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OCR GCSE PHYSICS A (J249): QUESTIONS BY TOPIC

Topic P5: Waves in matter (F)

GCSE Physics A Foundation Tier (J249) · Topic P5

61 questions · 217 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

18 questions · 50 marks

65

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QUESTIONS

61 questions · 217 marks · grouped by sub-topic, lowest tariff first



SUB-TOPIC P5.1

WAVE BEHAVIOUR

23 questions in this sub-topic · 96 marks · lowest tariff first



10 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]



12 A radio wave has a wavelength of 100 m. It has a speed of 3×10^8 m/s.

Use the equation: Wave speed = Frequency $\times$ Wavelength

Calculate the frequency of the wave.

- A** 3 MHz
- B** 30 MHz
- C** 300 MHz
- D** 3000 MHz

Your answer

[1]



2 A teacher measures the speed of water waves in a ripple tank.

What apparatus should she use?

- A** Ammeter and stopwatch
- B** Newton-meter and ruler
- C** Ruler and protractor
- D** Ruler and stopwatch

Your answer

[1]

14 A sound wave travels in air and enters water.

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

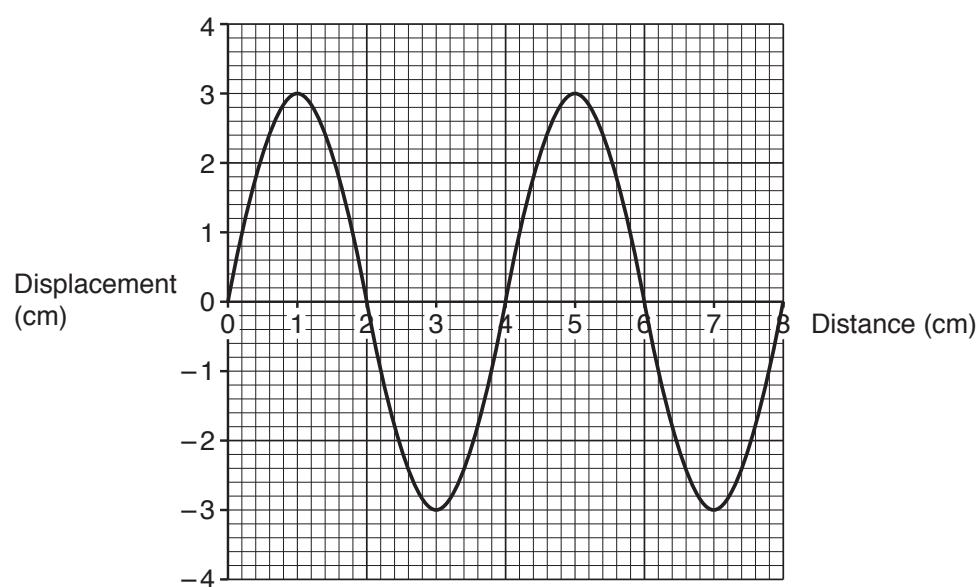
	Speed	Frequency	Wavelength
A	decreases	decreases	decreases
B	decreases	stays the same	decreases
C	increases	increases	increases
D	increases	stays the same	increases

Your answer

[1]



6 Look at the diagram of a wave.



What is the wavelength of the wave?

- A 2 cm
- B 3 cm
- C 4 cm
- D 6 cm

Your answer

[1]

15 Four students measure the time it takes a wave to travel the length of a ripple tank.

Each student collects three measurements of the time.

Student	Time taken (s)		
	1st measurement	2nd measurement	3rd measurement
A	2	2	1
B	2.1	2.1	2.4
C	2.1	2.0	2.2
D	2.11	2.49	2.23

Which student collected the **most** precise data?

Your answer

[1]



1 Estimate the reaction time of a student.

A 0.02 s

B 0.2 s

C 2 s

D 20 s

Your answer

[1]



6 Water waves are made in a ripple tank.

A student counts 4 waves passing a point per second.

What has the student worked out?

- A** Amplitude
- B** Frequency
- C** Period
- D** Wave speed

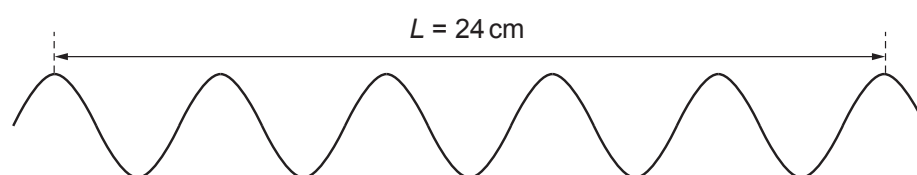
Your answer

[1]



15 A student makes a wave in a ripple tank.

The student measures distance, L .



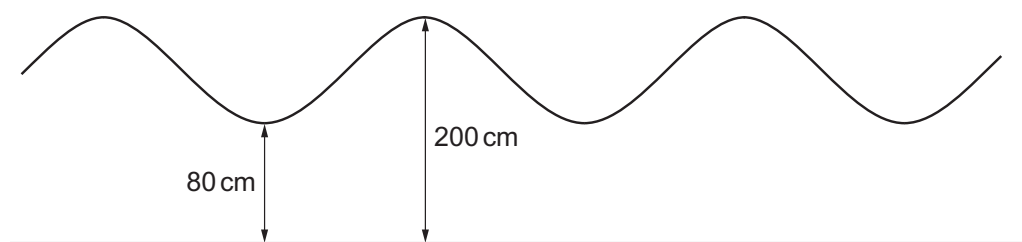
What is the wavelength of the wave?

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

Your answer

[1]

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



What is the amplitude of the waves?

