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OCR GCSE PHYSICS A (J249): QUESTIONS BY TOPIC

Topic P5: Waves in matter (H)

GCSE Physics A Higher Tier (J249) · Topic P5

65 questions · 237 marks · Mark schemes included

OCR GCSE (9–1) Physics A (Gateway Science) J249, June 2018 – June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.

Click any heading or question row below to jump straight to it.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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P5.3 WAVE INTERACTION

25 questions · 95 marks

58

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QUESTIONS

65 questions · 237 marks · grouped by sub-topic, lowest tariff first



SUB-TOPIC P5.1

WAVE BEHAVIOUR

18 questions in this sub-topic · 75 marks · lowest tariff first



- 2 A student measures the time it takes for the sound from a firework to reach the observer.

She takes 3 measurements of the time taken for four different distances, **A**, **B**, **C** and **D**.

Distance	Time taken (s)		
	1st measurement	2nd measurement	3rd measurement
A	2.16	2.19	2.17
B	1.99	2.02	1.97
C	1.80	1.81	1.89
D	1.69	1.68	1.71

Which distance **A**, **B**, **C** or **D**, has the largest range of values?

Your answer

[1]



- 1 A sound wave travels in air and enters water.

What happens to the sound wave as it enters the water?

	Speed	Frequency	Wavelength
A	decreases	decreases	decreases
B	decreases	stays the same	decreases
C	increases	increases	increases
D	increases	stays the same	increases

Your answer

[1]

- 6 The table contains descriptions of wavelength and frequency.

Which row in the table is correct?

	Wavelength	Frequency
A	Distance between a peak and its neighbouring trough.	Number of waves that go past a point in a second.
B	Distance between neighbouring peaks.	Number of waves that go past a point in a second.
C	Distance between neighbouring troughs.	Time period in seconds.
D	Height of the wave.	Number of waves produced.

Your answer

[1]



9 Six wave peaks hit a wall in one minute.

Determine the frequency of the waves.

A 0.1 Hz

B 6 Hz

C 10 Hz

D 360 Hz

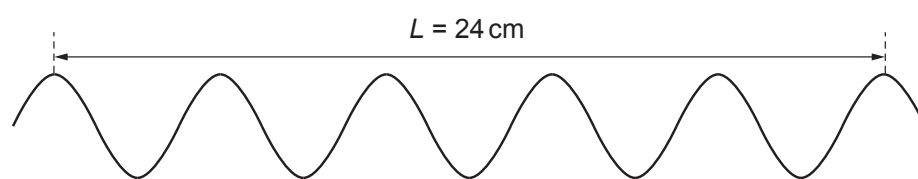
Your answer

[1]



2 A student makes a wave in a ripple tank.

The student measures distance, L .



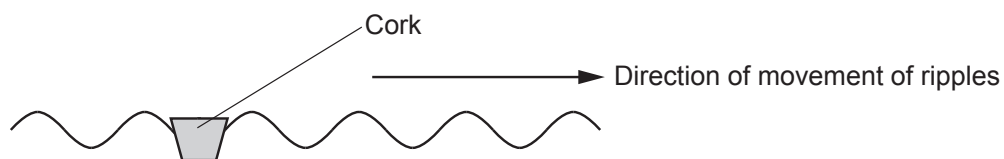
What is the wavelength of the wave?

- A 2.4 cm
- B 4.0 cm
- C 4.8 cm
- D 24 cm

Your answer

[1]

- 6 A cork floats on water. Ripples move across the surface of the water.



Which statement describes the motion of the cork?

- A It does not move.
- B It moves in the same direction as the direction of movement of the ripples.
- C It moves sideways parallel to the direction of movement of the ripples.
- D It moves up and down.

Your answer

☐

[1]

9 Which answer equals $2.45 \times 10^9 \text{ Hz}$?

A 2.45 GHz

B 2.45 kHz

C 2.45 MHz

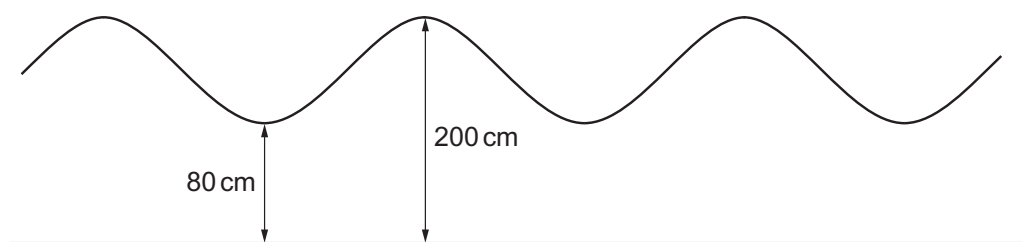
D 2.45 THz

Your answer

[1]



- 2 The diagram shows waves that are made in a pool of water.



What is the amplitude of the waves?

- A 60 cm
- B 80 cm
- C 120 cm
- D 200 cm

Your answer

[1]

1 A sound wave travels from air into water.

Which quantity stays the **same**?

- A Amplitude
- B Frequency
- C Speed
- D Wavelength

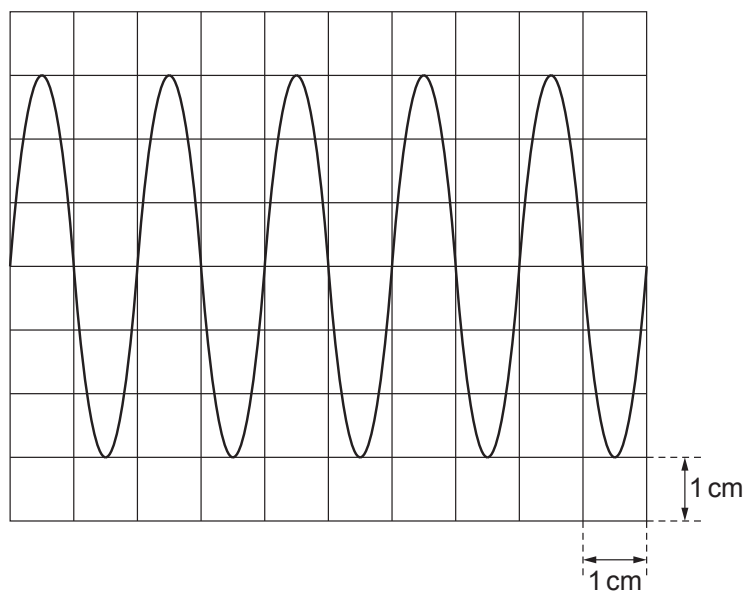
Your answer

[1]



- 4 An oscilloscope is used to display a wave.

The diagram shows the screen of the oscilloscope.



The horizontal scale is 5 ms/cm.

What is the time period of the wave?

- A 5 ms
- B 10 ms
- C 15 ms
- D 30 ms

Your answer

[1]

8 A radio wave has a frequency of 88 MHz.

What is 88 MHz converted to kHz?

- A** 0.088 kHz
- B** 88 000 kHz
- C** 88 000 000 kHz
- D** 88 000 000 000 kHz

Your answer

[1]



- 2** A sound wave travels from air to water. The speed of the sound wave is directly proportional to its wavelength.

The wavelength of the sound wave in air is 80 cm.

The speed of the sound wave increases by a factor of 4 when it enters the water.

What is the wavelength of the sound wave in the water?

- A** 20 cm
- B** 40 cm
- C** 160 cm
- D** 320 cm

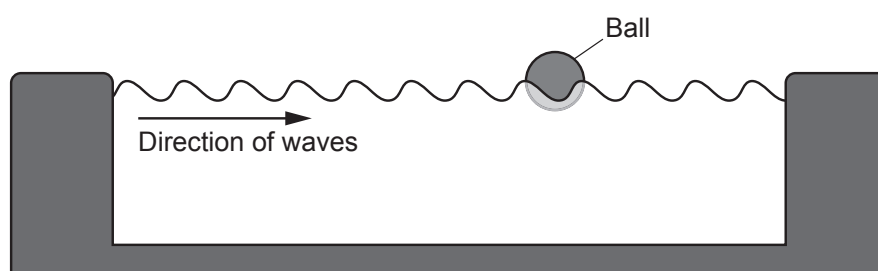
Your answer

[1]

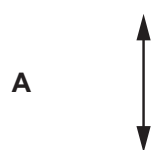


- 6 A ball is floating on the surface of some water.

Waves are created on the surface of the water as shown.



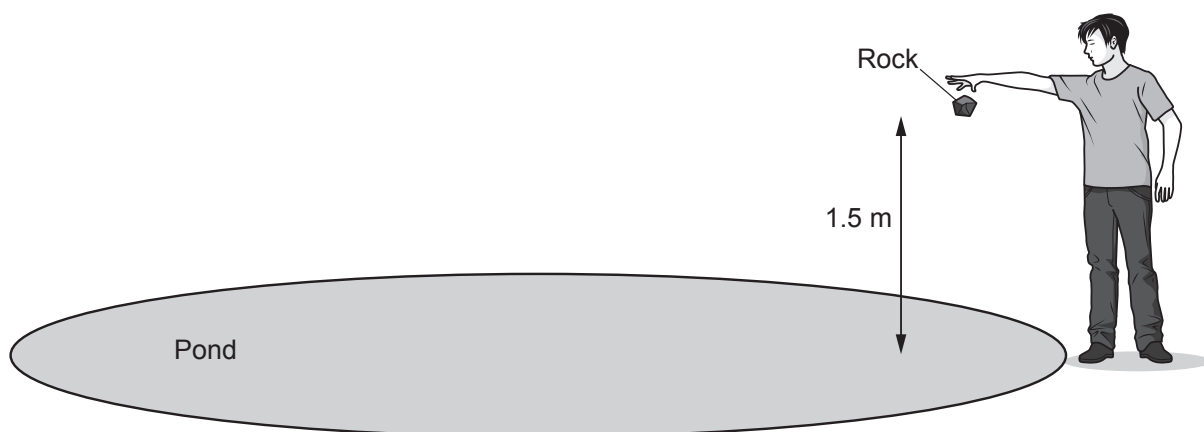
Which arrow shows the direction of movement of the ball due to the water waves?



Your answer

[1]

- 16** A student drops a rock into a pond from a height of 1.5 m.



- (a)** When the rock hits the water, it makes a sound. At the same time ripples form on the surface of the water.

The sound and the ripples are different types of waves.

Complete the table to describe the two waves.

	Type of wave	Direction of particle vibration
Sound		Particles vibrate to wave direction
Water ripples		Particles vibrate to wave direction

[4]

- (b)** The student drops an identical rock from a height of 2.0 m.

The student notices that the ripples produced by this rock have a larger amplitude than the ripples produced by the first rock.

- (i)** Explain why the rock dropped from a greater height produces ripples with a larger amplitude.

.....

 **[2]**

- (ii)** Describe how the student uses a metre ruler and a stop clock to determine the speed of the ripples.

.....

 **[3]**

24 (a) Some students try to measure the speed of sound, as shown in **Fig. 24.1**.

One student makes a loud sound by clapping her hands.

The sound of the clap reflects from the gym wall causing an echo.

Another student measures the time between hearing the clap and hearing the echo.

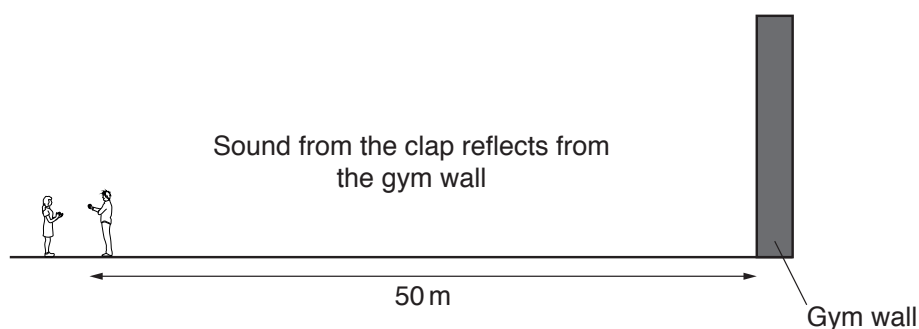


Fig. 24.1

They repeat the experiment three times and record their results in the table below.

Distance to wall (m)	Time 1 (s)	Time 2 (s)	Time 3 (s)	Mean time (s)
50	0.28	0.32	0.54	

(i) The student did not pay attention when recording **time 3**.

Calculate the **mean** time taken for the sound of the clap to return, using suitable values from the table.

Mean time taken = ... s [1]

(ii) Calculate the speed of sound for the clap.

Use your answer to (a)(i) and the equation: distance travelled = speed $\times$ time

Give your answer to **3** significant figures.

Speed of sound = ... m/s [4]

(iii) Describe **two** ways to improve and develop their method.

1

.....

2

.....

[2]



(b) Ultrasound wave pulses are used by vets to scan inner tissues inside animals.

The ultrasound pulses partially reflect from different layers of tissue. These reflected wave pulses (echoes) are collected by the detector as shown in **Fig. 24.2**.

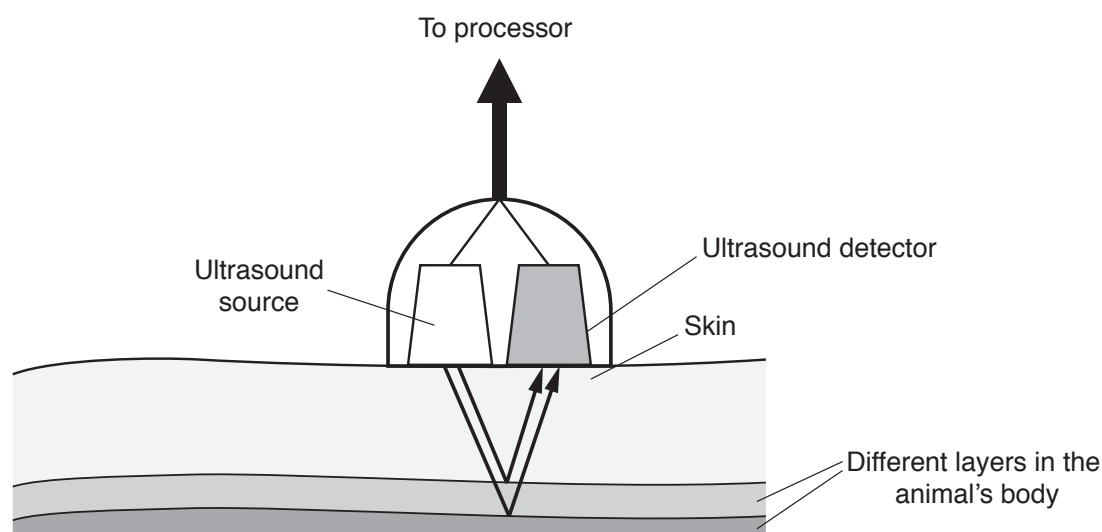


Fig. 24.2

In a scan using ultrasound pulses, three layers of tissue are detected, with each layer having a different thickness.

Describe and explain how the results from the detector can show:

- that there are three layers
- that each layer has a different thickness.

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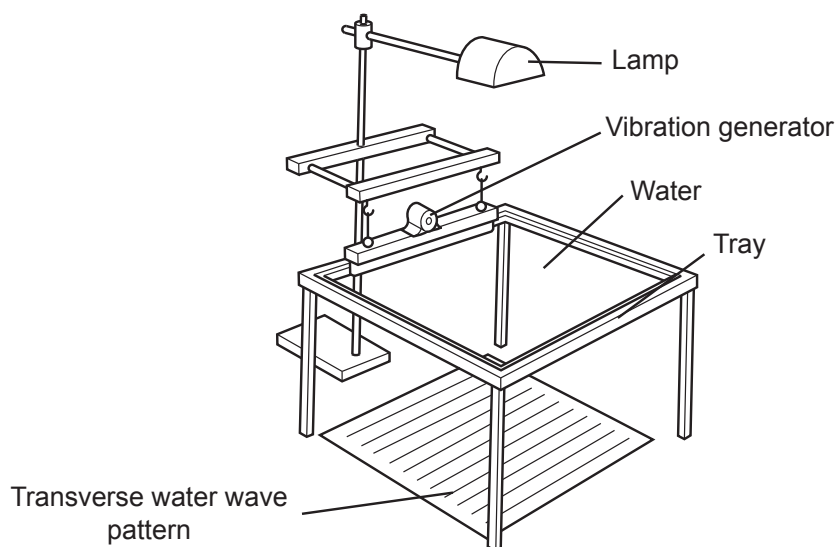
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.....

