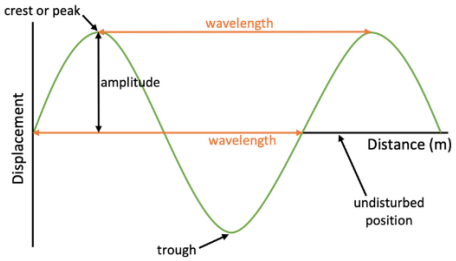
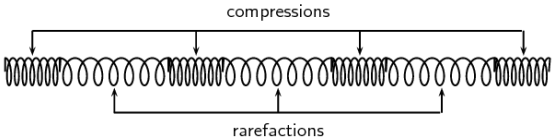
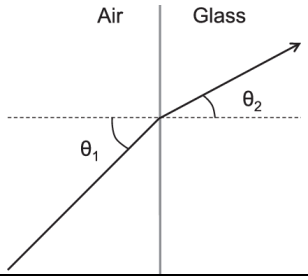
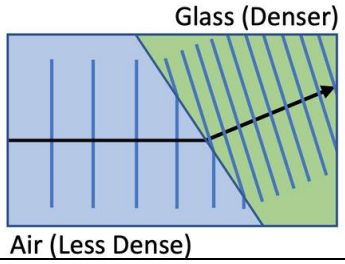
P6 Waves Part 1

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.**	 **-Peak/crest at maximum positive displacement** **-Trough at minimum negative displacement**
13	**Describe the features of a longitudinal wave**	 **Area of compression (high pressure)** **Areas of rarefaction (low pressure)**

Answer Key

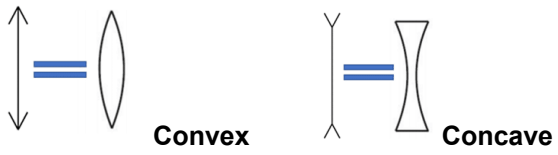
1	**Name the 7 groups in the electromagnetic spectrum in order.**	**Radio, microwaves, infra-red, visible, ultraviolet, X-rays, gamma rays**
2	Which part of the **electromagnetic spectrum** can our eyes detect?	Visible (light)
3	Which part of the **electromagnetic** spectrum has the **longest wavelength**/lowest 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^o) 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

P6 Waves Part 3

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 (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**

Answer Key

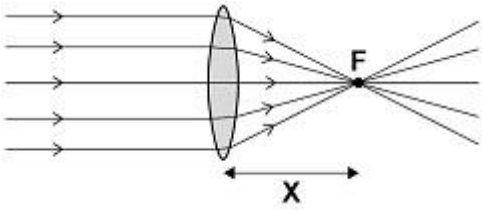
1.	What is the range of human hearing?	20Hz - 20kHz
2.	(HT) Why can humans only hear a limited range of frequencies?	Within the ear, sound waves cause the ear drum and other parts to vibrate which causes the sensation of sound. The conversion of sound to vibrations in solids works over a limited frequency range, restricting human hearing
3.	(HT) How does echo-sounding, including ultrasonography and seismic wave detection, allow us to investigate unobservable structures?	Vibrational waves are reflected and absorbed differently by different materials and so can give us information about structures we can't see.
4.	How are frequency, speed and wavelength affected when sound travels from one medium to another.	When a sound wave travels from one medium to another, its frequency remains constant but its speed may change, causing its wavelengths to change.
5.	**Draw the ray diagram representation of a convex and concave lens**	 **Convex** **Concave**
6.	State 2 similarities between convex and concave lenses	Both have a focal length; both work by refracting light
7.	What is the difference between convex and concave lenses?	A convex lens makes parallel rays converge to a focus; a concave lens makes parallel rays diverge (spread out)
8.	**How is colour related to differential absorption?**	**A coloured object, e.g. red, absorbs all wavelengths of light except the wavelength of that colour (e.g. red)**
9.	**How is colour related to differential transmission?**	**A coloured filter, e.g. green, transmits only light of that wavelength (e.g. green) and absorbs all other wavelengths**
10.	What is the difference between specular and diffuse reflection?	Specular reflection occurs on a smooth surface like a mirror parallel rays are reflected in a single direction. Diffuse reflection occurs on a rough surface: parallel rays are scattered in different directions
11.	**How does the temperature of an object affect the intensity of the radiation it gives out?**	**The higher the temperature, The higher the intensity**
12.	How does the temperature of an object affect the frequency of the radiation it gives out?	The higher the temperature, the higher the intensity of all frequencies, and the higher the peak
13.	(HT) How does absorption and emission of radiation affect the temperature of an object?	If absorption is higher than emission, the object's temperature increases.
14	**(HT) What factors determine the temperature of the Earth?**	**The rate that radiation from the Sun is absorbed, the amount of radiation that is reflected, and the amount of radiation that is radiated out into space.**