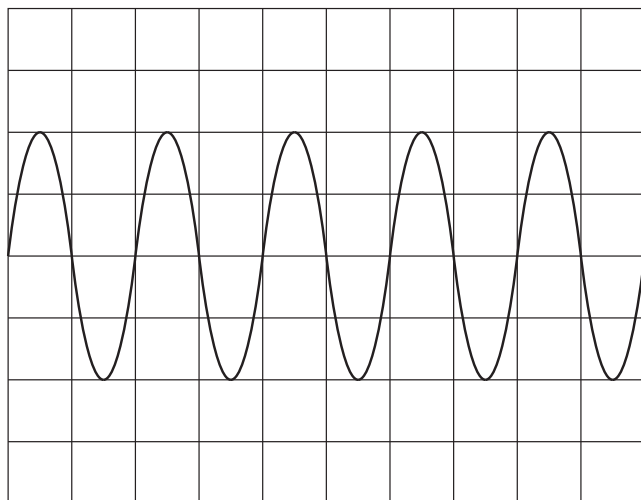
- A 60 cm
- B 80 cm
- C 120 cm
- D 200 cm

Your answer

[1]

2 An oscilloscope is used to display a wave.

How many complete waves are shown on the oscilloscope screen?



A 2

B 4

C 5

D 10

Your answer

[1]

14 A sound wave travels from air into water.

Which quantity stays the **same**?

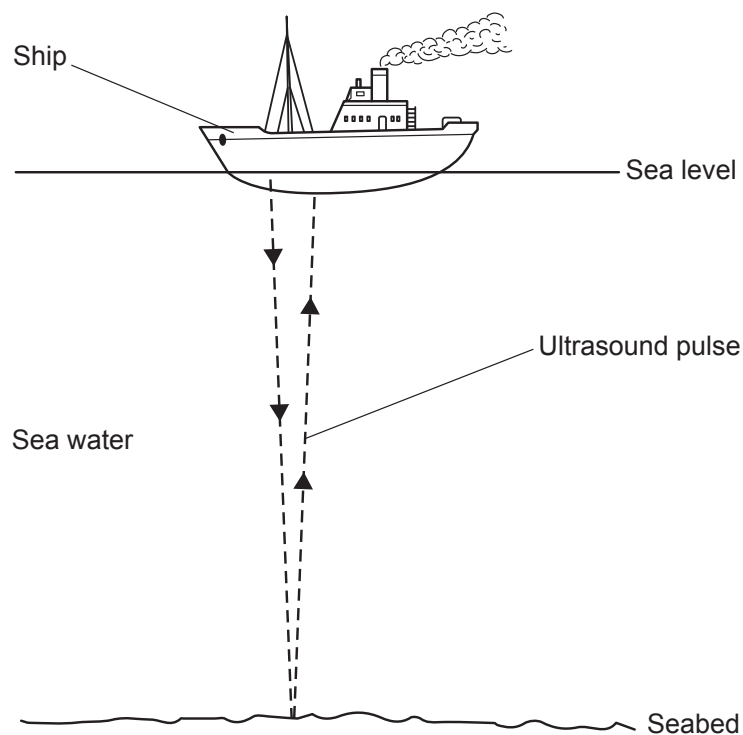
- A Amplitude
- B Frequency
- C Speed
- D Wavelength

Your answer

[1]



15 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]

- 15** 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]



19 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 greater than the speed of sound.

He decides to do an experiment to measure the speed of sound waves in air.

(a) Describe which measurements he needs to measure this speed.

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

(b) Which equation is used to calculate speed?

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

(c) Describe one way he could get valid results for this experiment.

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



18 A musician plays a guitar.

This makes a sound wave in the air.

(a) The frequency of the sound wave is 440 Hz.

The speed of sound is 330 m/s.

Calculate the wavelength of the sound wave.

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

Wavelength = ... m **[3]**

(b) Explain how sound travels through the air from the guitar.

Write about air particles in your answer.

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

(c) Fig. 18.1 is a graph of a sound wave.

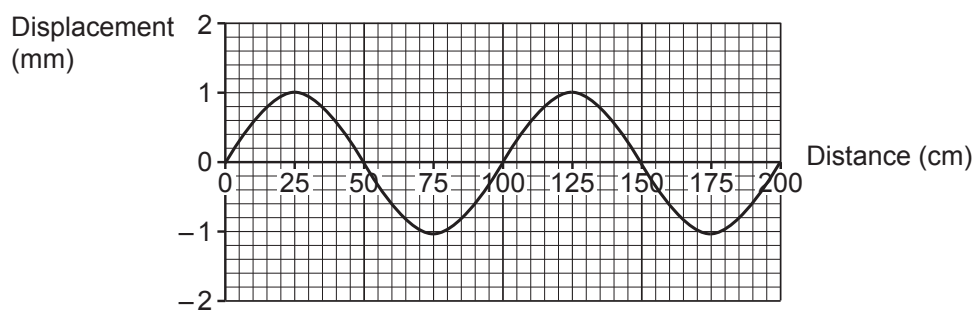


Fig. 18.1

Another sound wave has a **higher** frequency. The amplitude of the wave remains the **same**.

Draw this sound wave on Fig. 18.2.

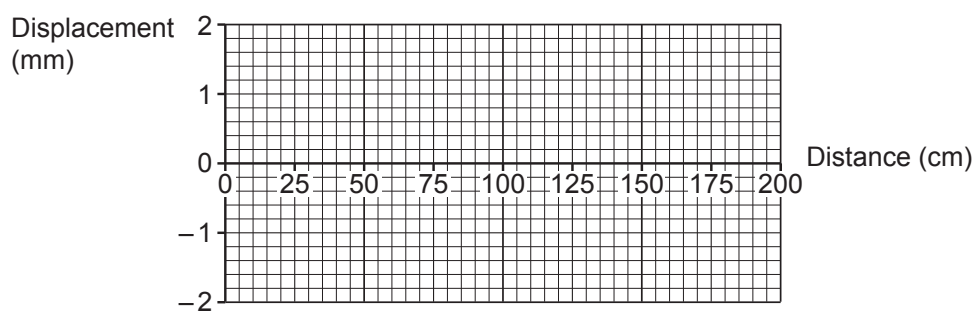


Fig. 18.2

[2]

20 (a) Fig. 20.1 is a graph of a wave.