[3]

17 A teacher uses water waves in a ripple tank to demonstrate **transverse** waves.



She makes measurements of the water waves.

(a) The frequency of the water waves is 0.5 Hz.

(i) Calculate the number of water waves produced in 5 seconds.

Answer = ... [1]

(ii) The teacher **increases** the frequency of the water waves.

Describe what happens to the speed **and** the wavelength of the water waves.

.....

 [2]

(iii) A student tries to describe water waves in the sea.

'The water waves move up and down. The water particles move all the way across the surface of the sea. This means that water moves in the direction of the waves.'

Part of his explanation is **incorrect**.

Write an improved and correct description about water waves in the sea.

.....

 [2]

Turn over

(b) A student watches a ball game on the school field.

The student sees the ball being hit with a bat but he hears the sound a short time after. This is because the speed of light is much greater than the speed of sound.

Describe an experiment which measures the speed of **sound** in air.

In your answer describe the measurements, calculations and procedures needed to gather **accurate** and **reliable** results.

You may draw a diagram as part of your answer.

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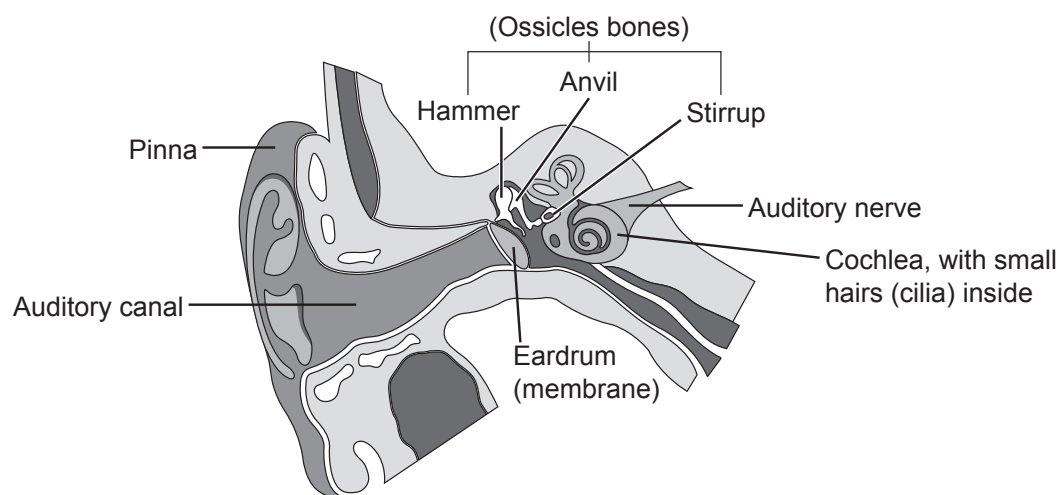
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..... [5]

(c) Look at the diagram of a human ear.



Sound wave disturbances, outside the ear, transfer energy to the small hairs (cilia) inside the cochlea.

The cochlea then sends nerve impulses along the auditory nerve to the brain.

Explain how sound wave disturbances in the air outside the ear transfer to the small hairs (cilia) inside the cochlea.

.....

.....

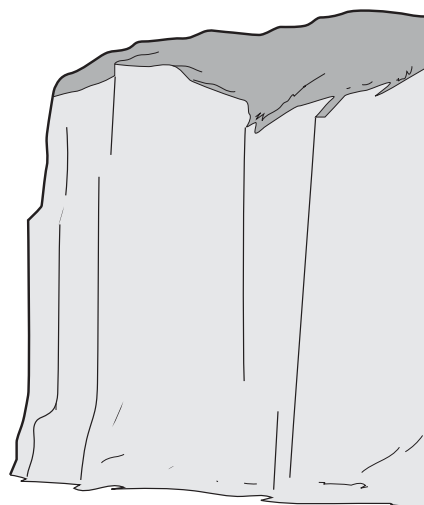
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..... [3]

18 A student is trying to calculate how far away they are from a large cliff.



(a) The student claps loudly once.

After a short time, they hear a second clap. The second clap is quieter.

(i) Explain why they hear the second clap **and** why the second clap is quieter.

.....

.....

.....

..... [2]

(ii) The student measures the time between the first clap and the second clap.

The time taken is 1.40 s.

The speed of sound in air is 330 m/s.

Calculate the distance from the student to the cliff.

Use the Data Sheet.

Distance = ... m [4]



(iii) The student measures the time between the first and second clap with a stopwatch.

Suggest **two** reasons why the distance calculated in (a)(ii) is **not** accurate.

1

2 [2]

(iv) Suggest how the experiment could be improved.

.....

..... [1]

(b) When the student claps, they hear the sound.

(i) Describe how the sound travels from the student's hand to their ear.

.....

.....

.....

..... [2]

(ii) Describe how the sound travels through the ear.

.....

.....

.....

..... [2]

(c) The student makes two different sounds, sound **A** and sound **B**.

	Frequency (Hz)
Sound A	600
Sound B	1200

Explain how the **wavelength** of sound **A** is different to the wavelength of sound **B**.

.....

.....

.....

..... [2]

- 18** A space mission in 1969 placed an object called a retroreflector on the surface of the Moon.

Fig. 18.1 shows the retroreflector.

Fig. 18.1

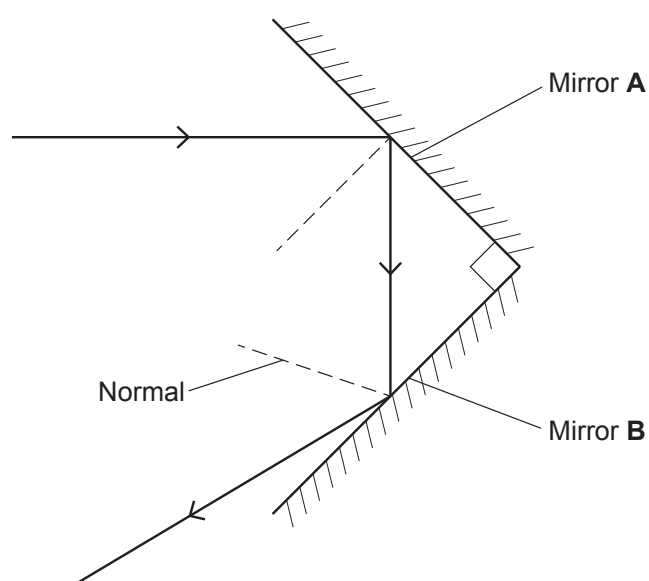


Laser light from the Earth is aimed at the retroreflector and reflects back to the Earth.

- (a)** A student draws a simple model of a retroreflector using two plane mirrors at right angles to each other.

Fig. 18.2 shows the student's model.

Fig. 18.2



Identify the **two** mistakes the student has made in **Fig. 18.2**.

Mistake 1

.....

Mistake 2

.....

[2]

- (b) The retroreflector was placed on a layer of dust on the surface of the Moon.

Since 1969, the efficiency of the retroreflector has decreased and it reflects less light back to the Earth.

Suggest why the retroreflector reflects less light.

.....
 [1]

- (c) The mass of the retroreflector is 77 kg.

An astronaut lifted the retroreflector a vertical distance of 0.50 m on the Moon.

Calculate the gravitational potential energy gained by the retroreflector.

The gravitational field strength on the Moon is 1.6 N/kg.

Use the Equation Sheet.

Gravitational potential energy = ... J [3]

- (d) A green laser emits light with a wavelength of 5.32×10^{-7} m.

The speed of the green light is 3.0×10^8 m/s.

Calculate the frequency of the laser light.

Use the Equation Sheet.

Give your answer to **2** significant figures.

Frequency = ... Hz [4]



- (e) Recently scientists have aimed infrared lasers at the Moon.

Explain why infrared radiation **cannot** be seen in the sky.

.....
..... [1]

- (f) Visible light and infrared radiation are transverse waves.

- (i) Describe the difference between visible light and infrared radiation using the words **frequency** and **wavelength**.

.....
.....
..... [2]

- (ii) Water waves are also transverse waves.

A scientist standing near the sea observes water waves moving past them.

Explain how the scientist can measure the **frequency** of the water waves.

.....
.....
.....
..... [2]

SUB-TOPIC P5.2

THE ELECTROMAGNETIC SPECTRUM

22 questions in this sub-topic · 67 marks · lowest tariff first



- 2 An electromagnetic wave transfers energy.

Which row in the table is correct?

	Electromagnetic wave	Energy transfer
A	Infra-red	From a heating element of a toaster to the bread inside
B	Radio	From a radio to a transmitter
C	Gamma rays	From a high voltage supply to heating water in food
D	X-rays	From bones in the body to an X-ray machine

Your answer

[1]



3 Which waves can damage cells and cause cancer?

- A** Radio, X-rays and infra-red.
- B** Sound, gamma-rays and microwaves.
- C** Sound, visible light and ultraviolet.
- D** Ultraviolet, gamma-rays and X-rays.

Your answer

[1]



10 All bodies emit electromagnetic radiation.

Body **R** is at a higher temperature than body **S**.

Which statement is correct?

- A** **R** emits radiation with a mean higher frequency.
- B** **R** emits radiation with a mean longer wavelength.
- C** **S** emits radiation with a higher intensity.
- D** **S** emits radiation with a mean shorter wavelength.

Your answer

☐

[1]

2 Which row in the table describes all electromagnetic waves?

	Type of wave	Speed of wave in space
A	Longitudinal	Changes with wavelength.
B	Longitudinal	Stays the same.
C	Transverse	Changes with wavelength.
D	Transverse	Stays the same.

Your answer

[1]



5 Electromagnetic waves can be ordered by frequency.

Which answer shows the waves in order of **increasing** frequency?

Low frequency —————→ **High** frequency

- | | | | |
|----------|---------------|---------------|-----------|
| A | Infra-red | Visible light | X-rays |
| B | Visible light | Infra-red | X-rays |
| C | Visible light | X-rays | Infra-red |
| D | X-rays | Visible light | Infra-red |

Your answer

[1]



10 When an electron in an atom changes energy level, it emits electromagnetic radiation.

Which row in the table is correct?

	Energy level of the electron	Type of radiation emitted
A	Decreases	Almost any electromagnetic radiation.
B	Decreases	Visible light only.
C	Increases	Almost any electromagnetic radiation.
D	Increases	Visible light only.

Your answer

[1]

12 The average temperature on the Earth has increased over the last century.

Which statement explains why?

- A** Radiation absorbed by the Earth has decreased.
- B** Radiation absorbed is less than radiation emitted.
- C** Radiation absorbed is greater than radiation emitted.
- D** Radiation emitted by the Earth has increased.

Your answer

[1]



3 Which statement about infra red radiation is correct?

- A** Infra red has the shortest wavelength in the electromagnetic spectrum.
- B** Infra red is emitted by humans.
- C** Infra red is next to radio waves in the electromagnetic spectrum.
- D** White objects absorb more infra red than black objects.

Your answer

[1]

12 An electrical circuit has an alternating current.

What type of wave can be produced by the alternating current?

- A** Gamma rays
- B** Radio
- C** Ultraviolet
- D** X-rays

Your answer

[1]

13 An atom loses an electron after absorbing some electromagnetic radiation.

Which row of the table describes what happens?

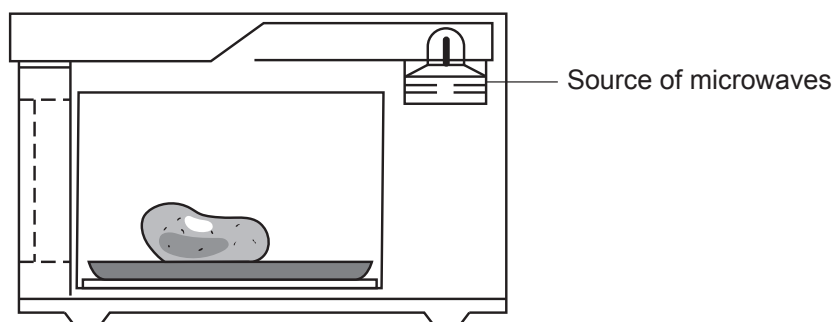
	Energy of electron	Charge on the atom
A	Decreases	Negative
B	Decreases	Positive
C	Increases	Negative
D	Increases	Positive

Your answer

[1]



- 7 The diagram shows food being heated in a microwave oven.



Read these statements about the microwave oven:

1. The microwaves energy.
2. The food's temperature increases because it the microwaves.

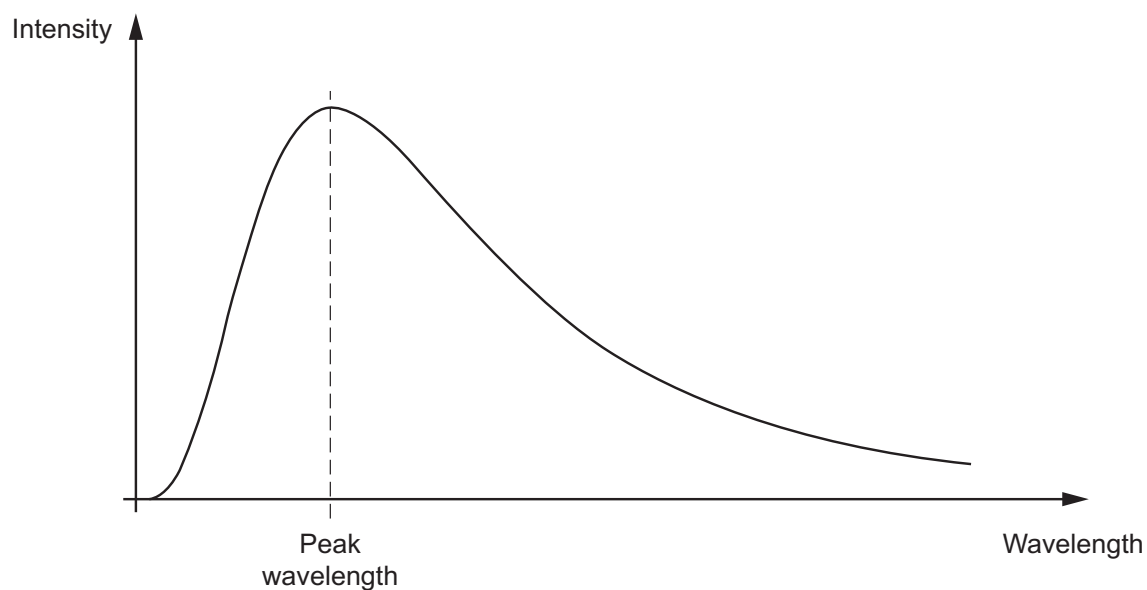
	Statement 1	Statement 2
A	refract	reflects
B	transfer	reflects
C	refract	absorbs
D	transfer	absorbs

Which row gives the correct words to complete the statements?

Your answer

[1]

- 10 A hot object emits radiation.
The graph shows how the intensity of the radiation varies with wavelength.



The temperature of the object **increases**.

Which row describes what happens to the peak wavelength and intensity of the radiation?

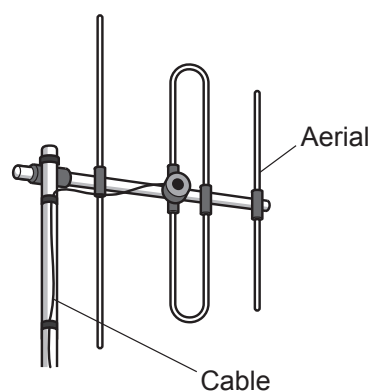
	Peak Wavelength	Intensity of the radiation
A	decreases	increases for all wavelengths
B	decreases	increases for the peak wavelength only
C	increases	increases for all wavelengths
D	increases	increases for the peak wavelength only

Your answer

[1]

11 A radio aerial receives radio signals.

The aerial is connected to a radio receiver using a cable.



How does the radio signal travel through the cable?