Foundation

Q1.

(a) **Figure 1** shows parallel rays of light being refracted by a convex lens.

Figure 1



What is distance '**X**' called?

_____

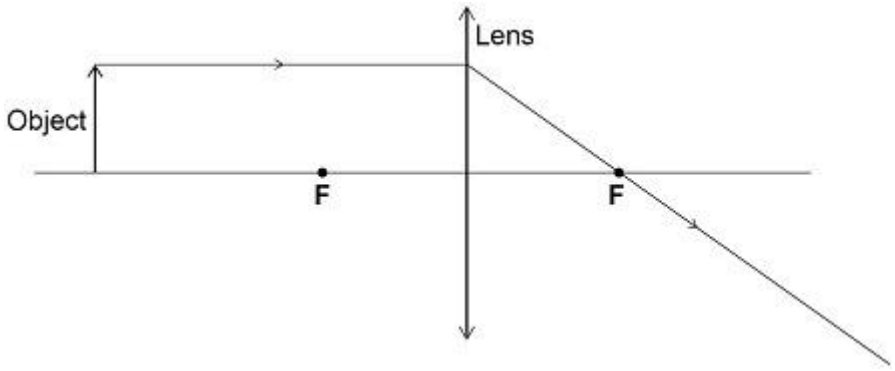
(1)

(b) Lenses can be used to form the image of an object.

Complete the ray diagram in **Figure 2** to show how a **convex** lens forms the image of the object.

Use an arrow to represent the image.

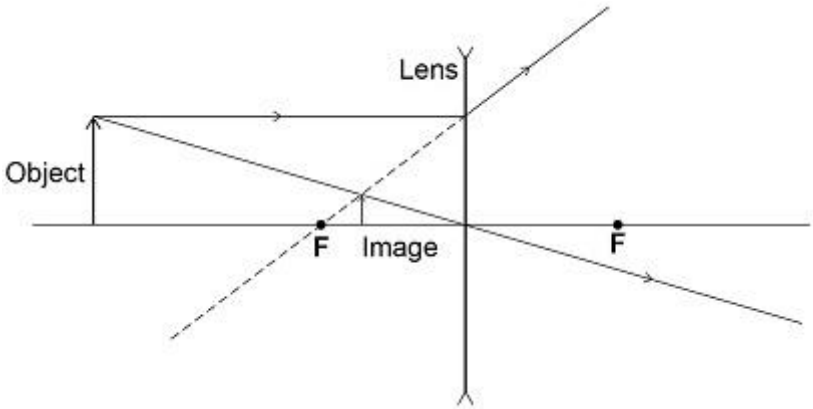
Figure 2



(2)

Figure 3 shows how a concave lens forms the image of an object.

Figure 3



(c) Give **one** similarity and **one** difference between the image formed by the convex lens and the image formed by the concave lens.

Similarity _____

_____

Difference _____

_____

(2)

(d) A person uses a lens to read the letters on the back of a coin.

The image height of the letters on the coin is 9.0 mm

The magnification produced by the lens is 6.0

Calculate the height of the letters on the coin.

Use the Physics Equations sheet.