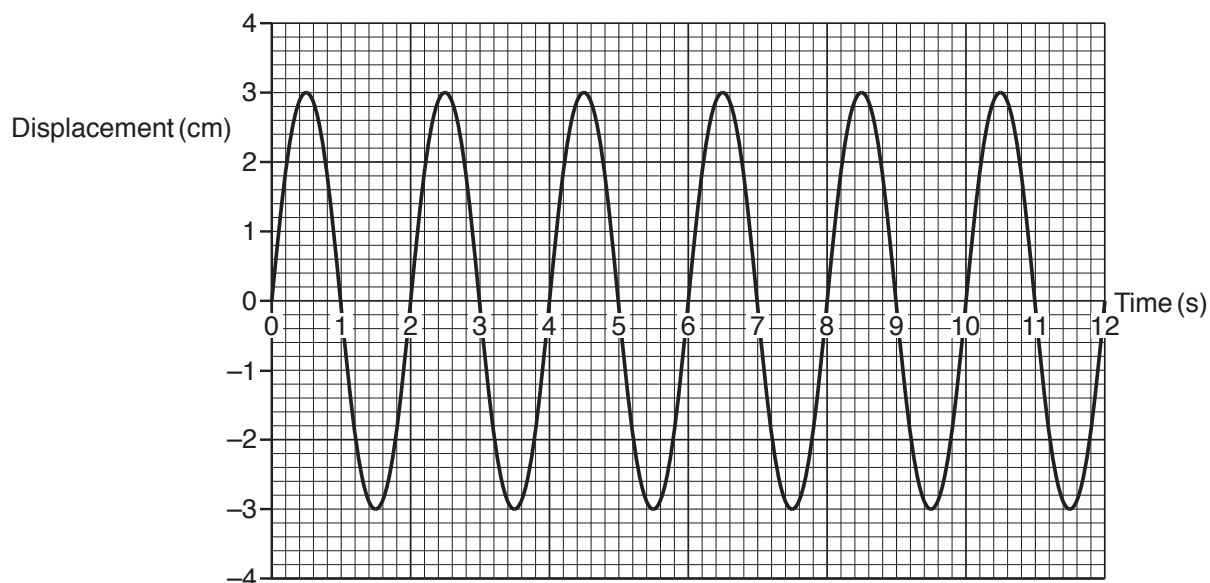


Fig. 20.1

(i) Use the graph in Fig. 20.1 to work out the time period of the wave.

Time period of the wave = ... s [1]

(ii) Use the graph in Fig. 20.1 to work out the amplitude of the wave.

Amplitude = ... cm [1]

(iii) The frequency of the wave in Fig. 20.1 is 0.5 Hz.

What is meant by the term **frequency**?

.....
 [1]

(b) A water wave has a frequency of 0.25 Hz and a wavelength of 6.0 m.

Calculate the speed of the wave.

Speed of the wave = ... m/s [3]

- (c) Surface water waves can be modelled using a slinky spring.

A student holds one end of the spring on a table. The other end is fixed to a wall.

Fig. 20.2 shows the spring **viewed from above the table**.

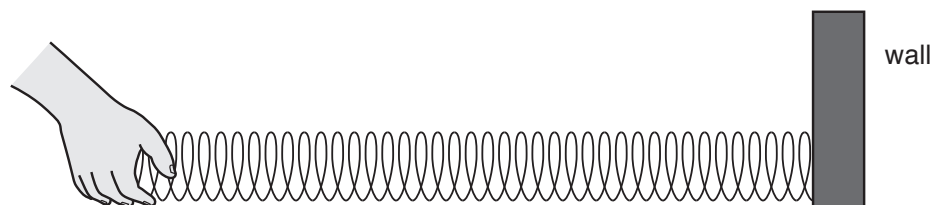


Fig. 20.2

- (i) Draw two arrows **on the diagram** in **Fig. 20.2** to show the movement of the student's hand when he makes a transverse wave. [1]

- (ii) Describe what happens to the **transverse** wave at the wall.

.....

.....

..... [1]

- (iii) In **Fig. 20.3** the student stops moving his hand.

This is what the coils in the spring look like after a short time:

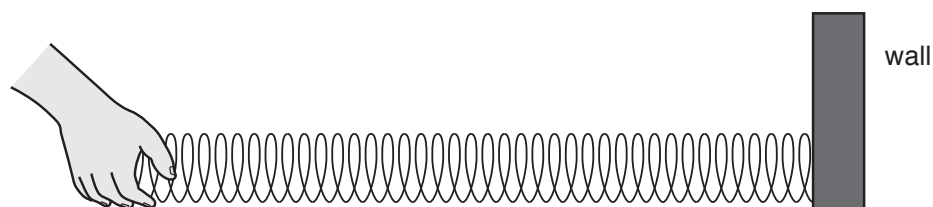


Fig. 20.3

This model of a water wave shows that the wave travels **not** the water.

Explain why.

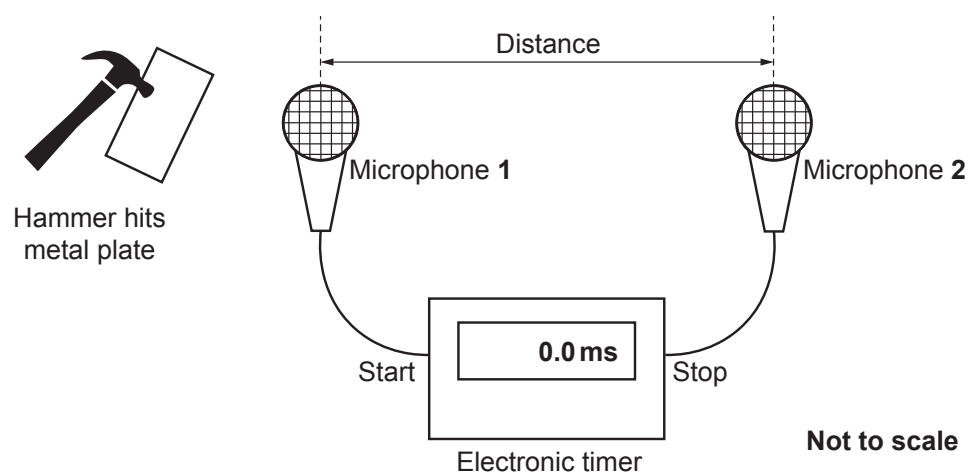
.....

.....