- A As a light wave
- B As a radio wave
- C As a sound oscillation
- D As an electrical oscillation

Your answer

[1]

4 Which electromagnetic waves can cause cancer **and** help treat cancer?

- A Gamma rays and X-rays
- B Infrared and X-rays
- C Microwaves and infrared
- D Radio waves and gamma rays

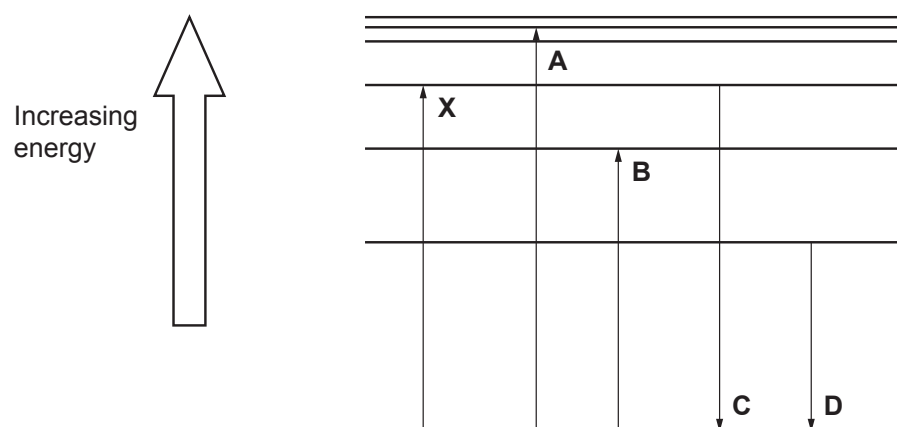
Your answer

[1]



12 The diagram shows energy levels in an atom.

Arrow **X** shows the movement of an electron that has absorbed infrared radiation.



Which arrow shows the movement of the same electron if it had absorbed radiation with more energy?

Your answer

[1]

1 An electromagnetic wave travels in a vacuum.

A second electromagnetic wave travelling in a vacuum has a smaller wavelength.

Which row describes how the frequency and velocity of the second electromagnetic wave compares with the frequency and velocity of the original wave?

	Frequency	Velocity
A	larger	equal
B	larger	larger
C	smaller	equal
D	smaller	larger

Your answer

[1]



5 Red light has a maximum wavelength of 750 nm.

Which part of the electromagnetic spectrum contains radiation with a wavelength of 850 nm?

- A** infrared
- B** ultraviolet
- C** visible light
- D** X-ray

Your answer

[1]

19 A radio signal is sent to Mars.

- (a) **Table 19.1** shows the distance from the Sun to Earth and the distance from the Sun to Mars, when Mars and Earth are closest.

Distance from the Sun to Earth	$1.50 \times 10^{11} \text{ m}$
Distance from the Sun to Mars	$2.28 \times 10^{11} \text{ m}$

Table 19.1

The radio signal travels at $300\,000\,000 \text{ m/s}$.

Calculate the minimum time for the radio signal to travel from Earth to Mars.

Use the data in **Table 19.1** and the equation: distance = speed $\times$ time

Time = ... s [4]

- (b) The average surface temperature on Earth is 15°C .

Suggest whether the average temperature on Mars is higher or lower than 15°C .

Use the data in **Table 19.1** to explain your answer.

.....

.....

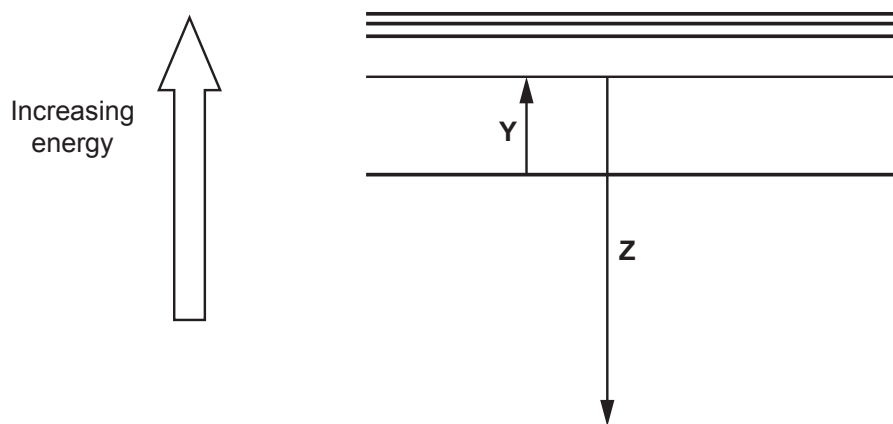
.....

.....

..... [2]

- 19 (a)** Atoms can emit or absorb electromagnetic radiation when electrons move between energy levels.

The diagram shows electron transitions **Y** and **Z** between energy levels in an atom.



- (i) Draw an arrow on the diagram showing the transition of an electron in the **lowest** energy level when it is lost from the atom. [2]

- (ii) Complete each sentence about the electron transitions in the diagram.

Use the words in the list.

absorbed	emitted	excited	ionised
higher than	lower than	the same as	

When an electron is, as shown by arrow **Y**, electromagnetic radiation is by the atom.

The frequency of electromagnetic radiation involved in transition **Z** is the frequency of the electromagnetic radiation involved in transition **Y**.

[2]

(b) Line spectra give astronomers information about the motion of distant galaxies.

The table gives the wavelength of a line in the spectrum of hydrogen observed in a laboratory on the Earth.

The table also gives the wavelength of the **same** line in the spectrum of hydrogen observed from galaxy **A** and galaxy **B**.

Source	Wavelength of line (nm)
Laboratory on the Earth	656
Galaxy A	712
Galaxy B	739

Explain how the data in the table can be used to compare the motion of galaxy **A** with galaxy **B**.

.....

.....

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.....

.....

..... **[4]**

21

(a) The Earth orbits the Sun.

Which statement is correct?

Tick (✓) **one** box.

The direction of the velocity of the Earth is towards the Sun.

☐

The Earth is accelerating.

☐

The Earth's velocity is the same as its speed.

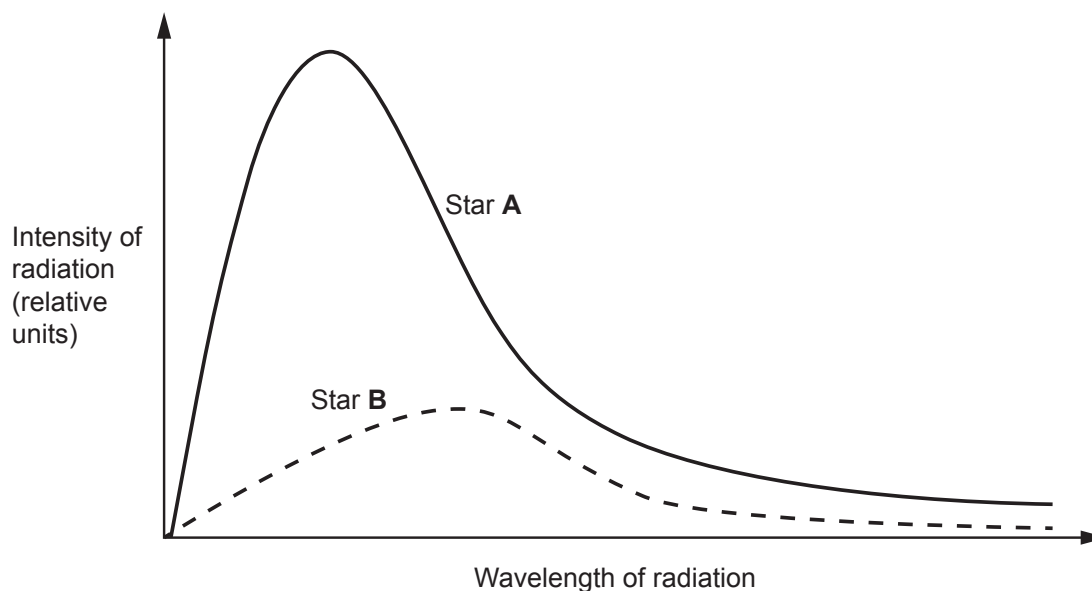
☐

The velocity of the Earth stays constant.

☐

[1]

(b) All objects emit radiation.

The graph shows how the intensity of the radiation emitted by star **A** and star **B** varies with the wavelength of the radiation.Describe **two** differences between the graph for star **A** and the graph for star **B**.

1

.....

2

.....

[2]

23 This question is about infra red (IR) and ultra violet (UV) radiation.

(a) It took humans a long time to discover IR and UV radiation.

Suggest **two** reasons why.

1

.....

2

..... **[2]**

(b) Look at the information about some UV radiation:

- The wavelength of the UV radiation is $0.18\ \mu\text{m}$.
- The wave speed of the UV radiation is $3.0 \times 10^8\ \text{m/s}$.

Calculate the frequency of the UV radiation.

Use the equation: wave speed = frequency $\times$ wavelength

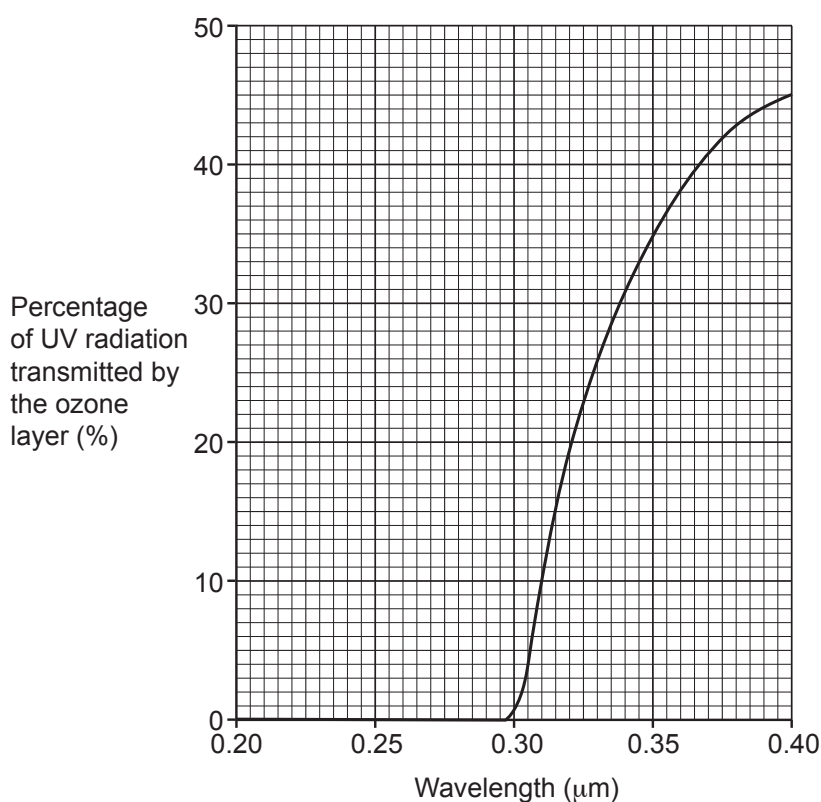
Give your answer to **2** significant figures.

Frequency = ... Hz **[5]**



- (c) The ozone layer is part of the Earth's atmosphere.

This graph shows how the percentage of UV radiation **transmitted** by the ozone layer depends on wavelength:



- (i) Describe the difference in the **absorption** of UV radiation at 0.31 μm and 0.37 μm.

Use data from the graph in your answer.

.....

.....

.....

..... [3]

- (ii) Why is the ozone layer important for humans on Earth?

Use the graph to help explain your answer.

.....

.....

.....

..... [2]

18 Look at the table showing information about the electromagnetic spectrum.

Radio	Micro-wave	Infra-red	Visible light	Ultra-violet	X-rays	Gamma-rays
3 MHz	30 GHz	3 THz		3000 THz	3 000 000 THz	300 000 000 THz
100 m	1 cm	100 μm				

(a) The speed of all electromagnetic radiation is $3 \times 10^8 \text{ m/s}$.

(i) Use data in the table to show that the speed of microwaves is $3 \times 10^8 \text{ m/s}$.

[2]

(ii) Ultra-violet waves typically have a frequency of 3000 THz.

Calculate the wavelength of these ultra-violet waves in nm.

Answer = ... nm [3]

(b) Ultra-violet waves can damage human skin.

Describe the damage caused to human skin by ultra-violet waves.

.....
 [1]



- (c) Sun cream can be used to protect skin from ultra-violet waves. Sun creams have different sun protection factors (SPF).

Look at the information about a bottle of sun cream.

This sun cream has a SPF of 10.

If used sensibly it can allow you up to $10 \times$ longer in the Sun without increasing the risk from ultra-violet waves.

- (i) A doctor says 'adults should not sunbathe for more than 20 minutes in the midday sunshine when **not** using sun cream'.

If an adult used sun cream with SPF 6, how long could they safely sunbathe for?

Answer = ... minutes [1]

- (ii) The doctor says that children should always use at least SPF 50 sun cream.

Suggest reasons why.

.....
.....
.....
..... [2]

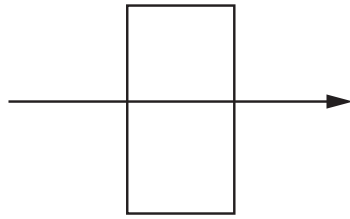
SUB-TOPIC P5.3

WAVE INTERACTION

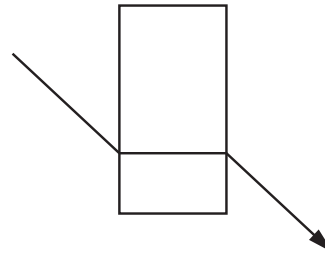
25 questions in this sub-topic · 95 marks · lowest tariff first



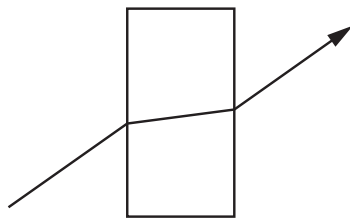
3 Look at the diagrams of a light ray as it passes from air through a glass block.



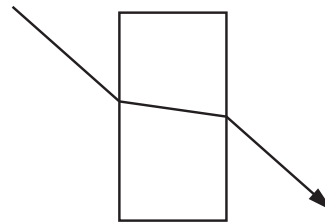
A



B



C



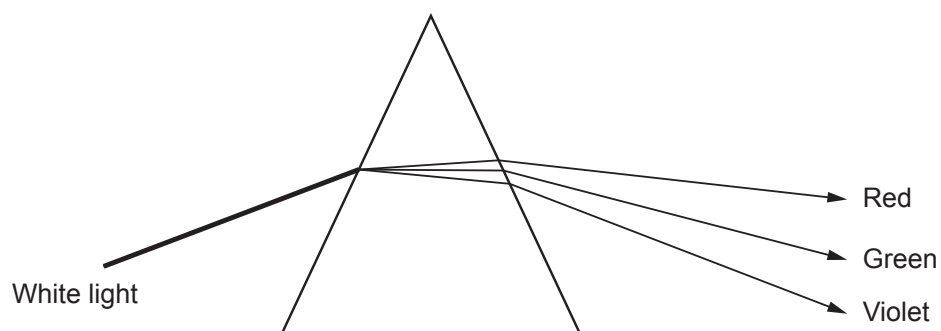
D

Which diagram shows an **incorrect** refraction?

Your answer

[1]

15 Look at the diagram of white light as it passes through a prism.



A spectrum of colours is seen. It ranges from red to violet.

Why does the **violet** light refract **more** than the red light?

- A Violet light changes frequency more than red light.
- B Violet light has the largest change in speed.
- C Violet light has the smallest change in speed.
- D Violet light increases its speed in the glass prism.

Your answer

[1]

- 8 The maximum frequency of sound that a person can hear changes as they get older.

Which row in the table explains this change?