_____

_____

_____

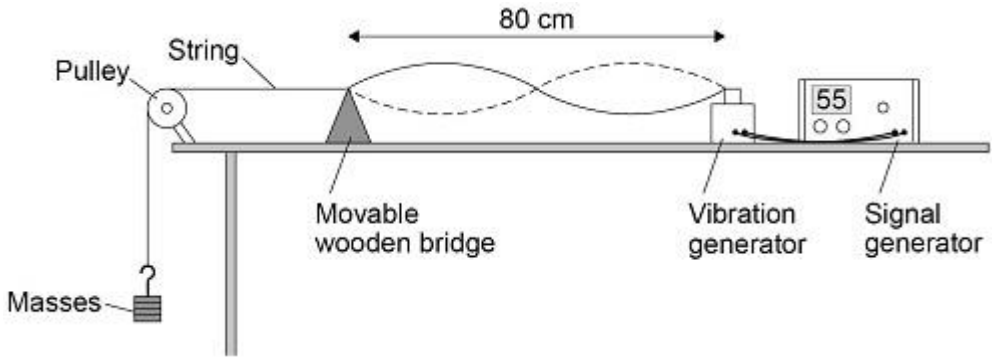
_____

Height = _____ mm

(3)

(Total 8 marks)

Q2. The following figure shows the apparatus used to investigate the waves in a stretched string.



The frequency of the signal generator is adjusted so that the wave shown in the figure is seen.

At this frequency the string vibrates between the two positions shown in the figure.

(a) The wavelength of the wave shown in the figure above was measured as 80 cm

What piece of apparatus would have been suitable for measuring this wavelength?

_____

(1)

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

_____

(1)

(c) The string in the figure above vibrates at 55 Hz

Calculate the wave speed of the wave shown in the figure.

Use data given in the figure.

_____

_____

_____

Wave speed = _____ m/s

(3)

(d) The frequency of the signal generator is increased.

This makes the wavelength of the wave change.

The wave speed stays the same.

Describe how the apparatus could be adjusted to show one complete wave without reducing the frequency.

_____

_____

(2)

(e) A student wants to investigate how the speed of a wave on a stretched string depends on the tension in the string.

The student uses the apparatus in the figure above.

Describe a method the student could use for this investigation.

(4)

(Total 11 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?

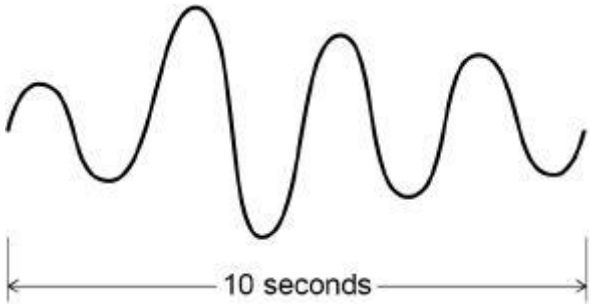
Tick **one** box.

- 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.

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)

HIGHER

Q4.

Ultraviolet is a type of electromagnetic wave.

(a) Give **one** use of ultraviolet.

_____

(1)

(b) An ultraviolet wave has a wavelength of 300 nanometres.

Which of the following is equal to 300 nanometres?

Tick (✓) **one** box.

3×10^{7} m ☐

3×10^{-7} m ☐

3×10^{9} m ☐

3×10^{-9} m ☐

(1)

(c) The speed of ultraviolet waves is 3×10^{8} m/s.

Calculate the frequency of the ultraviolet wave.

Use your answer to part (b)

_____

_____

_____

_____

_____

Frequency = _____ Hz

(3)

(d) The table below gives the wavelength of an ultraviolet wave and three other electromagnetic waves.

Ultraviolet	Wave E	Wave F	Wave G

Wavelength in nanometres	300	0.1	600	100 000

Draw **one** line from each wave to the name of the wave.

Wave	Name
Wave E	Infrared
Wave F	Visible light
Wave G	X-rays

(1)

(e) Electromagnetic waves are transverse.

Some other types of wave are longitudinal.

Describe the difference between transverse and longitudinal waves.