..... [1]

21 A student measures the speed of sound.

They use this equipment:



This is the student's method:

- A sound is created when the hammer hits the metal plate.
- When the sound reaches microphone 1, the electronic timer starts.
- When the sound reaches microphone 2, the electronic timer stops.
- This process is repeated several times.

(a) They record the time displayed on the timer in a table:

Measurement	Time (ms)
1	6.7
2	6.3
3	6.7
4	6.6

Calculate the mean time.

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

Mean time = ... ms [2]

(b) They do **not** place the hammer and plate **between** the two microphones.

Suggest **one** reason why.

.....
 [1]

(c) Another student repeats the same experiment.

These are the student's measurements:

- The distance between the microphones is 2.4 m.
- The mean time measured is 7.5 ms.

(i) Calculate the speed of sound.

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

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

(ii) Describe how the student can measure the distance between the microphones.

.....
 [1]

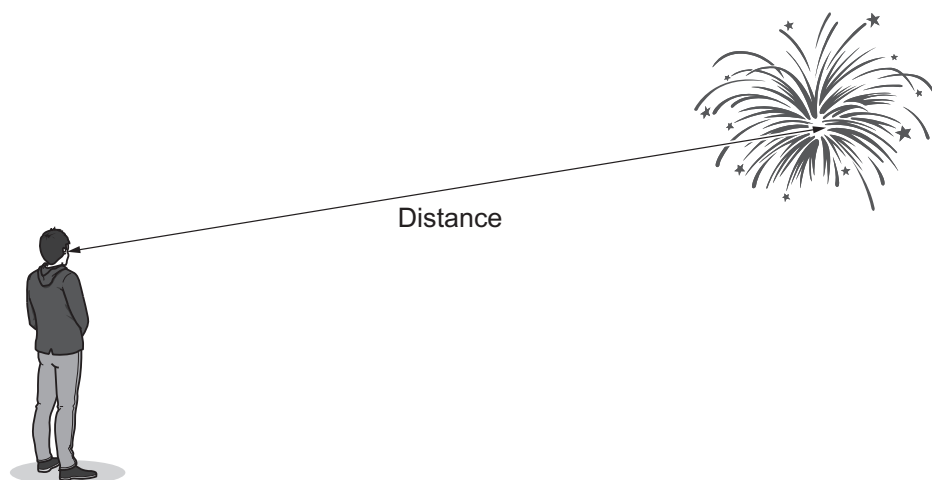
(iii) The student looks up the speed of sound on a reliable website. They find the value for the speed of sound is 330 m/s.

Suggest why this is different from your value calculated in **21(c)(i)**.

.....
 [1]



18 A child is watching a firework display.



(a) The speed of light in air is 3×10^8 m/s.

Explain why the child sees the firework **before** they hear it.

.....
 [1]

(b) Complete each sentence below about sound travelling through air.

Use the words from the list.

electromagnetic

longitudinal

parallel

perpendicular

transverse

Sound waves are

The air particles vibrate to the direction of travel of the wave.

[2]

- (c) The child measures the time between seeing and hearing the firework.

The time they measure is 0.42 s.

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

Calculate the distance from the child to the firework.

Give your answer to 2 significant figures.

Use the Data Sheet.

Distance = ... m [4]

- (d) Explain why the distance calculated in (c) is not the actual distance.

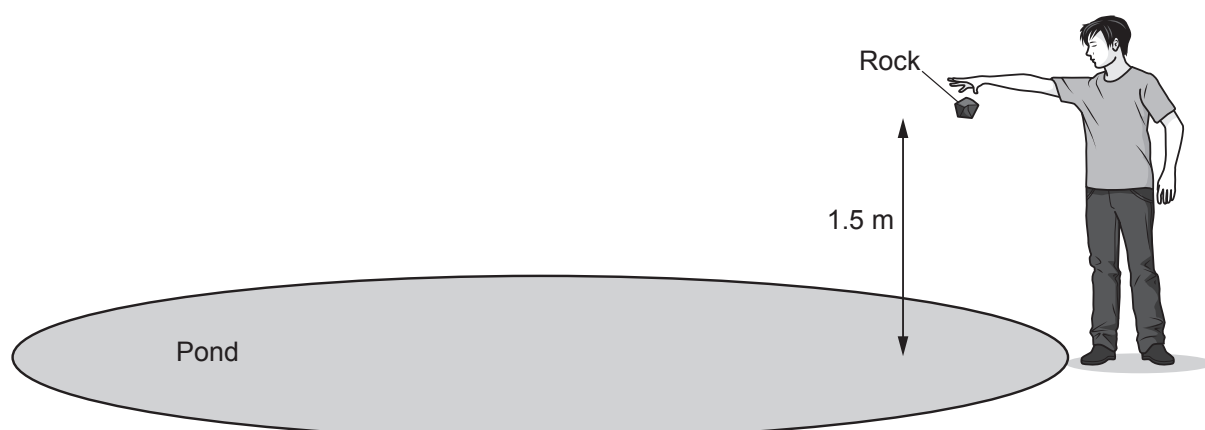
.....

.....

.....

..... [2]

- 22** 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.

.....

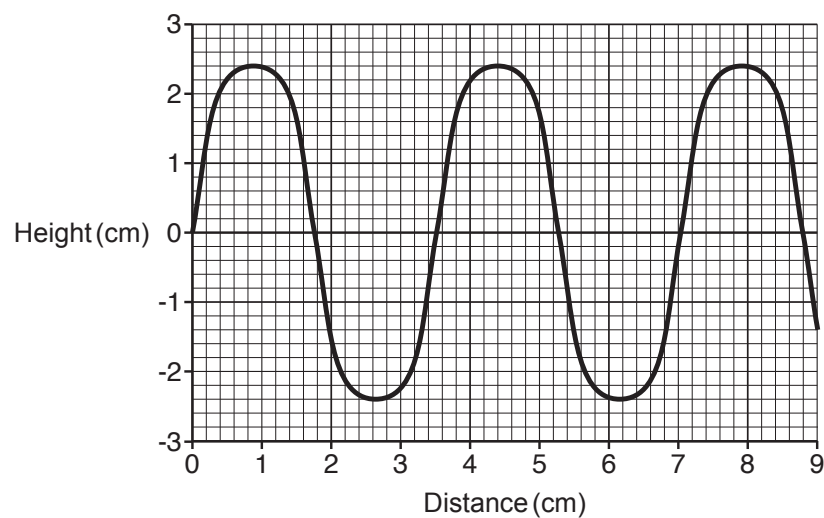
 **[2]**

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

.....