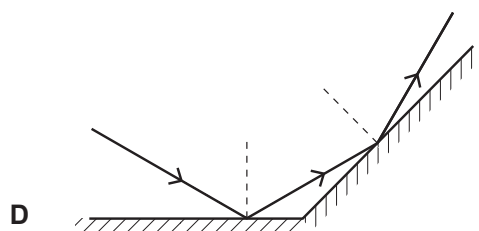
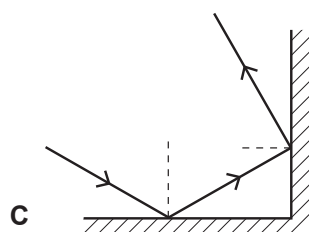
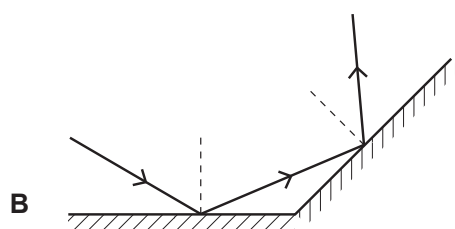
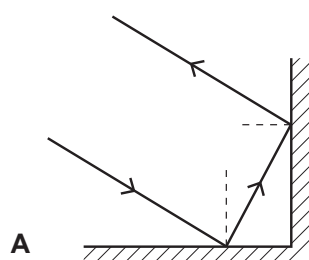
	Maximum frequency of sound a person can hear	What part of the ear is damaged?
A	Decreases with age	Cochlea
B	Decreases with age	Eardrum
C	Increases with age	Cochlea
D	Increases with age	Eardrum

Your answer

[1]



13 Look at the diagrams of a light ray reflecting from two identical surfaces.

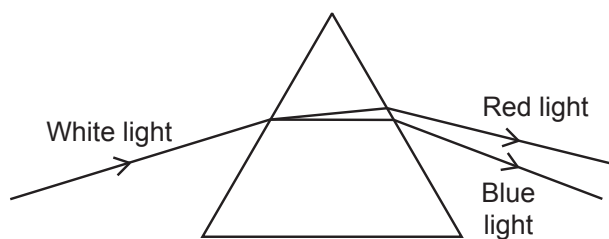


Which diagram is correct?

Your answer

[1]

10 A student uses a glass prism to split white light into different colours.



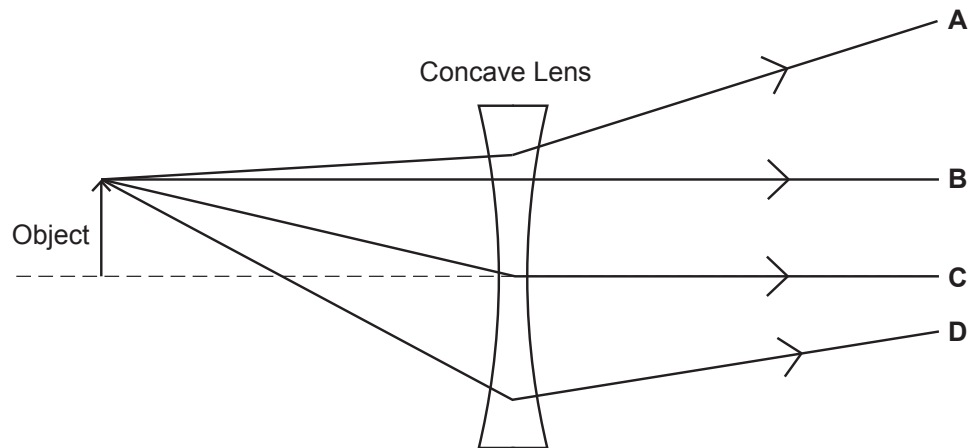
Which statement describes the light in the prism?

- A** Blue light is refracted less than red light.
- B** Blue light slows down more than red light.
- C** Red light has a shorter wavelength than blue light.
- D** Red light has a smaller frequency change than blue light.

Your answer

[1]

- 5 The diagram shows four possible paths for a ray of light from an object passing through a concave lens.



Which letter shows the correct path of the ray?

Your answer

[1]

6 A student investigates absorption of coloured light in a dark laboratory.

The student shines green light onto a blue object.

What colour does the object appear?

A Black

B Blue

C Cyan

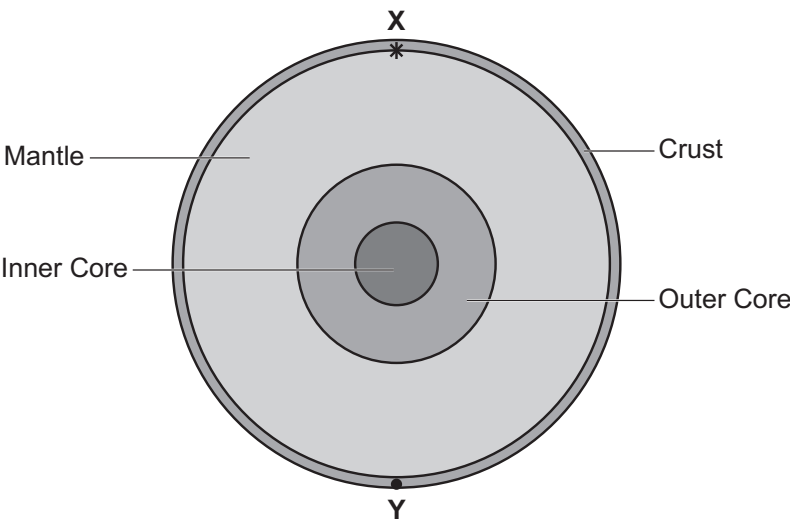
D Green

Your answer

[1]



8 The diagram shows a cross-section of the Earth.



An earthquake takes place at point X.
Which type(s) of seismic waves would be detected at point Y?

	P-Waves	S-Waves
A	no	no
B	no	yes
C	yes	no
D	yes	yes

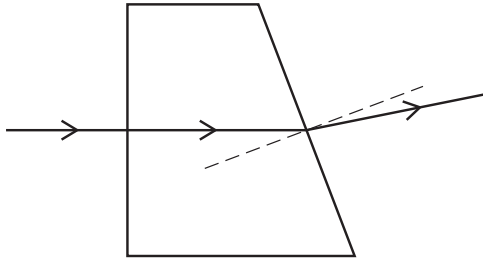
Your answer ☐

[1]

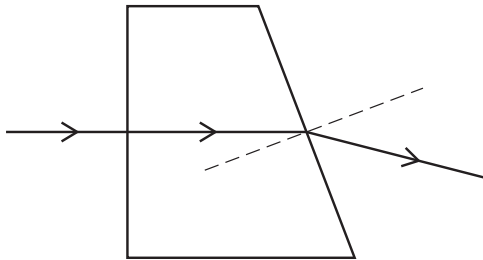
11 A student uses a ray box to shine a ray of light through a glass block.

Which diagram shows a correct path for the ray?

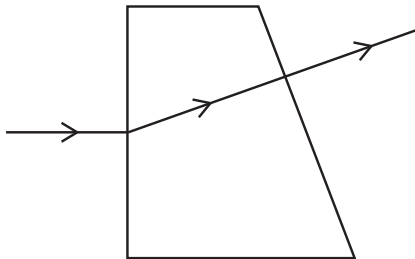
A



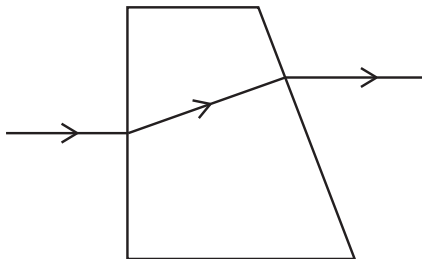
B



C



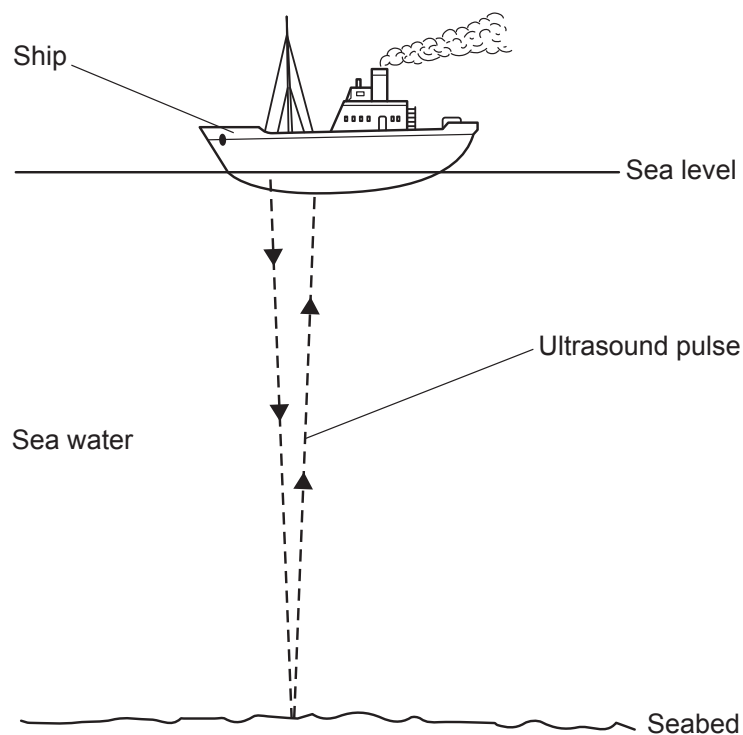
D



Your answer

[1]

- 2 Ultrasound pulses can be used to measure the depth of the seabed.



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

The seabed is 3600 m below sea level.

An ultrasound pulse is emitted from the ship.

How long is it before the ultrasound pulse **returns** to the ship?

Use the equation: distance travelled = speed × time

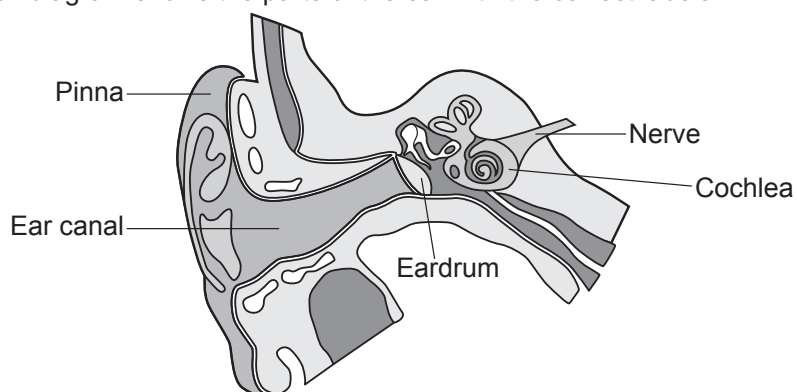
- A 0.40 s
- B 0.80 s
- C 2.4 s
- D 4.8 s

Your answer

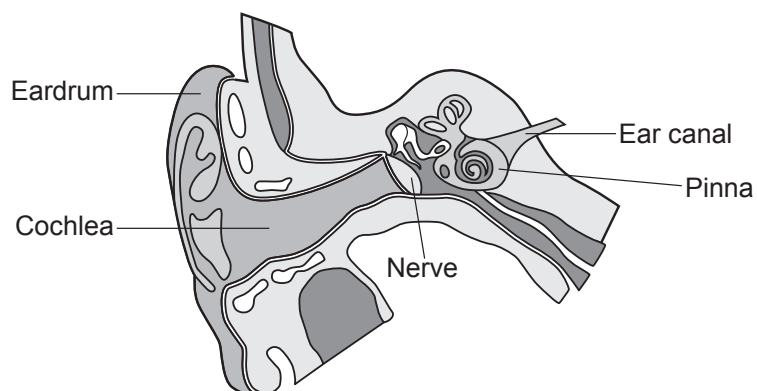
[1]

5 Which diagram shows the parts of the ear with the correct labels?

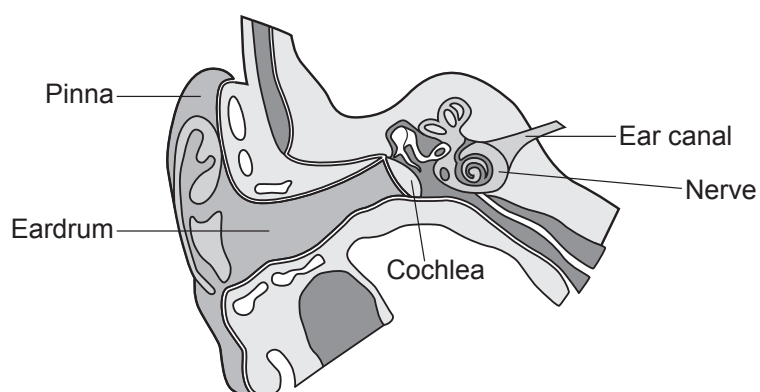
A



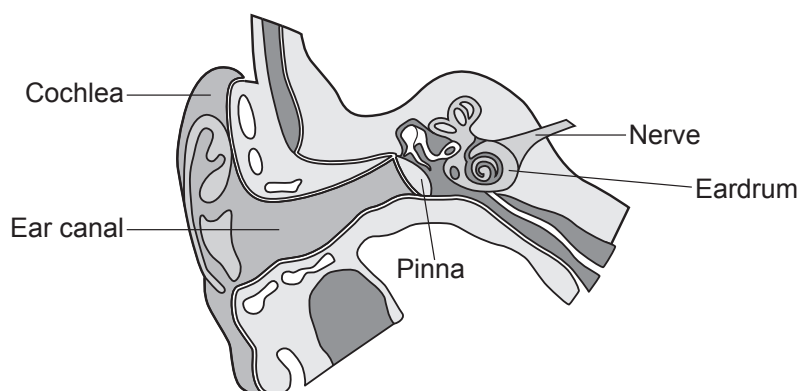
B



C



D



Your answer

[1]

6 Which sentence about P seismic waves is correct?

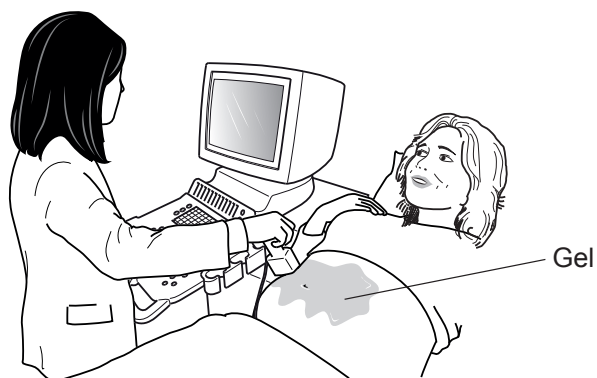
- A** P waves are slower than S waves.
- B** P waves are transverse.
- C** P waves can travel through solids and liquids.
- D** P waves can travel through solids but not liquids.

Your answer

[1]

- 9 Ultrasound scans are used to take pictures of unborn babies.

Before the ultrasound scan, gel is placed on the skin.



Which sentence explains why the scan **only** works when the gel is used?

- A The gel amplifies the ultrasound waves.
- B The gel lubricates the skin.
- C The gel reflects the ultrasound waves.
- D The gel transmits the ultrasound waves.

Your answer

☐

[1]

6 What causes the hearing range of humans to decrease as they age?

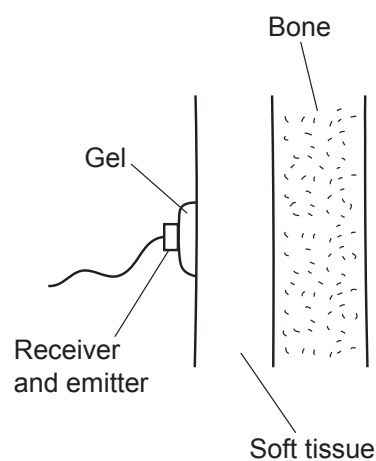
- A** Lower frequencies cannot be heard.
- B** The eardrum vibrates more quickly.
- C** The pinna gets smaller.
- D** The shorter hairs in the cochlea stop working first.

Your answer

[1]



- 9 The diagram shows a patient having an ultrasound scan.



The speed of ultrasound in soft tissue is 1500 m/s.

The echo from the boundary between the soft tissue and the bone is received 2.0×10^{-5} s after the ultrasound is emitted.

What is the thickness of the soft tissue?

Ignore the thickness of the gel.

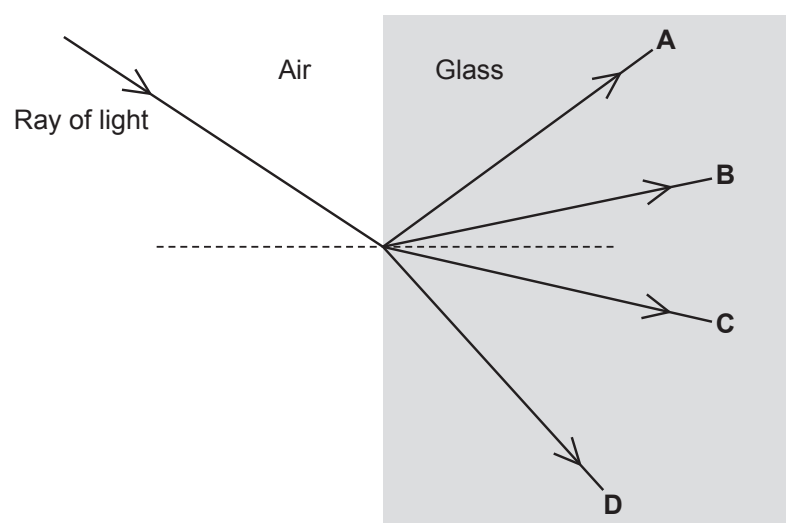
Use the equation: distance travelled = speed $\times$ time

- A 0.015 m
- B 0.030 m
- C 0.060 m
- D 0.075 m

Your answer

[1]

- 9 The diagram shows a ray of light travelling from air into glass.