_____

_____

_____

_____

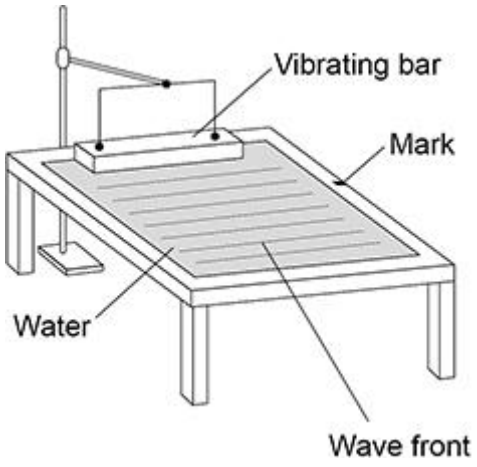
(2)

(Total 8 marks)

Q5.

A teacher demonstrated some features of waves using a ripple tank.

The figure below shows the ripple tank.



(a) The teacher measured the time taken for 10 wave fronts to pass the mark.

The teacher repeated this measurement three times and calculated the mean.

What is the advantage of repeating measurements and calculating a mean?

_____

_____

(1)

(b) The teacher's measurements for the time taken for 10 wave fronts to pass the mark were:

8.4 s 7.8 s 8.1 s

Calculate the mean frequency of the wave.

Give your answer to 2 significant figures.

_____

_____

_____

_____

_____

_____

_____

_____

_____

Mean frequency (2 significant figures) = _____ Hz

(5)

(c) In a different investigation, the teacher wanted to determine the speed of water waves in the ripple tank.

The teacher did **not** measure the wavelength of the wave.

Explain how the teacher could determine the speed of the wave.

_____

_____

_____

_____

_____

_____

(3)

(Total 9 marks)

Q6.

A door is fitted with a security lens and a lock.

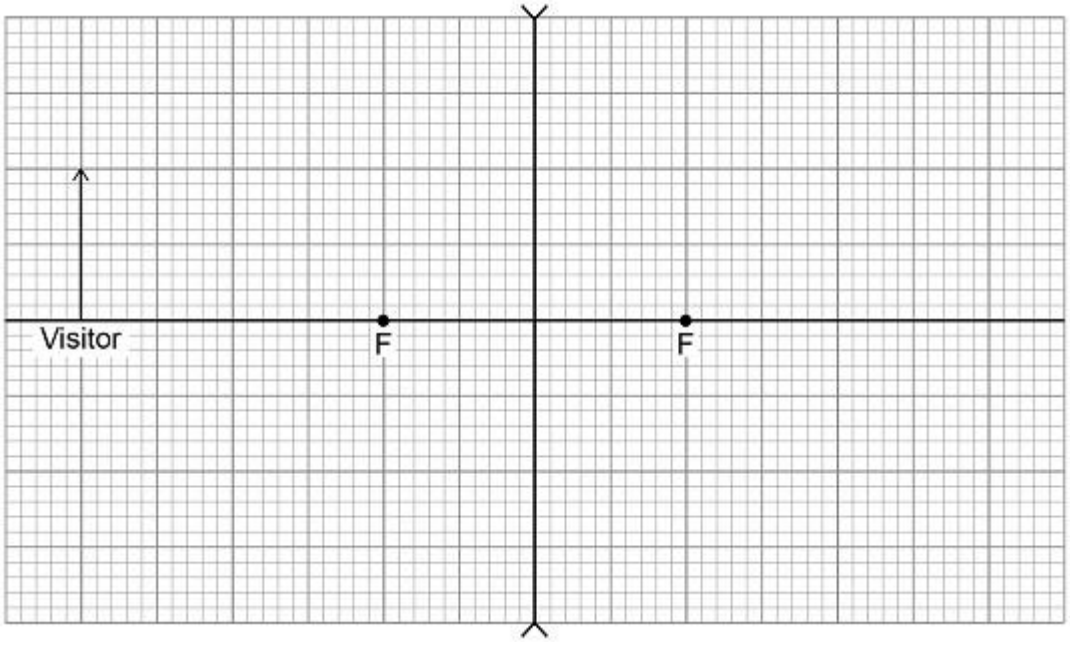
The security lens allows a person to see a visitor before opening the door.

The security lens is concave.

(a) The diagram below is an incomplete ray diagram representing a visitor standing near the security lens.

Complete the diagram to show how an image of the visitor is formed by the concave lens.

Draw an arrow to represent the image.