 **[3]**

16 Look at the diagram of a water wave.



(a) (i) What is the **wavelength** of this wave?

Answer = ...cm [1]

(ii) What is the **amplitude** of this wave?

Answer = ...cm [1]

(iii) The wavelength of the wave is changed to 25 cm. Two waves are produced each second.

Use the equation: Wave speed = Frequency $\times$ Wavelength

Calculate the speed of the wave.

Answer = ...m/s [2]



(b) Water waves are transverse and sound waves are longitudinal.

(i) Describe how water particles move in a **transverse** water wave.

.....
 [1]

(ii) Describe how air particles move in a **longitudinal** sound wave.

.....
 [1]

(c) Look at the diagram of the electromagnetic spectrum.

Radio	Microwave	Infra-red	Visible light	Ultra-violet	X-rays	Gamma-rays
-------	-----------	-----------	---------------	--------------	--------	------------

(i) Name a wave that has a longer wavelength than red light.

..... [1]

(ii) Name a wave that has a higher frequency than violet light.

..... [1]

(iii) State two **uses** of gamma-rays.

1.
 2.
- [2]



17 Ripples are made on the surface of the water. The ripples can be used to model waves.

(a) (i) State the type of wave modelled by the ripples.

..... [1]

(ii) Describe how the water molecules move as the wave travels across the pond.

.....
 [1]

(iii) 10 ripples hit the side of the pond in 20 seconds.

Calculate the frequency of the ripples.

Frequency = ... Hz [2]

(b) Student **A** and student **B** drop stones into a pond.

(i) Student **A** measures the frequency and wavelength of the water ripples. **Table 17.1** shows his results:

Frequency (Hz) of ripples	0.6
Wavelength (m) of ripples	0.1

Table 17.1

Calculate the wave speed of the ripples.

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

Wave speed = ...m/s [2]



- (ii) Student **B** measures the same ripples as student **A**.

She measures:

- The distance one ripple travels.
- The time it takes the ripple to travel this distance.

Table 17.2 shows student **B**'s results:

Distance ripple travels (m)	2.40
Time taken (s)	30.0

Table 17.2

Name the equipment student **B** uses to measure the distance and time.

Distance

Time [2]

- (iii) Use results in **Table 17.2** to calculate the wave speed of the ripples.

Wave speed = ...m/s [3]

- (iv) Student **A** and student **B** obtained different answers for the wave speed of the ripples.

Suggest why.

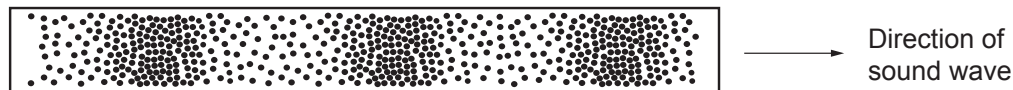
.....

 [1]

16 This question is about waves.

(a) Fig. 16.1 shows a diagram of a sound wave travelling through air.

Fig. 16.1



The dots in the diagram represent air particles.

(i) Which type of wave is a sound wave?

Put a ring around the correct answer.

electromagnetic

longitudinal

radio

transverse

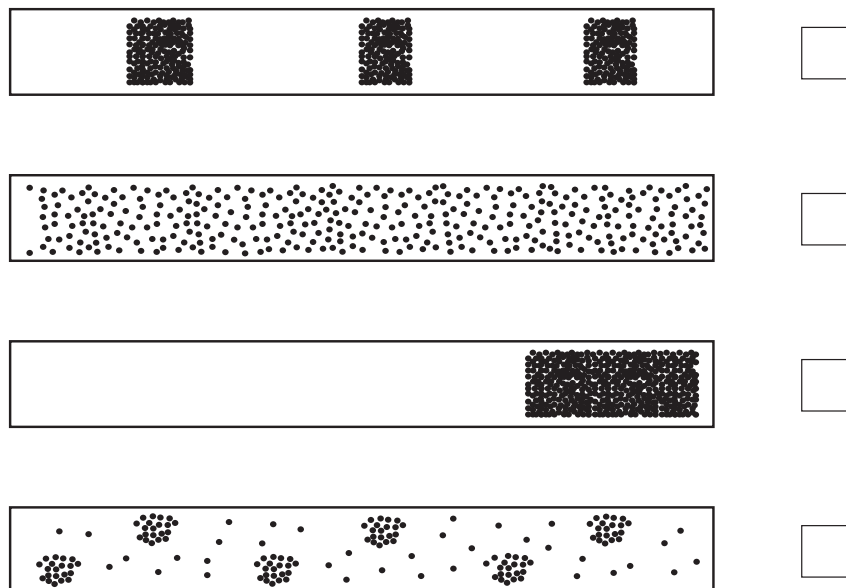
[1]

(ii) Fig. 16.2 shows four diagrams of the air particles after the sound wave has passed.

Which diagram is correct?

Tick (✓) **one** box.

Fig. 16.2



[1]

- (b) Complete the sentences to describe what happens to the properties of a sound wave as it travels **from** air **into** water.

Use words from the list.

decreases	increases	stays the same
-----------	-----------	----------------

The frequency of the sound wave

The velocity of the sound wave

The wavelength of the sound wave

[2]

- (c) The lists show two groups of words about waves: a **start** of a sentence and an **end** of a sentence.

Draw **one** line from each **start** of the sentence to the matching **end** of the sentence.

Start

End

Amplitude

is an electromagnetic wave.

Light

is the maximum displacement of a wave.