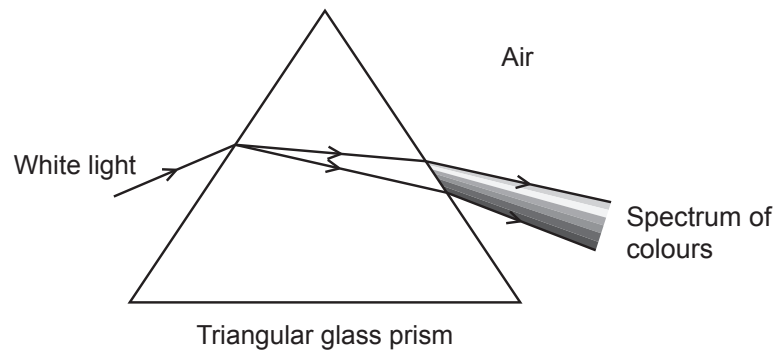


Which line shows the **refracted** ray of light?

Your answer

[1]

12 The diagram shows white light passing through a triangular glass prism.



Which sentence describes why white light disperses into a spectrum of different colours?

- A** Each colour changes frequency by different amounts when they cross the boundary between glass and air.
- B** Each colour changes speed by different amounts when they cross the boundary between glass and air.
- C** Each colour decreases in amplitude by different amounts.
- D** Each colour transfers energy at different rates while in the glass.

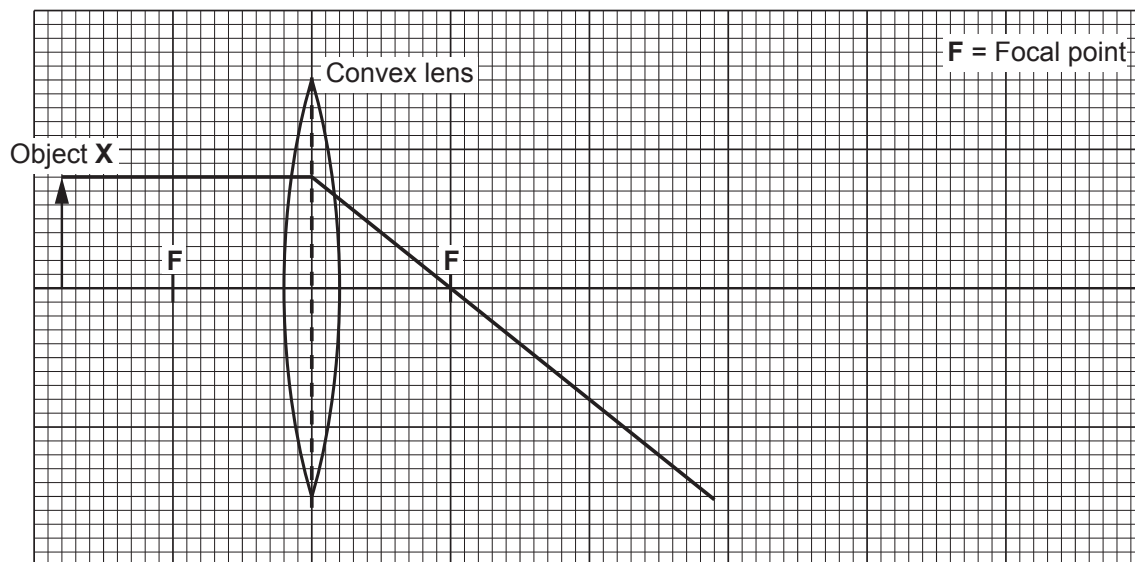
Your answer

[1]

16 A projector is used to create a larger image of an object.

(a) The diagram shows one light ray as it passes through the convex lens.

Draw **one** more ray on the diagram to show where the image is formed. Label the image **Y**.



[2]

(b) The projector contains a white light source.

Explain how this white light source can be used to get **red** light.

.....
 [2]

(c) (i) The projector is connected to the mains power supply. The projector has an earth wire.

State the potential difference between the earth wire and the live wire in normal use.

Potential difference = ... V [1]

(ii) A projector with a plastic case does not need an earth wire.
 A projector with a metal case needs an earth wire.

Explain why.

.....

 [2]

16 This question is about visible light.

- (a) (i) State **one** change that happens to light when it travels from water into air.

..... [1]

- (ii) Diagram in **Fig. 16.1** shows a ray of light from a fish in a container of water.

Complete the ray diagram in **Fig. 16.1** to show the path of the ray after it leaves the water.

Include a normal line in your diagram.

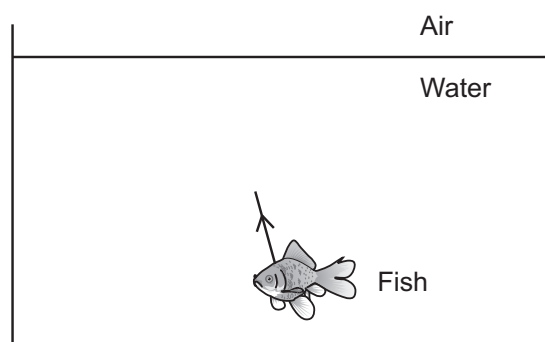


Fig. 16.1

[3]

- (b) Diagram in **Fig. 16.2** shows three incident rays hitting the surface of the fish. Light is scattered from the surface of the fish.

Complete the diagram in **Fig. 16.2** to show the scattered rays.

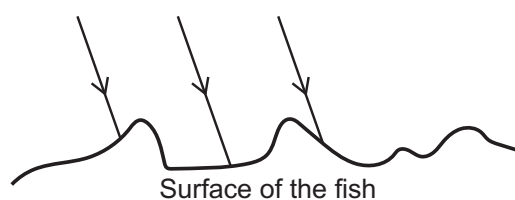


Fig. 16.2

[1]

(c) The fish appears red under white light.

Explain why the fish appears black under green light.

.....

.....

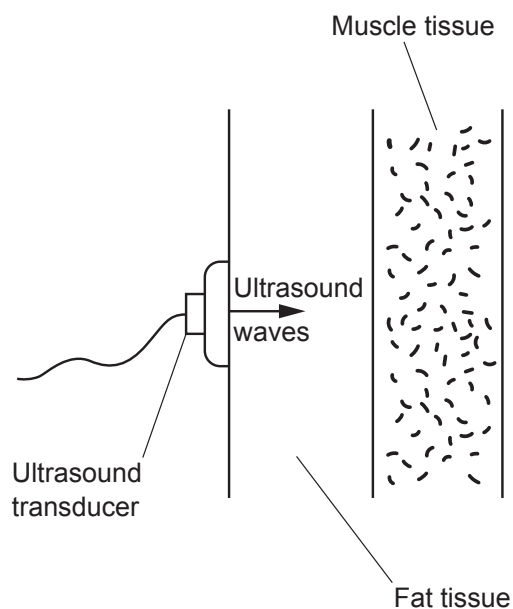
..... [2]



22 Ultrasound waves are used to produce images of the inside of the human body.

The ultrasound waves reflect from the boundary between two different materials inside the human body.

The diagram shows an ultrasound transducer that emits and receives ultrasound waves.



A computer is connected to the ultrasound transducer.

The computer records a time of 2.8×10^{-7} s between emitting one ultrasound wave and receiving the reflection of this wave from the boundary between the fat tissue and the muscle tissue.

The speed of ultrasound waves in fat tissue is 1500 m/s.

(a) Calculate the thickness of the fat tissue.

Use the Equation Sheet.

Thickness of fat tissue = ... m **[3]**

- (b) The wavelength of the ultrasound wave in the fat tissue is 4.3×10^{-4} m.

Calculate the frequency of the ultrasound wave.

Use the equation: wave speed = frequency $\times$ wavelength

Give your answer to **2** significant figures.

Frequency = ... Hz **[4]**

- (c) When the ultrasound wave hits the boundary between the fat tissue and the denser muscle tissue, the ultrasound wave is partially reflected and partially transmitted.

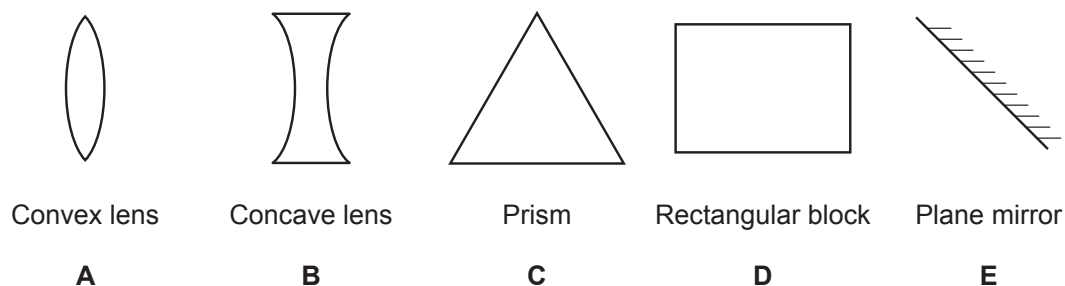
The transmitted ultrasound wave continues into the denser muscle tissue.

Explain the change in wavelength of the ultrasound wave as it passes from fat tissue into muscle tissue.

.....
.....
..... **[2]**

- 16 (a)** A student shines three parallel rays of red light at different glass objects. **Fig. 16.1** shows the glass objects.

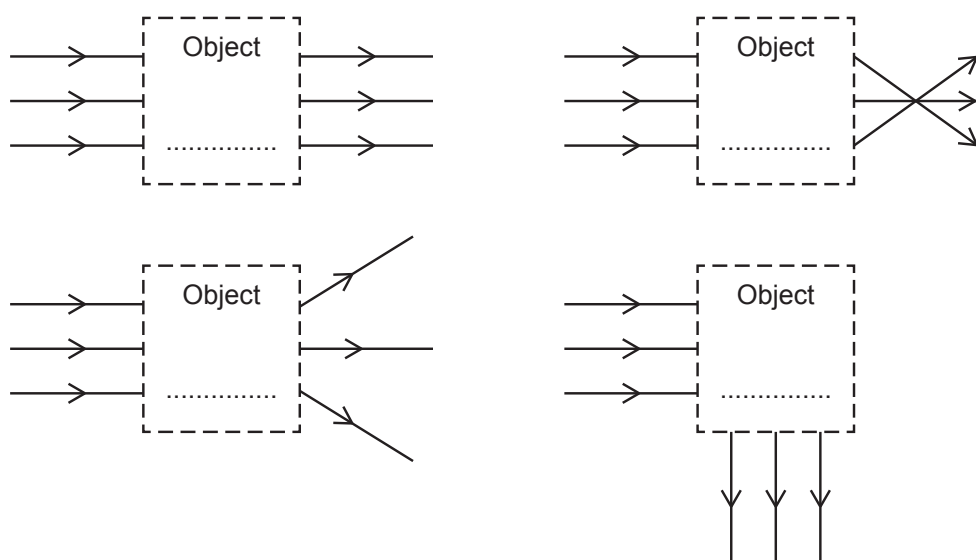
Fig. 16.1



The student draws ray diagrams to show what happens to the three parallel rays of red light.

Write **one** letter in each box in **Fig. 16.2** to identify which glass object produces that ray diagram.

Fig. 16.2



[4]

- (b) The wavelength of red light in glass is $4.33 \times 10^{-7} \text{ m}$.

The speed of red light in glass is $2.0 \times 10^8 \text{ m/s}$.

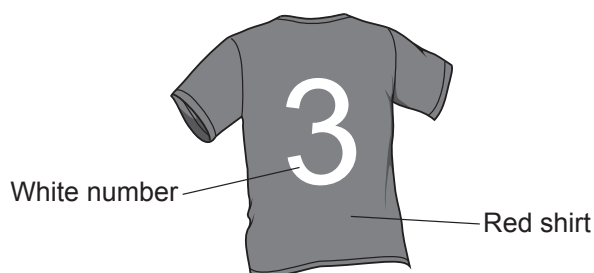
Calculate the frequency of the red light in glass.

Use the equation: wave speed = frequency $\times$ wavelength

Give your answer to **2** significant figures.

Frequency = ... Hz [4]

- (c) A football player wears a red shirt with a white number 3 on the back.



- (i) What is the colour of the shirt and the number when viewed under **blue** light?

Colour of shirt

Colour of number [1]

- (ii) Another football player says, 'Under **red** light, I cannot read the number on the shirt.'

Explain why.

.....

..... [1]

18 A student investigates reflection and refraction of light rays.

(a) The student sends a ray of red light into a glass prism.

Fig. 18.1 shows the light ray as it leaves the glass prism.

On **Fig. 18.1** complete the ray of light as it travels towards **and** through the glass prism.

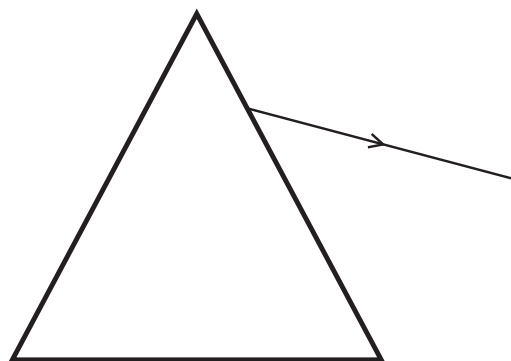


Fig. 18.1

[2]

(b) **Fig. 18.2** shows two mirrors placed at 90° to each other.

A light ray hits one of the mirrors at 45° .

On **Fig. 18.2** complete the ray of light as it reflects from both mirrors.

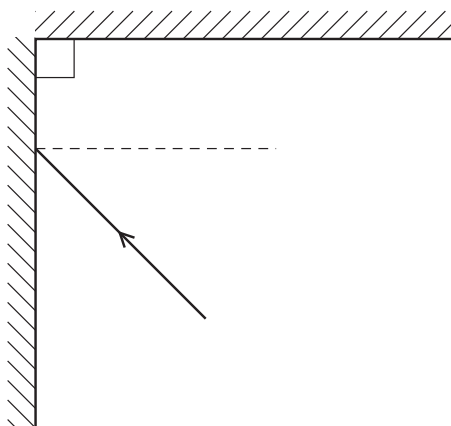


Fig. 18.2

[2]

- (c) White light is made of different colours.

White light passes through a transparent filter **X**.

Filter **X** absorbs green, blue, indigo and violet light.

The light then passes through another transparent filter **Y**, as shown in **Fig. 18.3**.

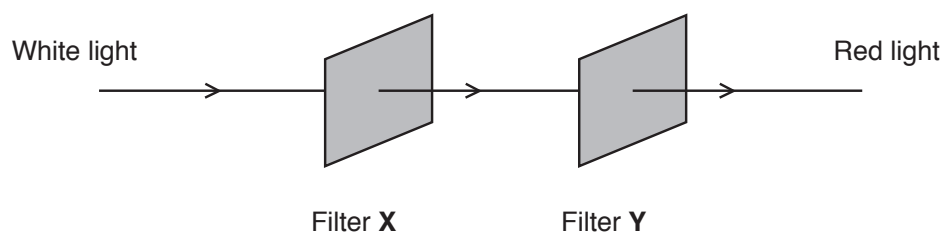


Fig. 18.3

The light that leaves filter **Y** is red.

- (i) What colours are transmitted by filter **X**?

.....

 [1]

- (ii) What colours are absorbed by filter **Y**?

.....

 [1]

- (d) A wall is painted red.

When some coloured lights shine on it, the wall appears black.

- (i) Explain why.

.....
 [1]

- (ii) Suggest **two** different colours of light that would cause the wall to appear black.

..... and [1]

- (e) An optician uses red and green light to test vision.

Fig. 18.4 is a ray diagram showing **red light** passing through a lens.