(3)

(b) The visitor moves further away from the security lens in the door.

How does the size of the image change?

Tick (✓) **one** box.

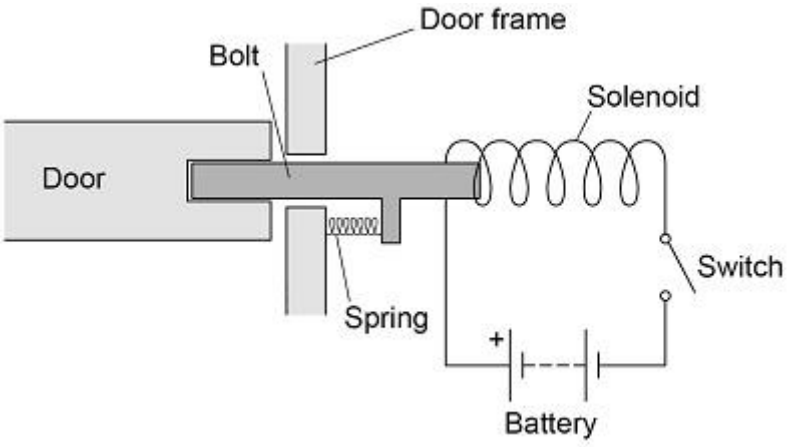
Decreases ☐

Increases ☐

Stays the same ☐

(1)

The diagram below shows a diagram of the lock. The door unlocks when the switch is closed.



(c) Which material should the bolt be made from?

Tick (✓) **one** box.

Aluminium	☐
Brass	☐
Copper	☐
Iron	☐

(1)

(d) Explain why the door unlocks when the switch is closed.

_____

_____

_____

_____

_____

_____

(3)

(e) When the door unlocks, a force of 2.88 N is applied to the spring.

The spring extends by 1.50 cm.

Calculate the spring constant of the spring.

_____

_____

_____

_____

_____

Spring constant = _____ N/m

(4)

(f) Give **two** ways the resultant force on the bolt could be increased.

1 _____

_____

2 _____

_____

(2)

(Total 14 marks)

Q1.

(a) focal length

this answer only

1

(b) one correct line drawn from the top of the object, passing through the lens and crossing or meeting given line

ignore any arrow drawn on the line

if two lines are drawn, both must be correct

1

inverted image drawn at the correct position and length

arrowhead required

1

(c) similarity

(both are) diminished

1

difference

concave is <u>virtual</u> and convex is <u>real</u>

or

concave is upright and convex is inverted

allow smaller for diminished

a comparison must be made

ignore reference to positions of images

1

(d)

*an answer of 1.5 (mm) scores **3** marks*

$$6.0 = \frac{9.0}{\text{object height}}$$

1

$$\text{object height} = \frac{9.0}{6.0}$$

1

object height = 1.5 (mm)

*provided working can be seen, an attempt to convert 9.0 mm to cm or m with all other steps correct scores **2** marks*

1

[8]

Q2.

(a) metre rule

allow metre ruler

allow tape measure

do not accept ruler

do not accept metre stick

1

(b) (wave) speed = frequency × wavelength

allow $v = f\lambda$

1

(c)

*an answer of 44 (m/s) scores **3** marks*

80 cm = 0.8 m

1

v = 55 × 0.8

this mark may be awarded if wavelength is incorrectly or not converted

1

v = 44 (m/s)

allow correct calculation using an incorrectly or not converted wavelength

*an answer of 4400 (m/s) scores **2** marks*

1

(d) move the (wooden) bridge

1

to the right

dependent on 1st mp being scored

1

OR

change the mass/weight (on the string) scores **1** mark

add more masses/weights (to the string) scores both marks

(e) **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 lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

add or take away masses from the string (ignore any stated values)

adjust frequency using the signal generator and/or move the wooden bridge

observe a steady / stationary pattern measure the wavelength

calculate wave speed from frequency and wavelength

a Level 1 answer should include a way of changing tension a complete Level 2 answer would include either changing frequency and/or moving the bridge

[11]

Q3.

(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]

Q4.