Wavelength

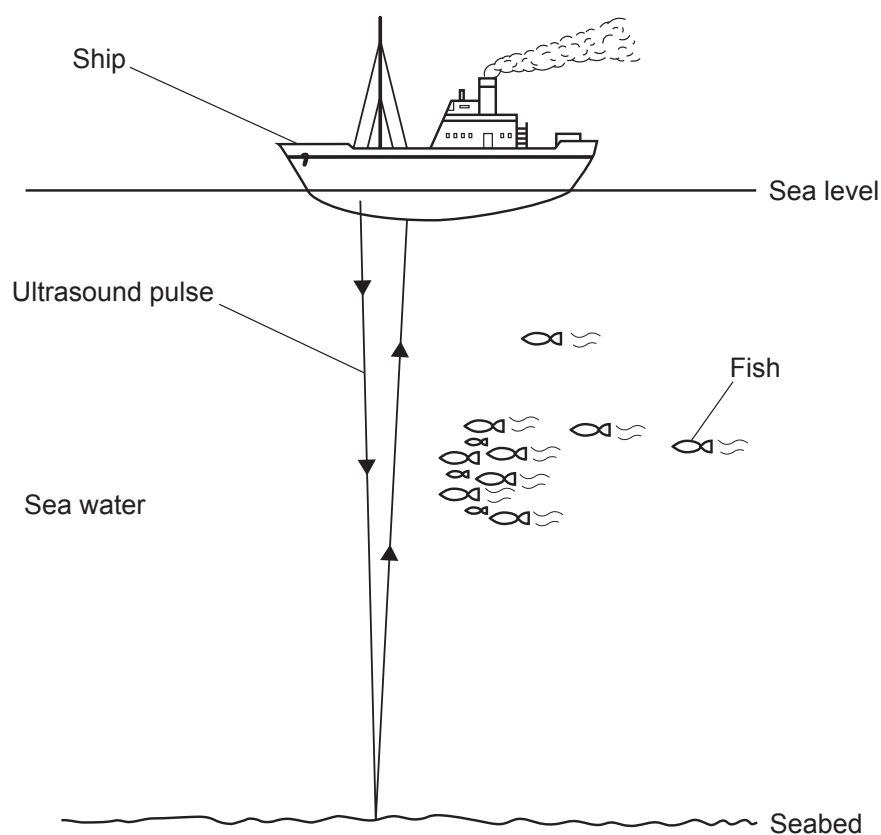
is the distance between one wave peak and the next wave peak.

[2]



(d) Fig. 16.3 shows how ultrasound pulses can be used to find distances in water.

Fig. 16.3



(i) Sometimes more than one echo is received by the ship from each ultrasound pulse.

Suggest why.

.....
 [1]

(ii) An ultrasound pulse takes 0.60 s to travel to the seabed and back to the ship.

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

Calculate the distance from the ship to the seabed.

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

(e) A sound wave has a frequency of 500 Hz.

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

Calculate the wavelength of the sound wave.

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

Wavelength = ... m [3]



SUB-TOPIC P5.2

THE ELECTROMAGNETIC SPECTRUM

20 questions in this sub-topic · 71 marks · lowest tariff first



- 1 Some electromagnetic waves are used to scan a person in hospital.

Which statement is true about a scan that uses **electromagnetic** waves?

- A Micro-waves are used to scan skin.
- B Ultrasound waves are used to scan an unborn baby.
- C Ultra-violet is used to scan for cancer.
- D X-rays are used to scan for broken bones.

Your answer

[1]

7 Which row **A**, **B**, **C** or **D**, is true for electromagnetic waves?

	Transmission	Type	Movement in space
A	Transmit energy from absorber to source	Longitudinal	Travel through space at different velocities
B	Transmit energy from absorber to source	Transverse	Travel through space at different velocities
C	Transmit energy from source to absorber	Longitudinal	Travel through space where all have the same velocity
D	Transmit energy from source to absorber	Transverse	Travel through space where all have the same velocity

Your answer

[1]

3 What type of wave is light?

- A** A longitudinal electromagnetic wave
- B** A longitudinal P wave
- C** A transverse S wave
- D** A transverse electromagnetic wave

Your answer

[1]



4 Which statement is **true** for electromagnetic waves?

- A High frequency electromagnetic waves have a long wavelength.
- B High frequency electromagnetic waves have no wavelength.
- C Low frequency electromagnetic waves have a long wavelength.
- D Low frequency electromagnetic waves have a short wavelength.

Your answer

[1]



8 Which row in the table is correct?

	Electromagnetic wave	Use
A	Radio	Killing bacteria
B	Microwaves	Mobile phones
C	X-rays	Optical fibres
D	Gamma rays	Tanning beds

Your answer

[1]

15 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]



13 The table shows **two** uses of electromagnetic radiation.

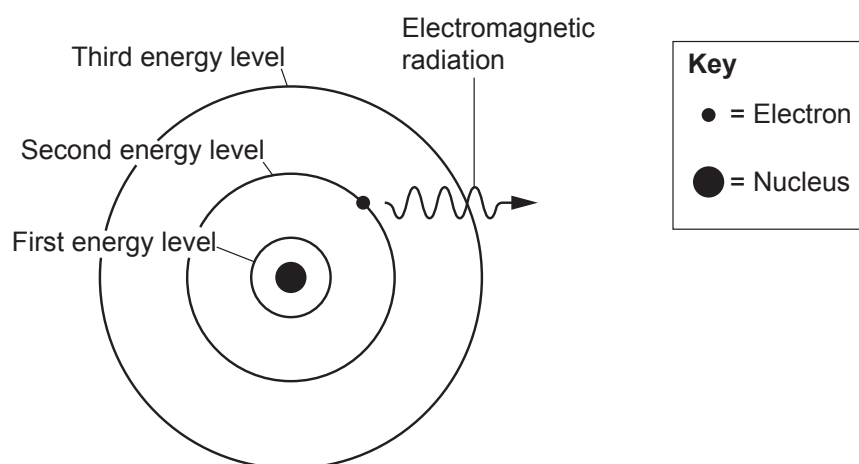
Which row in the table is correct?

	Used for satellite communication	Used for measuring temperature
A	Microwaves	Infra red
B	Microwaves	Ultraviolet
C	Visible light	Infra red
D	Visible light	Ultraviolet

Your answer

[1]

- 4 This diagram shows an electron in the second energy level in an atom.



What happens to the electron when it emits electromagnetic radiation?