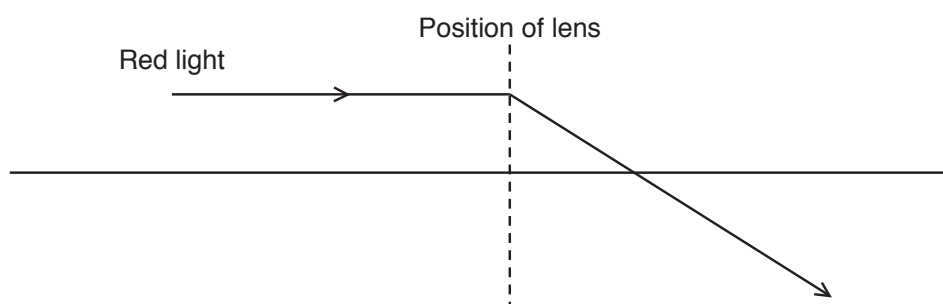


Fig. 18.4

- (i) Green light passes through the same lens as in **Fig. 18.4**.

Complete the ray diagram in **Fig. 18.5** for **green light**. The focal point for red light F_R is shown.

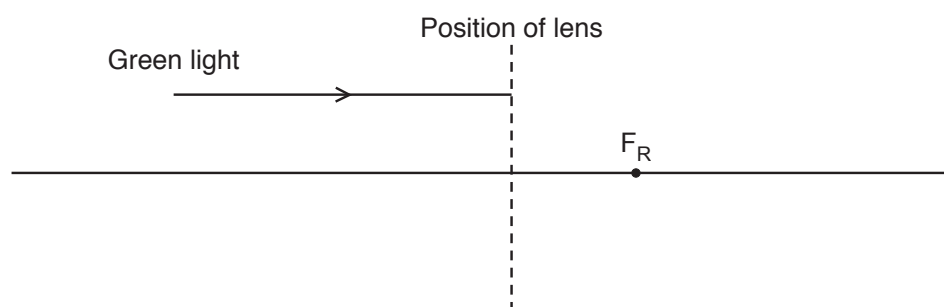


Fig. 18.5

[1]

- (ii) Explain your answer to (e)(i).

.....
 [1]

- (iii) Is the lens in **Fig. 18.4** and **18.5** suitable for correcting long-sight or short-sight?

Tick (✓) **one** box.

Long-sight ☐

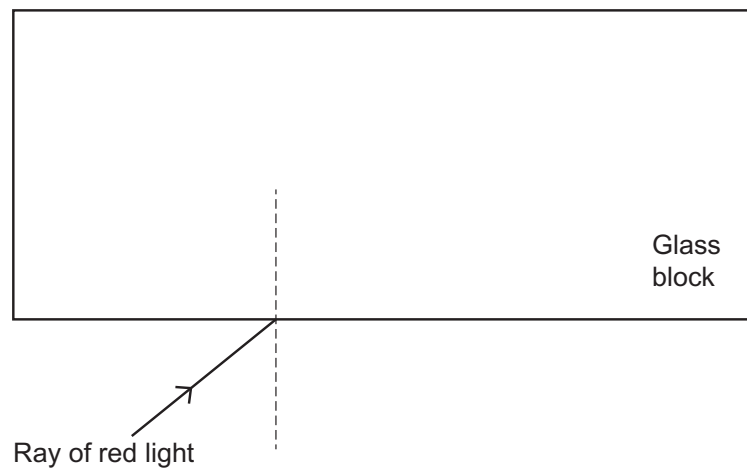
Short-sight ☐

Explain your answer.

.....
 [2]

22 Fig. 22.1 shows a ray of red light from a laser entering a rectangular glass block from the air.

Fig. 22.1



When the red light enters the glass block from the air it will refract.

(a) Draw the path of the refracted ray inside the glass block in **Fig. 22.1**. **[1]**

(b) Explain why red light refracts as it enters the glass block.

.....

.....

.....

..... **[2]**

- (d) The student replaces the red laser with a **green** laser and repeats the experiment for the same angles of incidence.

The student notices that the angles of refraction for the green light are all different from the angles of refraction for the red light.

Explain why the angles of refraction are different when light of a different colour is used.

.....

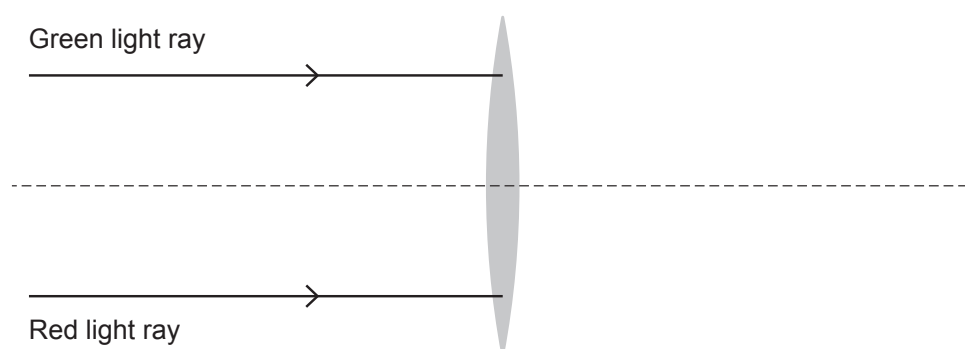
.....

.....

..... [2]

- (e) The student replaces the glass block with a glass lens and directs both the red and green lasers into the lens at the same time as shown in **Fig. 22.2**.

Fig. 22.2



Complete **Fig. 22.2** by continuing the paths of the red and green light rays.

[2]

19 Ultrasound waves can be used to create an image of part of the inside of a body.

(a) Ultrasound waves have a higher frequency than ripples on the surface of water.

Describe **another** difference between ultrasound waves and ripples on the surface of water.

Explain your answer.

.....

.....

.....

..... [2]

(b) The graph in **Fig. 19.1** shows how displacement of the ultrasound wave varies with distance.

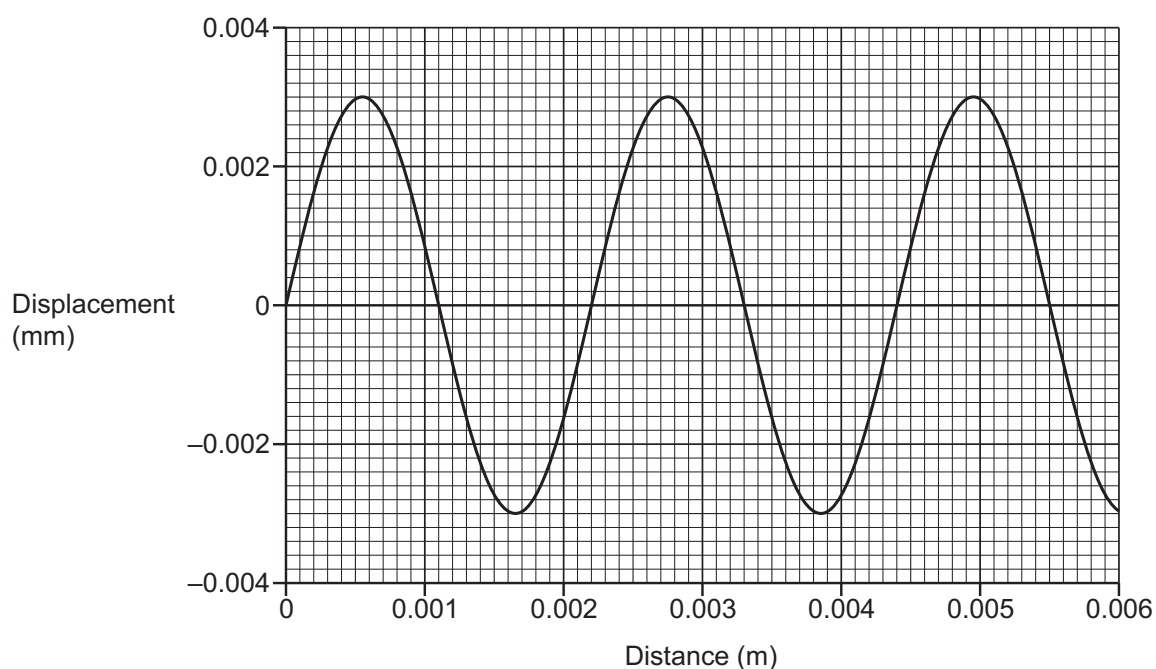


Fig. 19.1

(i) Use the graph in **Fig. 19.1** to determine the wavelength of the ultrasound wave.

Wavelength = ... m [1]

(ii) The speed of ultrasound waves in (b)(i) is 4500 m/s.

Calculate the frequency of the ultrasound wave in **Fig. 19.1**.

Use the equation: wave speed = frequency $\times$ wavelength

Give your answer in **standard form** and to **2** significant figures.

Frequency = ... Hz **[4]**



- (c) Doctors can use an ultrasound scan to measure the size of a person's kidney.

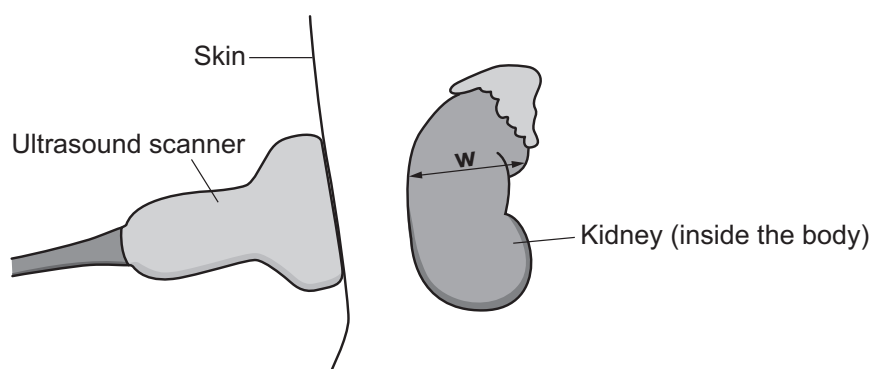


Fig. 19.2

Complete the sentences using the words below.

Each word may be used once, more than once, or not at all.

Increases

Decreases

Stays the same

The ultrasound scanner is made from a solid ceramic material.

As the wave enters the body, the speed

As the wave enters the body, the frequency

[2]

- (d) (i) Explain what happens to the ultrasound wave when it reaches the kidney.

.....

 **[2]**

- (ii) **Fig. 19.2** shows the thickness of the kidney, **w**.

Explain how ultrasound waves are used to measure **w**.

.....

 **[2]**

- (e) A doctor uses an ultrasound scan instead of X-rays to measure the kidneys.

Explain why.

.....
 **[1]**

MARK SCHEMES

official Pearson Edexcel mark schemes



Question			Answer	Marks	AO element	Guidance
2			C ✓	1	1.2	



Question				Answer		Marks	AO element	Guidance	
1				D ✓		1	2.2		



Question			Answer	Marks	AO element	Guidance
6			B ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
9			A ✓	1	2.2	



Question				Answer	Marks	AO element	Guidance
2				C ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
6				D ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
9				A ✓	1	1.2	



Question				Answer	Marks	AO element	Guidance
2				A ✓	1	1.1	



Question	Answer	Marks	AO element	Guidance
1	B	1	1.1	



Question	Answer	Marks	AO element	Guidance
4	B	1	1.1	ALLOW 10 (ms)



Question	Answer	Marks	AO element	Guidance
8	B	1	1.2	



2	D	1	2.1	A: $80 \div 4$ B: $80 \div 2$ C: 80×2 D: 80×4
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Question	Answer	Marks	AO element	Guidance
6	A	1	1.1	



16	(a)	<table><tr><td></td><td>Type of wave</td><td>Direction of particle vibration</td></tr><tr><td>Sound</td><td>longitudinal ✓</td><td>Particles vibrate parallel ✓ to wave direction</td></tr><tr><td>Water ripples</td><td>transverse ✓</td><td>Particles vibrate perpendicular ✓ to wave direction</td></tr></table>		Type of wave	Direction of particle vibration	Sound	longitudinal ✓	Particles vibrate parallel ✓ to wave direction	Water ripples	transverse ✓	Particles vibrate perpendicular ✓ to wave direction	4	4 × 1.1	ALLOW in same direction for parallel ALLOW at right angles/90° for perpendicular IGNORE left to right / side to side / up and down / vertical If no other marks awarded: ALLOW 1 mark for identifying transverse as having perpendicular vibrations if linked to sound and/or ALLOW 1 mark for identifying longitudinal as having parallel vibrations if linked to water ripples
	Type of wave	Direction of particle vibration												
Sound	longitudinal ✓	Particles vibrate parallel ✓ to wave direction												
Water ripples	transverse ✓	Particles vibrate perpendicular ✓ to wave direction												
	(b)	(i) Any two from: Rock has more energy in its gravitational store ✓ Rock has more energy in its kinetic store (when it hits the water) ✓ Rock transfers more energy (to the water) ✓	2	2 × 2.1	ALLOW rock has more gravitational/potential energy / (G)PE ALLOW rock has more kinetic energy / KE / moving faster / accelerating for a longer time If no other marks awarded: ALLOW rock hits the water harder/with more force OR ALLOW rock has more energy									

Question			Answer	Marks	AO element	Guidance
16	(b)	(ii)	(Idea of use of metre ruler) to measure a (set) distance the ripple travels ✓ (Idea of use of stop clock) to measure the time for a ripple to travel the (set) distance ✓ (speed =) distance (travelled) ÷ time (taken) ✓ OR (Idea of use of metre ruler) to measure distance between (many) ripples/crests/troughs ✓ (Idea of use of stop clock) to obtain frequency using sensible method ✓ (speed =) wavelength x frequency ✓	3	3 × 3.3a	ALLOW either method but if methods are mixed only award the marks scored from the highest scoring method IGNORE measuring drop height / distance travelled by falling rock IGNORE time travelled by falling rock ALLOW measure the distance travelled by a ripple in a (set) time for 2 marks ALLOW measure the time it take for a ripple to travel a (set) distance for 2 marks ALLOW words or symbols ALLOW e.g. measure distance between 10 crests and divide by 9 / measure length of 10 waves and divide by 10 ALLOW e.g. 1 ÷ time for 1 wave / count number of waves in 10 s and divide by 10 ALLOW words or symbols



24	(a)	(i)	Mean = $(0.28 + 0.32) = 0.30$ (s) ✓	1	1.2	ALLOW 0.3 (s) DO NOT ALLOW answers with all 3 readings used giving a mean of $(0.28+0.32+0.54) / 3 = 0.38$ (s)
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 333 (m/s) award 4 marks Use of distance = 100 m ✓ Recall $(s =) d / t$ ✓ $100 / 0.3$ ✓ $(s =) 333$ (m/s) (3 sig. figs.) ✓	4	2.1 1.2 2.1 2.1	ALLOW ECF from 24(a)(i) ALLOW $100 \div 0.38$ ✓✓✓ ALLOW 263 (m/s) ✓✓✓✓ ALLOW ECF for 3 rd and 4 th marking points if incorrect distance is used ALLOW $50 \div 0.3$ or 166.7 ✓✓ ALLOW $50 \div 0.38$ or 131.6 ✓✓ ALLOW 132 ✓✓✓ ALLOW 167 ✓✓✓
		(iii)	Any two from: Inconsistent results should be repeated ✓ More readings of time should be done and the mean calculated ✓ (Explanation of) clap-echo method ✓ Larger/different distances used ✓	2	2×3.3b	Clap-echo method effectively may gain 2 marks as it also uses the idea of multiple readings.