(a) any **one** from:

- (sun) tan
- energy efficient lamps

allow

- *(invisible) security coding*
- *detecting forged bank notes*
- *kill microbes*
- *attract insects*
- *sterilise (surgical) equipment*
- *cause the body to produce vitamin D*
- *increasing the growth rate of plants*
- *water purification*

1

(b) 3×10^{-7} m

1

(c) $3.0 \times 10^8 = \text{frequency} \times 3 \times 10^{-7}$

allow ecf from part (b)

1

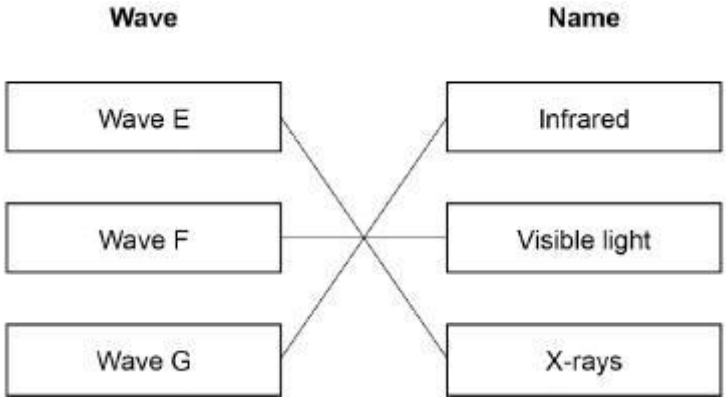
$$\text{frequency} = \frac{3.0 \times 10^8}{3 \times 10^{-7}}$$

1

frequency = 1×10^{15} (Hz)

1

(d)



all three lines correct for **1** mark

1

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

allow direction of wave travel for direction of energy transfer

1

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

1

[8]

Q5.

(a) to reduce the effect of random errors

allow gives a more accurate mean

ignore reference to anomalous results

ignore measurements are more accurate

1

(b) $\frac{(8.4+7.8+8.1)}{3} = 8.1$ (s)

1

$\frac{8.1}{10} = 0.81$ (s)

= 0.81 (s)

1

$$\text{frequency} = \frac{1}{0.81}$$

allow a correct substitution of an incorrectly calculated

value for time

1

frequency = 1.2345…

this mark may be awarded if the time is incorrectly calculated

1

frequency = 1.2 (Hz)

allow a calculated value correctly rounded to 2 sig figs

1

(c) measure the distance travelled by a wave using a metre rule

allow measure the length of the (ripple) tank using a metre rule

1

measure the time taken (for the wave to travel the measured distance) with a timer / stopwatch

1

divide the distance by the time

dependant on scoring the first two mark points

1

[9]

Q6.

(a) any **two** correct lines drawn from the top of the visitor and passing through the lens

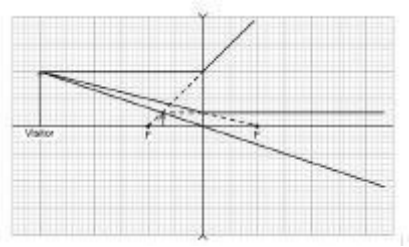
allow construction lines that are not dashed

2

image drawn at the correct position and with the correct orientation

mark only scores if first two marks scored.

*a convex lens diagram scores **0** marks*



1

(b) Decreases

1

(c) Iron

1

(d) there is a current in the solenoid / circuit

allow a charge flows through the solenoid / circuit

1

creating a magnetic field

allow the solenoid / coil is magnetised

1

attracting the bolt

1

(e) 1.50 cm = 0.015 m

1

2.88 = k × 0.015

this mark may be awarded if distance is incorrectly/not converted

1

k = 2.88 / 0.015

this mark may be awarded if distance is incorrectly/not converted

1

k = 192 (N/m)

allow a correctly calculated answer using an incorrectly/not converted distance

1

(f) Any **two** from:

- increase the current (in the solenoid / circuit)

  *allow any sensible suggestion for increasing the current such as increasing the p.d. / power of the battery **OR** using lower resistance wire in the solenoid*

- add more turns to the solenoid

  *do **not** allow increase the number of coils*

- use a spring with a lower spring constant

  allow use a weaker spring

2

[14]