- A** It becomes excited.
- B** It is lost from the atom.
- C** It moves to the first energy level.
- D** It moves to the third energy level.

Your answer

[1]

10 Which statement about electromagnetic waves in air is **always** correct?

- A High frequency waves have a higher velocity than low frequency waves.
- B High frequency waves have a longer wavelength than low frequency waves.
- C Low frequency waves have a longer wavelength than high frequency waves.
- D Low frequency waves have a lower amplitude than high frequency waves.

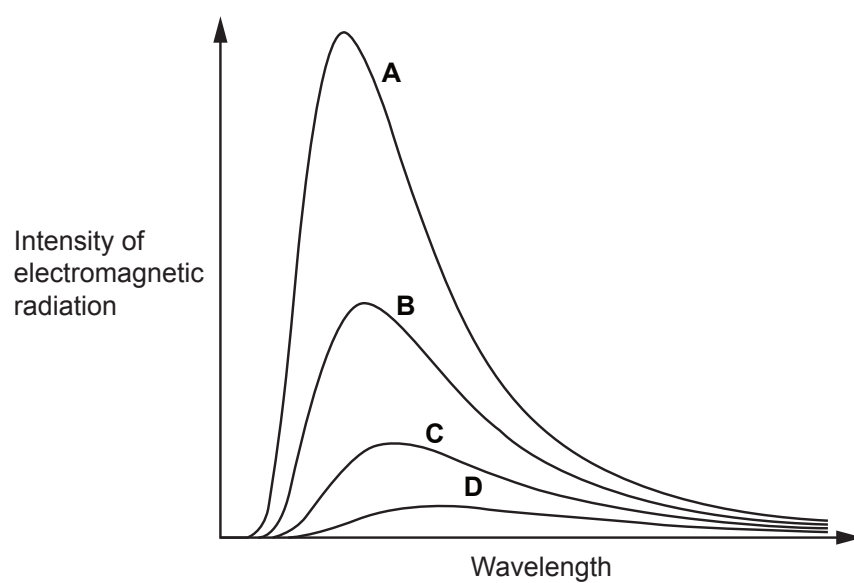
Your answer

[1]



- 11 The graph shows the electromagnetic radiation emitted by four objects at different temperatures.

Which object has the **highest** temperature?



Your answer

[1]

3 Which row explains how energy moves from object **X** to object **Y** by an **electromagnetic wave**?

	Object X	Electromagnetic wave	Object Y
A	absorbs energy	emits energy	transfers energy
B	absorbs energy	transfers energy	emits energy
C	emits energy	absorbs energy	transfers energy
D	emits energy	transfers energy	absorbs energy

Your answer

[1]

14 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]

19 A student looks at two identical metal spoons, **A** and **B**.

Spoon **A** was placed in hot water at 70 °C.

Spoon **B** is at 20 °C.

(a) Which spoon emits the most radiation?

Tick (✓) **one** box.

Spoon **A**

☐

Spoon **B**

☐

Explain your answer.

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

(b) Explain why both spoons look identical to the student, even though they are at different temperatures.

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

22 Atoms can absorb and emit electromagnetic radiation.

(a) Describe **two** possible effects on an electron in an atom when it absorbs electromagnetic radiation.

1

.....

2

.....

[2]

(b) Alpha radiation is **not** emitted in the processes in part **(a)**.

Explain why.

.....

.....

.....

[2]



19 A star like the Sun emits radiation as electromagnetic waves.

(a) Part of the electromagnetic spectrum is shown in the table.

radio	microwaves	infrared	visible			
-------	------------	----------	---------	--	--	--

(i) Complete the table to show the electromagnetic waves in order of **decreasing** wavelength.

Use the words in the list.

gamma-rays	ultra-violet	X-ray
------------	--------------	-------

[2]

(ii) Complete the sentence about electromagnetic waves in space.

Use the words in the list.

decreases	increases	stays the same
-----------	-----------	----------------

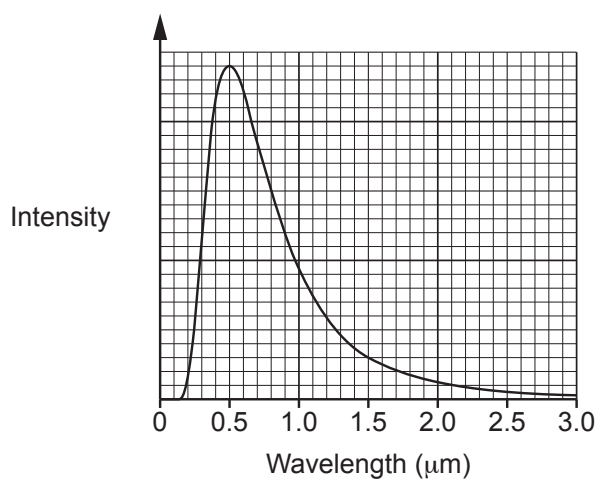
As the wavelength of an electromagnetic wave increases, the frequency

.....

[1]

(b) Fig. 19.1 shows how the intensity of the Sun's radiation changes with wavelength.

Fig. 19.1



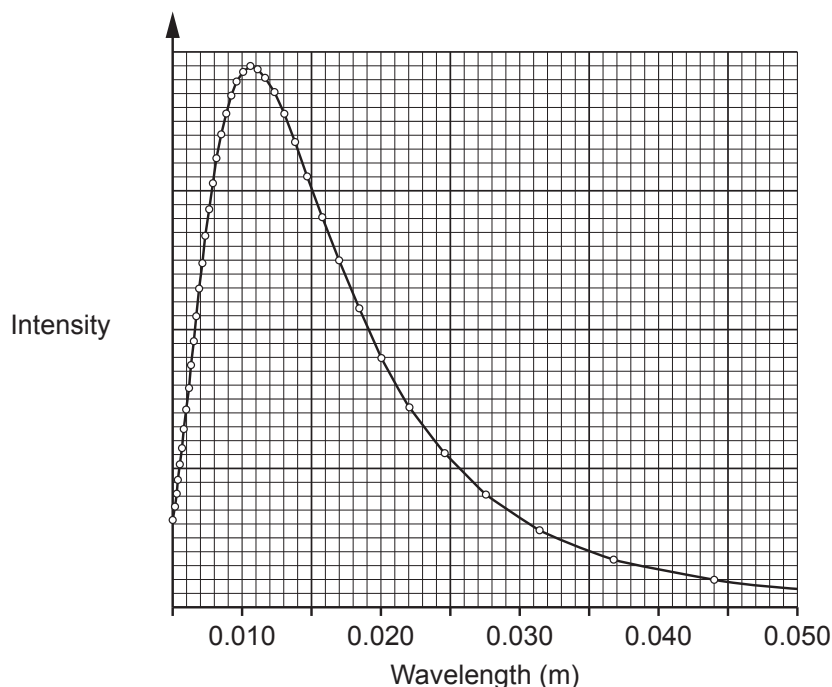
Use **Fig. 19.1** to find the wavelength of the Sun's radiation at **maximum** intensity.

