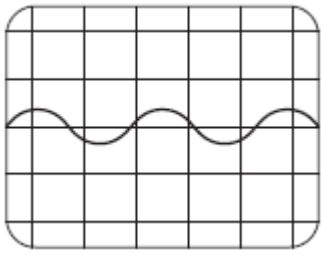



**Figure 2** shows the trace produced by the sound wave on the CRO.

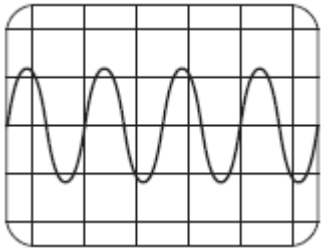
**Figure 2**



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)**

## Q4.

Infrared and microwaves are two types of electromagnetic radiation.

(a) State **one** example of the use of each type of radiation for communication.

Infrared: _____

Microwaves: _____

**(2)**

(b) Some of the properties of infrared and microwaves are the same.

State **two** of these properties.

1. _____

_____

2. _____

_____

**(2)**

**(Total 4 marks)**

## HIGHER

**Q5.**

A student made water waves in a ripple tank.

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

_____

_____

_____

_____

_____

_____

**(4)**

The student recorded values for the frequency and the wavelength of waves in the ripple tank.

**Table 1** and **Table 2** show the results.

**Table 1**

| **Reading** | **1** | **2** | **3** |
|---|---|---|---|
| **Frequency in hertz** | 9.8 | 9.4 | 9.3 |

**Table 2**

| **Reading** | **1** | **2** | **3** |
|---|---|---|---|
| **Wavelength in cm** | 1.7 | 2.2 | 2.1 |

(b) Determine the mean wave speed.

_____

_____

_____

_____

_____

Mean wave speed = _____ m/s

**(4)**

(c) What is the advantage of taking repeat readings and then calculating a mean?

_____

_____

**(1)**

(d) The speed of the wave is affected by the depth of the water in the ripple tank.

The deeper the water the faster the wave.

Explain how the depth of the water affects the wavelength of the wave if the frequency is constant.

_____

_____

_____

_____

**(2)**

**(Total 11 marks)**

## Q6.

A car aerial receives radio waves from a radio transmitter.

Radio waves are transverse waves.

Sound waves are longitudinal waves.

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

_____

_____

_____

_____

**(2)**

(b) The radio waves have a frequency of $4.8 \times 10^9$ Hz

Wave speed of electromagnetic waves = $3.0 \times 10^8$ m/s

Calculate the wavelength of the radio waves.

Give your answer to 2 significant figures.

_____

_____

_____

Wavelength = _____ m

**(3)**

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

**(3)**

**(Total 8 marks)**

## Q7.

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.

_____

_____

_____

_____

_____

_____

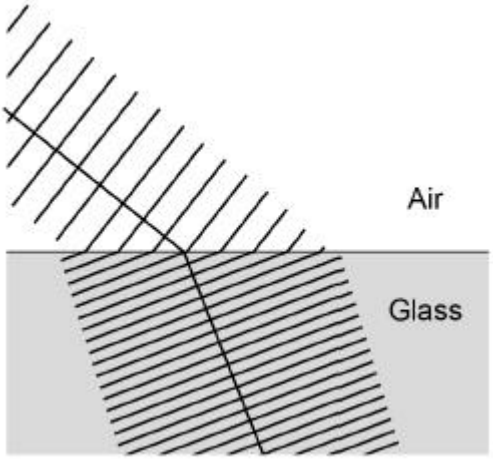
**(3)**

**(Total 8 marks)**

## Q8.

Wave front diagrams are used to explain why light refracts when it passes from air into glass.

**Figure 1**




(a) Explain why the light refracts as it passes from air into glass.

_____

_____

_____

_____

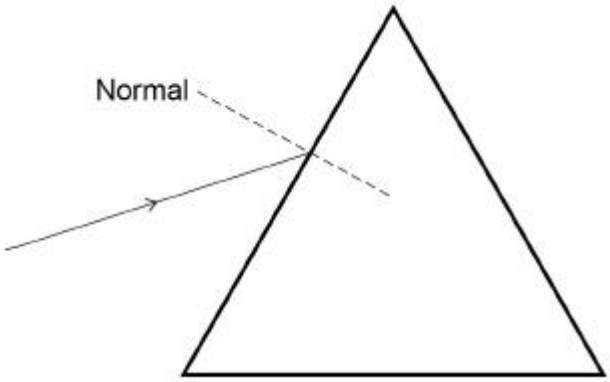
_____

_____

**(3)**

(b) **Figure 2** shows a ray of red light entering a glass prism.

**Figure 2**




Complete the ray diagram to show the ray emerging from the glass prism.