Question	Answer	Marks	AO element	Guidance
(b)	idea of 3 echoes/reflections/returning pulses (from each pulse) / AW ✓ takes different times to travel (there and back) through different layers/distances/thicknesses / time (interval) between echoes is different/not regular / AW ✓ BUT the thicker the layer/the longer the distance, the bigger the time interval/takes longer to travel (there and back) / AW ✓✓	3	3×2.1	ALLOW (idea of measuring) the time taken for the wave to be reflected back (for different layers)



17	a	i	2 ½ or 2.5 ✓	1	1.2	
		ii	Speed is unchanged / stays the same ✓ Wavelength reduces ✓	2	2.1 2.1	Answer must indicate idea of speed Answer must indicate idea of wavelength IGNORE answers that merely state 'no change and reduces'
		iii	Any two from: Water / particles move up and down / oscillate vertically ✓ Water / particles move at 90° / perpendicular to the direction of wave (travel) / AW ✓ Energy moves in direction of the wave (travel) / AW ✓	2	2 x 1.2	IGNORE any statements that are just repeated from the question. IGNORE water waves move up and down ALLOW energy moves at 90° to wave vibrations / movement ✓✓
	b		(Idea of) action to produce sound and seen by observer / received by receiver ✓ Measure an appropriate distance eg between source and observer or between microphone(s) / speaker ✓ Measure an appropriate time eg between seeing action and hearing sound or on CRO / or frequency from signal generator ✓ (Idea of) calculating speed = distance / time or velocity = frequency x wavelength ✓ (Idea of) improvements to experiment eg repeat and average readings / retake readings if they are anomalous / use a different method / use different equipment / use longer distances ✓	5	1.1 2.2 2.2 3.2b 3.3b	ALLOW marks to be awarded from a clear diagram ALLOW higher level methods eg using standing waves ALLOW equation in any form

Question		Answer	Marks	AO element	Guidance
	c	Any 3 from: Outer ear (pinna) / auditory canal transfers sound to ear drum ✓ Ear drum vibrates ✓ Ossicles / small bones / anvil, hammer or stirrup vibrate ✓ Ossicles / small bones / anvil, hammer or stirrup amplify vibration ✓ Liquid in cochlea transmits movement (to small hairs) ✓ Small hairs / cilia vibrate ✓	3	1.1 2 x 2.1	ALLOW ear drum moves in and out



18	(a)	(i)	The sound reflects/echoes (from the cliff) ✓ The amplitude of the sound decreases with distance / some of the energy/wave/sound is absorbed (by the cliff/air) ✓	2	2 × 1.1	IGNORE bounces ALLOW energy lost as travelling through air / energy dissipated into surroundings/cliff ALLOW sound/waves/energy spreads out ALLOW some sound/waves/energy reflect/travel in different directions IGNORE just energy lost
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 231 (m) award 4 marks (distance =) speed × time ✓ (distance travelled by wave =) 330×1.40 ✓ (distance travelled by wave =) 462 (m) ✓ (distance to cliff =) $\frac{1}{2} \times 462 = 231$ (m) ✓	4	1.2 3 × 2.1	ALLOW symbol equation / equation in any form ALLOW 0.7 seen for 1 mark ALLOW 330×0.7 for 3 marks ALLOW 3 marks for answer of 462(m)
		(iii)	Any two from: Due to reaction time ✓ Sound may not be heard (clearly) ✓ The student might start the stopwatch too early / stop the stopwatch too late / be distracted ✓ Wind/temperature/humidity/rain affects the speed ✓	2	2 × 3.2a	IGNORE human error ALLOW cliff surface is not flat so waves take different times to return ALLOW starts/stops stopwatch at the wrong time / can't clap and press button at the same time IGNORE weather conditions

Question			Answer	Marks	AO element	Guidance
18	(a)	(iv)	Any one from: Repeat the measurements and take a mean ✓ (Idea of) recording sound (and playback) to find accurate time ✓ Use another person (next to first student) to measure the time between clap and echo ✓	1	3.3b	ALLOW (idea of) clap-echo method / measuring time for multiple claps ALLOW (idea of) a method using microphone(s) linked to computer/oscilloscope/electronic timers
	(b)	(i)	Any two from: (Sound travels as) a longitudinal wave ✓ (Sound travels as) compressions and rarefactions ✓ Air particles vibrate ✓ Vibrations are <u>parallel</u> to the direction of energy transfer/ wave travel ✓	2	2 × 1.1	
		(ii)	Any two from: Outer ear/pinna/auditory canal (transfers sound to ear drum) ✓ Ear drum (vibrates) ✓ (passed to/vibrates) ossicles/small bones/anvil/hammer/stirrup ✓ (Liquid in) cochlea (transmits movement to small hairs) ✓ Hairs/cilia (vibrate) ✓	2	2 × 1.1	If vibrations not mentioned, maximum of 1 mark ALLOW vibrates/oscillations/oscillates/moves in and out for idea of vibrations ALLOW ossicles/small bones/anvil/hammer/stirrup amplify vibration



Question			Answer	Marks	AO element	Guidance
18	(c)		Wavelength of A is longer (than B) / double (B) / ORA ✓ And any one from: Wavelength is inversely proportional to frequency ✓ Wavelength = wave speed ÷ frequency <u>and</u> speed (of sound) is constant ✓ As frequency decreases, wavelength increases ✓ As frequency halves, wavelength doubles ✓	2	2 × 2.1	ALLOW 2 marks for calculations to show this e.g. $\lambda_A = 0.55(\text{m})$ and $\lambda_B = 0.275(\text{m})$ ALLOW a lower frequency/less waves per second means a longer wavelength / ORA Maximum of 1 mark if speed changes

18	(a)	Angle of incidence not equal to angle of reflection (at mirror B/second reflection) / AW ✓ Normal line is not at 90° (to surface of mirror B) / AW ✓	2	2 × 1.1	IGNORE not at correct angle If no other marks scored: ALLOW (second) reflected ray should be parallel to original ray for 1 mark
	(b)	dust on it/retroreflector ✓	1	3.2a	ALLOW it is dirty/dull/scratched/not smooth
	(c)	First check the answer on the answer line If answer = 61.6 (J) award 3 marks Select: (gravitational potential energy =) mass × gravitational field strength × height / (E =) mgh ✓ (E =) $77 \times 0.5 \times 1.6$ ✓ (E =) 61.6 (J) ✓	3	1.2 2 × 2.1	ALLOW 62 (J) ALLOW equation in any form

	(d)	First check the answer on the answer line If answer = 5.6×10^{14} (Hz) award 4 marks Select and rearrange: (frequency =) wave speed ÷ wavelength / $f = v \div \lambda$ ✓ (f =) $3 \times 10^8 \div 5.32 \times 10^{-7}$ ✓ (f =) $5.639... \times 10^{14}$ ✓ (f =) 5.6×10^{14} (Hz) (2 s.f.) ✓	4	1.2 2.1 2.1 1.2	 ALLOW correct substitution into unarranged equation for 1 mark ALLOW $5.639... \times 10^n$ for 2 marks ALLOW 5.6×10^n for 3 marks ALLOW this mark for clear evidence of an incorrect answer (correctly rounded) to two significant figures (not a bald answer to 2 s.f.)
	(e)	Eyes can only detect a limited range of (electromagnetic) waves / wavelength is too large (to be seen) / frequency is too small (to be seen) ✓	1	1.1	ALLOW (frequency/wavelength of) IR is outside of the range of EM waves that is detectable to the eye / eye is not able to see that frequency/wavelength of wave ALLOW eyes can <u>only</u> detect (visible) light BUT IGNORE IR is not visible to the eye / eyes cannot see/detect IR
	(f) (i)	Visible light has a larger frequency (than infrared) / ORA ✓ Visible light has shorter wavelength (than infrared) / ORA ✓	2	2 × 1.1	IGNORE longer/shorter frequency

	(ii)	Any two from: Count number of waves (passing a point) ✓ Measure time (for these waves with a stopwatch) ✓ Divide number of waves (passing a point) by the time (for these waves) ✓ Alternative method (idea of) measure time period / time for 1 wave ✓ Use frequency = $1 \div$ time period ✓	2	2 × 2.2	ALLOW count how many times an object e.g. cork bobs up and down IGNORE time it takes waves to travel a certain distance ALLOW count number of waves in a certain time for 2 marks If no other marks scored: (idea that) frequency is the number of waves per second for 1 mark
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Question			Answer	Marks	AO element	Guidance
2			A ✓	1	1.2	



Question			Answer	Marks	AO element	Guidance
3			D ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
10			A ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
2				D ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
5				A ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
10			A ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
12			C ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
3				B ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
12			B ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
13			D ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
7				D ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
10				A ✓	1	2.2	



Question	Answer	Marks	AO element	Guidance
11	D	1	2.1	



Question	Answer	Marks	AO element	Guidance
4	A	1	1.1	



Question	Answer	Marks	AO element	Guidance
12	A	1	2.1	



Question	Answer	Marks	AO element	Guidance
1	A	1	1.1	



Question	Answer	Marks	AO element	Guidance
5	A	1	1.1	



19	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 260 (s) award 4 marks (time =) distance ÷ speed ✓ distance = $(2.28 \times 10^{11} - 1.50 \times 10^{11}) = 7.8 \times 10^{10}$ (m) ✓ (time =) $7.8 \times 10^{10} \div 300\,000\,000$ ✓ (time =) 260 (s) ✓	4	1.2 3 × 2.1	ALLOW 0.8×10^{11} (m)
	(b)	(Mars is further from the Sun) so receives less energy/heat from the Sun/sunlight ✓ Temperature on Mars is lower ✓	2	2 × 3.2b	ALLOW other sensible explanation. e.g. Mars has a thin atmosphere / does not have an atmosphere so there is little/no greenhouse effect (AW) ALLOW it is difficult to know without knowing about the atmosphere on Mars

19	(a)	(i)	Arrow with direction vertically upwards ✓ Arrow from lowest energy level to highest energy level ✓	2	2 × 2.1	ALLOW to above the highest energy level
		(ii)	Excited and absorbed ✓ Higher than ✓	2	2 × 1.1	BOTH required for first mark
	(b)		Any four from: (Both lines show) redshift ✓ Redshift for galaxy B > redshift for galaxy A / ORA ✓ (Redshift means that) galaxy/galaxies are moving away (from the Earth) ✓ Galaxy B is further away (from the Earth than galaxy A) / ORA ✓ Galaxy B is moving faster (than galaxy A) / ORA ✓ Galaxy B is moving away from galaxy A ✓	4	3.1a 3.1a 1.1 3.2b	ALLOW galaxy with longest wavelength for galaxy B throughout answer DO NOT ALLOW one galaxy moving towards (the Earth) ALLOW the more distant galaxy is moving faster / ORA ALLOW galaxy B is moving away faster (than galaxy A) / ORA for 2 marks (mp3 and mp5)

21	(a)	The Earth is accelerating ✓	1	1.1	
	(b)	Any two from: Star A has higher (maximum) intensity than star B / Star B has lower (maximum) intensity than star A ✓ Star A graph intensity peaks at shorter wavelength than star B / Star B graph intensity peaks at longer wavelength than star A ✓	2	2 × 3.1a	IGNORE stronger/more radiation If no other marks are scored: ALLOW star A is hotter than star B / ORA

Question		Answer	Marks	AO element	Guidance
Maximum of 3 marks if only explanation of radiation absorbed/emitted or effect of Earth's atmosphere is mentioned.					
21	*	(c)	6	3 × 1.1 3 × 3.1b	AO1.1– Demonstrate knowledge and understanding of scientific ideas to explain the radiation absorbed and emitted by the Earth. - The Earth radiates (infrared) radiation back into space - The Earth emits less radiation than it absorbs. - If energy/radiation absorbed = energy/radiation emitted by the Earth, the temperature of the Earth stays constant - If energy/radiation absorbed > energy/radiation emitted by the Earth, the temperature of the Earth increases - The Earth absorbs UV/light/shorter wavelength (infrared) radiation - The Earth emits longer wavelength (infrared) radiation AO3.1b - Analyse information and ideas to explain the effect of the Earth's atmosphere on the actual temperature of the Earth. - Atmosphere/greenhouse gases trap/reflect (infrared) radiation - Amount of greenhouse gases is increasing - Greenhouse effect is increasing - Without atmospheric/greenhouse gases, temperature of the Earth would be very cold - Greenhouse gases/CO₂ in atmosphere absorb some of the Earth's emitted (infrared) radiation

		Level 1 (1–2 marks) A basic explanation of the radiation absorbed and emitted by the Earth OR a basic explanation of the effect of the Earth's atmosphere. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit.</i>			- Greenhouse gases/CO₂ in atmosphere emit (infrared) radiation - Some of the (infrared) radiation emitted by the Earth is radiated/reflected back towards the Earth's surface - Some of the (infrared) radiation emitted by the Earth is radiated/reflected by the atmosphere/ (greenhouse) gases/CO₂
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23	(a)	Our eyes can only detect / we can only see a small part of the EM spectrum/visible light ✓ So new inventions/technology/machines were needed (to detect beyond visible light) ✓	2	2 × 1.2	ALLOW we cannot see UV/IR ALLOW machines/inventions/technology were not available to detect it
	(b)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1.7×10^{15} (Hz) award 5 marks 0.18 μm = 1.8×10^{-7} m ✓ (Frequency =) wave speed ÷ wavelength ✓ (Frequency =) $3.0 \times 10^8 \div 1.8 \times 10^{-7}$ ✓ (Frequency =) 1.666666... × 10^{15} ✓ (Frequency =) 1.7×10^{15} (Hz) (2sf) ✓	5	3 × 1.2 2 × 2.1	ALLOW 3 marks for 1.6666×10^n (POT and SF error) ALLOW 4 marks for 1.7×10^n (POT error) ALLOW 1 mark for their value of frequency rounded correctly to 2SF
	(c) (i)	(Transmission) at 0.31 μm = 9-11 % AND (Transmission) at 0.37 μm = 41 % ✓ Absorption at 0.31 μm = 89-91 % AND Absorption at 0.37 μm = 59 % ✓ (much) more UV is absorbed at 0.31 μm compared to 0.37 μm / ORA ✓	3	3 × 3.1a	ALLOW the difference in transmission is between 30-32% ALLOW the difference in absorption is between 30-32% ALLOW ECF 100 minus their value from graph for absorption values ALLOW more UV is absorbed at shorter wavelengths / ORA
	(ii)	Any TWO from: Ozone layer absorbs/prevents <u>most/lots/some</u> UV / ORA ✓ Ozone layer absorbs the most dangerous UV ✓ (wavelengths)	2	2 × 2.1	DO NOT ALLOW Ozone absorbs <u>all</u> UV. ALLOW UV is harmful (to humans)

Question	Answer	Marks	AO element	Guidance
	(Too much) UV causes (skin) cancer/damages (skin) cells ✓			

18	a	i	(Wave speed =) frequency x wavelength ✓	2	1.1	ALLOW correct symbol equation eg $(v =) f \times \lambda$ ALLOW equation in any form ALLOW any frequency and corresponding wavelength from the table substituted into this equation IGNORE units for this marking point only
			3.2b		ALLOW 30 000 000 000 x 0.01 or 30 000 000 000 x 1×10^{-2} ALLOW reverse arguments using speed and wavelength or speed and frequency	
			30 x 10 ⁹ x 0.01 or 30 x 10 ⁹ x 1×10^{-2} ✓			

Question			Answer	Marks	AO element	Guidance
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 100 (nm) award 3 marks (Wavelength =) velocity ÷ frequency ✓ $\frac{3 \times 10^8}{3000 \times 10^{12}}$ or 1×10^{-7} ✓ = 100 (nm) ✓	3	1.2 2.1 2.1	ALLOW ($\lambda =$) $v \div f$ IGNORE $v = f \times \lambda$ and $f = v / \lambda$ or words ALLOW 3×10^8 divided by any frequency from the table IGNORE units for this marking point only
	b		(skin) cancer / (skin) aging ✓	1	1.1	ALLOW sunburn / blisters / wrinkles / mutates cells / ionises cells IGNORE kills cells / damages cells / just burns
	c	i	120 (minutes) ✓	1	2.2	
	c	ii	Any two from: children have (more) sensitive skins ✓ children have cells / skins that are more at risk from skin cancers ✓ children lack awareness of the time they spend in the sunshine ✓ the idea that they advise a higher SPF than they (really) need just to be sure they are safe ✓	2	1.1 2.1	IGNORE just to reduce risk of burning ALLOW skin is vulnerable / more easily damaged / more affected by UV / delicate / has less melanin / AW ALLOW idea that damage to cells builds up over time ALLOW children are outside for longer / spend more time in the sun



Question	Answer	Marks	AO element	Guidance
d*	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) A detailed explanation of how ultrasound and X-rays are used. AND A detailed evaluation of the risks / benefits of using the two different waves to scan patients in hospital, which may include use of information from the table. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) An explanation of how ultrasound and X-rays are used. AND An evaluation of the risks / benefits of using the two different waves to scan patients in hospital. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) EITHER An explanation of how ultrasound and X-rays are used. OR An evaluation of the risks / benefits of using the two different waves to scan patients in hospital. OR An explanation of ultrasound or X-rays AND an evaluation of the risks / benefits of ultrasound or X-rays. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks - No response worthy of credit.	6	2 x 1.2 1 x 2.2 1 x 3.1b 2 x 3.2a	AO1.2 Demonstrate knowledge and understanding of X-rays and ultrasound X-rays show bone Ultrasound shows eg soft tissue / kidneys/ blood flow / prenatal scan AO2.2 Applies knowledge and understanding of X-rays and ultrasounds X-rays damage / ionise living cells / causes cancer / damage foetus Ultrasound is harmless AO3.1b Analyses information to evaluate the differences in X-rays and ultrasound X-rays are absorbed by bone but do not show up soft tissues Ultrasound is (partially) reflected for soft tissues only AO3.2a Analyses information to make judgements about the risks and benefits: Ultrasound always safe and useful for soft tissue scanning X-rays can cause cancer but save lives with identifying bone problems X-rays have a frequency greater than 3×10^{16} Hz / (very small) wavelengths less than 10 nm to penetrate the body