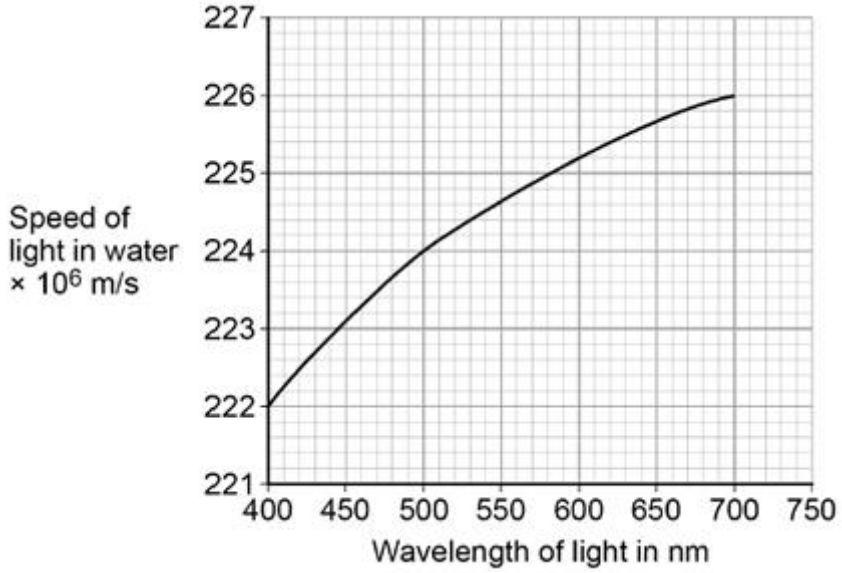
**(3)**

(c) White light is made up of a continuous spectrum of different wavelengths that all travel at $3 \times 10^8$ m/s in air.

Rainbows are produced because different wavelengths of light travel at different speeds in water.

**Figure 3** shows the speed of different wavelengths of light in water.

**Figure 3**




Explain why violet light is refracted the most as it enters water.

_____

_____

_____

_____

_____

_____

**(3)**

**(Total 9 marks)**

## Q1.

(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]**

## Q2.

(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]**

## Q3.

(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* $0.7\dot{7}\dot{2}$

*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]**

## Q4.

(a) **use of infrared:**
remote controls
fibre optic (communications)

**1**

**use of microwaves:**
mobile/cell phones

*accept mobiles*

*accept phone signals*

satellite (communications/TV)
wi-fi
Bluetooth

**1**

(b) any **two** from

- same speed
  **or**
  travel at the speed of light (in a vacuum)
- transverse

  *accept a full description of a transverse wave*
- transfer energy (from one place to another)
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed / transmitted
- can travel through a vacuum/space
- can be polarised

  *travels in straight lines is insufficient*

**2**

**[4]**

## Q5.

(a) **Level 2:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

**3–4**

**Level 1:** The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.

**1–2**

**No relevant content**

**0**

**Indicative content**

**Wavelength**

- place a metre rule at the side of the screen perpendicular to the wave fronts
- use the metre rule to measure the length of the screen
- take a photograph of the shadow on the screen
- count the number of complete waves on the screen
- determine the wavelength by dividing the length of the by the number of complete waves

**or**

- place a metre rule at the side of the screen perpendicular to the wave fronts
- take a photograph of the shadow on the screen
- use the metre rule to measure the distance between two wave front

**Frequency**

- count the number of waves that pass a given point
- time how long it takes for the waves to pass that point using a stop clock
- frequency is number of waves divided by time taken

**or**

- put a stop clock on the screen
- use a digital video camera to record the waves passing a point
- replay in slow motion and count the number of waves passing a point in 1 second

There must be a description of both frequency and wavelength measurement to access level 2

(b) mean f = 9.5 Hz

**1**

mean $\lambda = 0.020$ m

**1**

$v = 9.5 \times 0.020$

*allow a correct substitution of an incorrect value of mean frequency and/or wavelength*

**1**

v = 0.19 (m/s)

*allow a correct calculation using an incorrect value of mean frequency and/or wavelength*

**1**

**or**

v = 9.8 × 0.017
**and**
v = 9.4 × 0.022
**and**

v = 9.3 × 0.021 (2)

$$v = \frac{(1.67 + 2.07 + 1.95)}{3} \text{ (1)}$$

v = 0.19 (m/s) (1)

*allow a maximum of **2** marks if a single pair of values is used*

(c) reduces the effect of random errors

*allow anomalous readings can be discarded before calculating a mean*

**1**

(d) deeper water means longer wavelength

**1**

because

v increases and f is constant

*allow for a fixed frequency period is constant*

**1**

**[11]**

## Q6.

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

*allow direction of travel for energy transfer*

**1**

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

*allow direction of travel for energy transfer*

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

*if no other mark scored allow **1** mark for transverse waves have peaks and troughs **and** longitudinal waves have compressions and rarefactions*

**1**

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

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

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

**1**

λ = 0.0625 (m)

**1**

$\lambda = 0.063$ (m)
**or**
$\lambda = 6.3 \times 10^{-2}$ (m)

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

**1**

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

(c) any **three** from:

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

**3**

**[8]**

## Q7.

(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]**

## Q8.

(a) speed / velocity in the glass is lower

*speed / velocity changes is insufficient*

*allow the refractive index of glass is higher than that of air*

*allow glass has a higher optical density than air*

1

so the edge of the wave(front) entering the glass slows down

1

but the part of the wave(front) in the air continues at the higher speed / velocity (causing a change in direction)

1

(b) correct ray in the prism bent towards the normal

1

second normal at 90° at the point the ray emerges

1

correct emergent ray bent away from the normal

*this mark can be awarded without a normal line drawn*

1

(c) violet has the shortest wavelength (400 nm)

1

violet light travels the slowest in water

1

violet light undergoes the greatest change in speed (and direction)

1

**[9]**