Question	Answer	Marks	AO element	Guidance
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Question			Answer	Marks	AO element	Guidance
3			B ✓	1	2.2	



Question			Answer	Marks	AO element	Guidance
15			B ✓	1	1.2	

Question			Answer	Marks	AO element	Guidance
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Question			Answer	Marks	AO element	Guidance
8			A ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
13			D ✓	1	2.2	



Question				Answer	Marks	AO element	Guidance
10				B ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
5				A ✓	1	1.2	



Question				Answer	Marks	AO element	Guidance
6				A ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
8				C ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
11				B ✓	1	1.2	



Question	Answer	Marks	AO element	Guidance
2	D	1	2.1	ALLOW 4.8 (s)



Question	Answer	Marks	AO element	Guidance
5	A	1	1.1	



Question	Answer	Marks	AO element	Guidance
6	C	1	1.1	



Question	Answer	Marks	AO element	Guidance
9	D	1	1.1	



Question	Answer	Marks	AO element	Guidance
6	D	1	1.1	



Question	Answer	Marks	AO element	Guidance
9	A	1	2.1	



Question	Answer	Marks	AO element	Guidance
9	C	1	1.1	

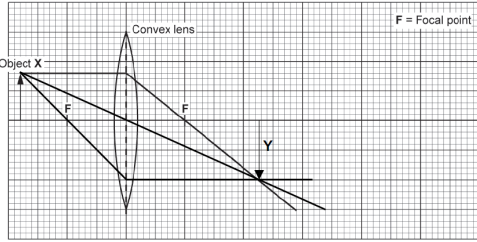


Question	Answer	Marks	AO element	Guidance
12	B	1	1.1	

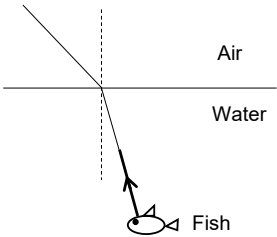


22	*	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Detailed description of the structure of the Earth AND Detailed explanation of the trends in Table 22.1. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Description of the structure of the Earth. AND Explanation of the trends in Table 22.1. OR Detailed description of the structure of the Earth. OR Detailed explanation of the trends in Table 22.1. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) A basic description of the structure of the Earth. OR A basic description of the trends in Table 22.1. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i>	6	2×3.1a 2×3.2a 2×2.1 AO3.1a Analyse information and ideas to interpret some basic trends in data • density increases as depth increases • speed (of P/S waves) increases as density increases • speed (of P/S waves) increases as depth increases AO2.1 Apply knowledge and understanding of scientific ideas to explain trends in the data • Earth contains layers • velocity changes at a boundary • as density changes at a boundary • particles more tightly packed • P is longitudinal, S is transverse AO3.2a Analyse information and ideas to make judgements about the structure of the Earth • core has highest density • core has highest speed for P waves • S waves do not travel through the core • so the outer core is a liquid • pressure highest in core / $P = \rho gh$ • pressure and so density increase with depth • large change in density between mantle and outer core
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Question	Answer	Marks	AO element	Guidance
	0 marks <i>No response or no response worthy of credit.</i>			

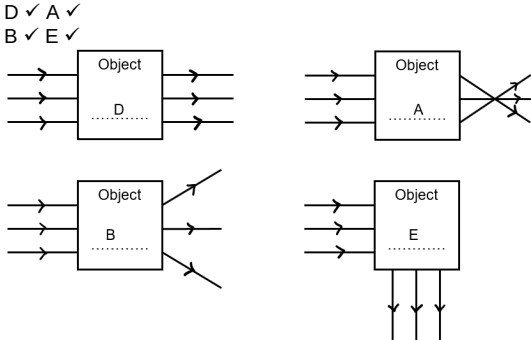
16	(a)	Either ray (centre ray or focal ray) drawn as indicated below ✓  Image upside down AND in the correct place ✓	2	2 × 2.2	ALLOW just one ray drawn If no rays drawn (or incorrect) but image is inverted, slightly larger and roughly in the correct place then award this mark IGNORE position of Y (if arrow is in the correct place) ALLOW tolerance of +/- 2 squares for image position
	(b)	A (red) filter is needed ✓ (The red filter) absorbs all colours/frequencies/wavelengths except red (light) ✓	2	2 × 2.1	ALLOW The red filter absorbs blue and green (light/frequency/wavelength) (but not red) ALLOW the filter transmits red light <u>only</u> / <u>only</u> lets red (light/frequency/wavelength) through
	(c) (i)	230 (V) ✓	1	1.1	

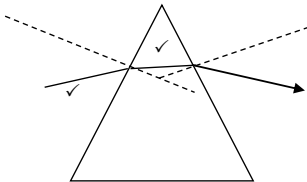
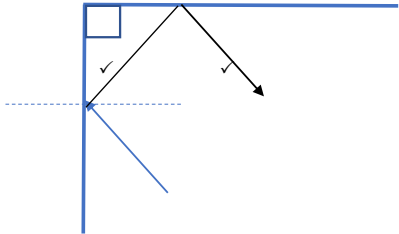
Question	Answer	Marks	AO element	Guidance
(ii)	(Earth wire together with fuse) prevents user from getting electric shock (if there is a fault) ✓ Plastic case is an insulator (so earth wire not required) ✓	2	2 × 1.1	ALLOW metal case could cause electric shock if no earth wire / AW ALLOW idea of earth wire carries current to Earth / AW ALLOW prevents projector becoming live / AW ALLOW plastic case is not a conductor / does not conduct electricity/current ALLOW appliance is double insulated

16	(a)	(i)	Any one from: It is refracted ✓ It changes direction/bends (away from the normal) ✓ The speed <u>increases</u> ✓ The wavelength <u>increases</u> ✓	1	1.1	DO NOT ALLOW bends towards the normal IGNORE speed/wavelength changes DO NOT ALLOW the speed/wavelength decreases
		(ii)	Ray continues in a straight line AND normal line drawn (90° by eye relative to interface) where incident ray meets the interface ✓ Ray enters the air AND is to the left of the normal line ✓ angle of refraction > angle of incidence AND angle of incidence < 90° ✓ 	3	3 × 1.2	DO NOT ALLOW if the ray emerges vertically or to the right-hand side of the normal IGNORE any reflected rays IGNORE direction of any arrows ALLOW marking points 2 and 3 to be awarded if the ray does not come from the fish
	(b)		At least two of the rays are reflected in different directions ✓	1	1 × 1.2	IGNORE any normal lines
	(c)		The fish <u>absorbs</u> the green (light) / <u>does not reflect</u> the green (light) / the fish reflects red (light) <u>only</u> ✓ There is no red (light) (to reflect) / the (green) light contains no red (light) / no light is reflected ✓	2	2 × 2.1	

22	(a)	First check the answer on the answer line If answer = 2.1×10^{-4} (m) award 3 marks select equation: (distance =) speed x time ✓ substitution: (distance =) $1500 \times (2.8 \times 10^{-7} \div 2)$ ✓ evaluation: (distance =) 2.1×10^{-4} (m) ✓	3	1.1 2 × 2.2	ALLOW 4.2×10^{-4} (m) for 2 marks (did not divide by 2) ALLOW equation in any form ALLOW (distance =) $1500 \times 2.8 \times 10^{-7}$ for 1 mark
	(b)	First check the answer on the answer line If answer = $3.48837 \dots \times 10^6$ (Hz) award 3 marks If answer = 3.5×10^6 (Hz) award 4 marks substitution: $1500 = \text{frequency} \times 4.3 \times 10^{-4}$ ✓ rearrangement: (frequency =) $1500 \div 4.3 \times 10^{-4}$ ✓ evaluation: (frequency =) $3.48837 \dots \times 10^6$ (Hz) ✓ evaluation to 2sf : (frequency =) 3.5×10^6 (Hz) ✓	4	1.2 3 × 2.2	ALLOW substitution and rearrangement in either order. ALLOW rearrangement in words or symbols ALLOW incorrect answer correctly rounded to 2sf for this mark if calculation attempted
	(c)	Sound wave travels faster in muscle/denser materials ✓ Frequency remains constant therefore wavelength increases ✓	2	2 × 1.1	



16	(a)		4	4 × 1.2		
	(b)	First check the answer on answer line If answer = 4.6×10^{14} (Hz) award 4 marks Rearrange to give: $(f =) v \div \lambda$ ✓ $(f =) 2 \times 10^8 \div (4.33 \times 10^{-7})$ ✓ $(f =) 4.62... \times 10^{14}$ (Hz) ✓ $(f =) 4.6 \times 10^{14}$ (Hz) (2sf) ✓	4	1.2 2.1 2.1 1.2	ALLOW 1 mark for correct substitution into unrearranged equation e.g., $2 \times 10^8 = f \times 4.33 \times 10^{-7}$ ALLOW $4.62... \times 10^n$ for 2 marks ALLOW 4.6×10^n for 3 marks ALLOW this mark for clear evidence of an incorrect answer (correctly rounded) to two significant figures (not a bald incorrect answer to 2 s.f.)	
16	(c)	(i)	(shirt) Black (number) Blue ✓	1	2.1	Both required for 1 mark
		(ii)	(White) number (and shirt) reflects red (light only) / (white) number (and shirt) looks red / (white) number and shirt look the same colour ✓	1	2.1	ALLOW (idea that) both look red / whole shirt looks red / both look the same colour DO NOT ALLOW red is absorbed by shirt/number / both look any incorrect colour IGNORE they blend in IGNORE any other colours absorbed

18	(a)	Diagram showing correct refractions 	2	2×1.2	If diagram is incorrect, maximum of one mark from: any rising line in air before the prism ✓ a line in the prism close to horizontal by eye and joining the exit ray ✓ IGNORE any arrows on rays	
	(b)		2	2×1.2	One mark for each correct reflection of about 90° by eye IGNORE any arrows on rays	
	(c)	(i)	(Filter X lets through) red, orange and yellow ✓	1	3.2b	DO NOT ALLOW any extra colours
		(ii)	(Filter Y absorbs) orange and yellow ✓	1	3.2b	DO NOT ALLOW any extra colours
	(d)	(i)	Any one from: Red (wall) absorbs all colours (in the light except red) ✓ (The wall) only reflects red light ✓	1	2.1	ALLOW there is no red in the coloured light to reflect / AW ALLOW (wall) cannot reflect other colours (of light)

Question			Answer	Marks	AO element	Guidance
		(ii)	Any two from: green ✓ blue ✓ indigo ✓ violet ✓ cyan ✓	1	2.1	DO NOT ALLOW orange / yellow / magenta
	(e)	(i)	Ray of green light focused between lens and F_R ✓	1	1.2	
		(ii)	green has shorter wavelength or higher frequency (than red) / shorter wavelengths refract more / show a larger change in speed / green light slows down more (than red light) / AW / ORA ✓	1	2.1	IGNORE green (light) refracts more IGNORE just green (light) slows down
		(iii)	long sighted✓ (Because lens is) convex/focusing/converging ✓	2	3.1a 3.2b	Mark independently

22	(a)	Refraction ray drawn with angle of refraction smaller than angle of incidence ✓	1	1.2	Judge by eye IGNORE direction of arrow and length of ray
	(b)	Glass is more (optically) dense than air ✓ The speed of light is lower in glass ✓	2	2 × 1.1	ALLOW glass has a different (optical) density (to air) DO NOT ALLOW glass is less (optically) dense ALLOW glass has a different refractive index (to air) ALLOW (the light) slows down DO NOT ALLOW the speed of light is higher in glass IGNORE ideas about wavelength and frequency If no other mark scored: ALLOW light changes speed (in glass)
22	(c)	(i) Measure angles with a protractor ✓ Angle (of incidence and angle of refraction) measured between ray and normal ✓ And any two from: Draw normal (where ray enters block) ✓ Trace along light rays (with a pencil) ✓ Detail on tracing rays e.g., draw crosses along rays first then remove block and join them up ✓ Change the angle of incidence (to measure different angles of refraction) ✓ Plot a graph to show relationship between angle of incidence and angle of refraction ✓	4	2 × 1.2 2 × 3.3a	ALLOW can be shown on Fig 22.1 ALLOW draw line at 90° (where ray enters block) ALLOW draw a line entering block and shine laser along it ALLOW use of pins on rays to trace where the light rays are
	(c)	(ii) Calculate a constant from one pair of data values ✓ Calculate a constant from a different pair of angles and compare ✓	2	2 × 3.2a	e.g., $22/14 = 1.57$ $34/22 = 1.55$ $48/30 = 1.60$ $55/33 = 1.67$ $62/36 = 1.72$ ALLOW use of vertical ratios e.g., $48/34 = 1.41$ $30/22 = 1.36$ etc ALLOW use of calculated constant from one pair of data values to show that it does not work with another pair of data values e.g., $22/14 = 1.57$ and $48 \div 1.57 \neq 30$ ALLOW use of vertical ratios e.g., $48/34 = 1.4$ but $30/22 = 1.36$ etc
	(d)	(Green and red light have) different wavelengths/frequencies ✓ (Idea that) the amount the speed changes (in glass) is different for each colour ✓	2	2 × 1.1	ALLOW red light has longer wavelength/smaller frequency / ORA DO NOT ALLOW red light has shorter wavelength/larger frequency / ORA ALLOW red light slows down the least (in glass) / ORA ALLOW speed of red light in glass is larger (than speed of green light) ALLOW speed in glass is different for each colour DO NOT ALLOW speed of red light in glass is smaller (than speed of green light) / ORA
	(e)	Both rays drawn as straight lines and refract towards principal axis ✓ The green ray crosses the principal axis closer to the lens than the red ray ✓	2	1.2 1.1	



19	(a)		Ultrasound waves are <u>longitudinal</u> ✓ OR Ripples are <u>transverse</u> ✓ Oscillations/vibrations (of particles) in ultrasound/longitudinal waves are <u>parallel</u> to the direction of energy transfer / ultrasound has compressions and rarefactions ✓ OR Oscillations/vibrations (of particles) in the ripples/transverse waves are <u>perpendicular</u> to the direction of energy transfer ✓	2	2 × 1.1	ALLOW direction of travel/propagation for energy transfer IGNORE direction of wave motion
	(b)	(i)	0.0022 (m) ✓	1	2.2	
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 2.0×10^6 (Hz) award 4 marks (Rearrange: frequency =) speed / wavelength OR (f =) 4500 / 0.0022 ✓ (f =) 2 045 455 (Hz) ✓ (f =) 2 000 000 (Hz) ✓ (f =) 2.0×10^6 (Hz) ✓	4	1.2 2 × 2.1 1.2	ALLOW ecf from (b)(i) ALLOW three marks for 2.0 MHz ALLOW a mark for their answer to 2 significant figures ALLOW a mark for their answer in standard form
	(c)		Decreases ✓ Stays the same ✓	2	2 × 2.1	

Question	Answer	Marks	AO element	Guidance
(d) (i)	(Partial) reflection/absorption at the front of the kidney ✓ (Partial) reflection at the back of the kidney ✓	2	2 × 2.1	Both of the marking points can be awarded by a suitably clear diagram (or additional drawings on the given diagram) ALLOW 1 mark maximum for just reflection/bounces back
(ii)	Measure the <u>time</u> between reflections ✓ Use distance = $\frac{1}{2} \times \text{speed} \times \text{time}$ (to find the size) ✓	2	2 × 2.2	ALLOW distance = speed x time and mention of time halved
(e)	There is no (known) risk associated with ultrasound / ultrasounds are safer than X-rays / X-rays pass through soft tissue (so would not detect the kidney) / X-rays are ionising (radiation) ✓	1	1.1	ALLOW X-rays used to detect bones/pass through kidney ALLOW ultrasound detects soft tissue/organs