Show your working on **Fig. 19.1**.

(c) In 1965, two scientists detected electromagnetic waves coming from space.

Fig. 19.2 shows the graph for these electromagnetic waves.

Fig. 19.2



The table shows the wavelengths of some different electromagnetic waves.

Electromagnetic waves	Wavelength range (m)
radio	> 0.3
microwaves	$0.000\,025 - 0.3$
infrared	$0.000\,000\,75 - 0.000\,025$
visible light	$0.000\,000\,4 - 0.000\,000\,75$

(i) Use the table and **Fig. 19.2** to name the electromagnetic wave at maximum intensity.

..... [1]

(ii) Which theory about the universe does the radiation for (c)(i) provide evidence for?

..... [1]

- 17 The diagram shows star shaped stickers attached to a wall.

The stickers can sometimes be seen in the dark because they emit electromagnetic waves and glow.



- (a) Which region of the electromagnetic spectrum is emitted by the stickers so they can be seen in the dark?

..... [1]

- (b) A student thinks the stars look green when they glow.

Green light has a wavelength of $5.3 \times 10^{-7} \text{ m}$ and a speed of $3.0 \times 10^8 \text{ m/s}$.

Calculate the frequency of green light.

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

Frequency = ... Hz [3]

- (c) The student observes that the stickers only glow in the dark after being exposed to light for a few hours.

Complete the sentences to explain the student's observation.

Use words from the list.

absorb**emit****higher****lower****reflect****refract**

When light shines onto a sticker, atoms in the sticker energy from the light.

When this happens, the electrons in the atoms move to a energy level.

After some time, the electrons will move back to a energy level.

When this happens, the electrons green light.

[3]

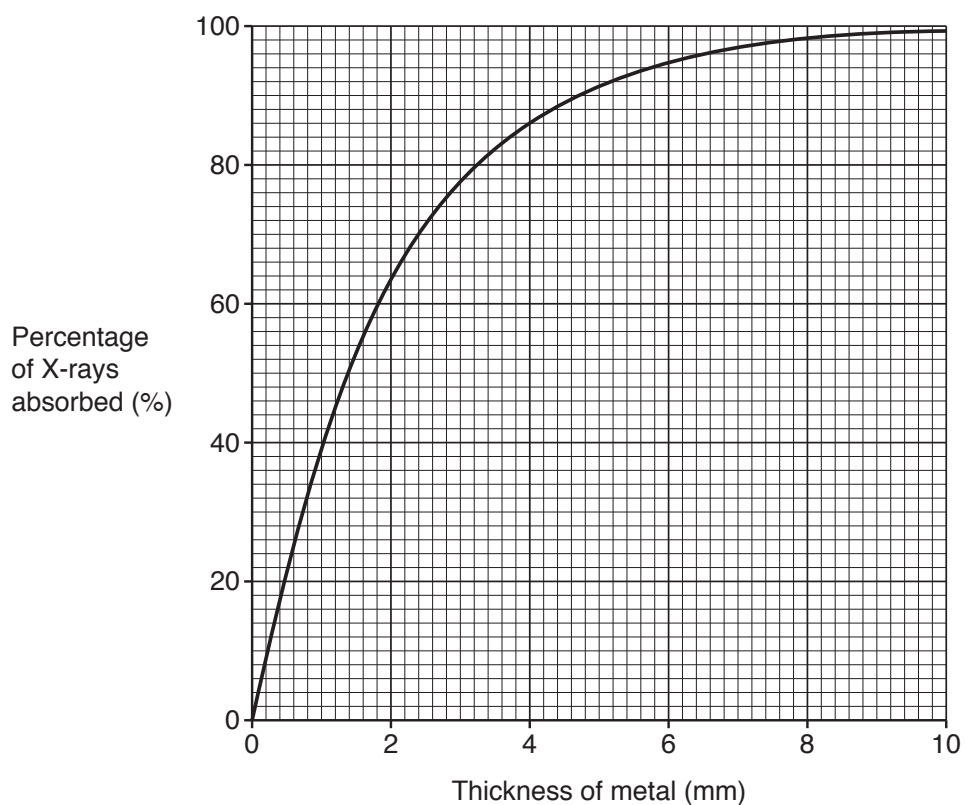
16 This question is about X-rays and visible light.

(a) State one **similarity** and one **difference** between X-rays and visible light.

Similarity

Difference [2]

(b) This graph shows how the absorption of X-rays changes with the thickness of metal.



(i) What percentage of X-rays is absorbed by 4 mm of metal?

Percentage of X-rays absorbed = ... % [1]

- (ii) Calculate the percentage of X-rays passing **through** 4 mm of metal.
Use your answer to **16(b)(i)** to help you.

Percentage of X-rays = ... % [2]

- (c) Use the words from the list to complete the sentences about the Universe.

You may use each word once, more than once, or not at all.

Big-Bang

Contracting

CMBR

Expanding

LDR

Red giant

Red shift

Solar system

The is a model of how the universe began.

Light from distant galaxies has a longer wavelength when it reaches Earth than when it was emitted.

This is called

Distant galaxies are moving away faster so the universe is

.....

[3]



19 X-rays and infrared radiation are involved in the scanning of patients in hospitals.

(a) A radiographer uses X-rays to scan the inside of a patient's body.

(i) Describe **one** hazardous effect of X-rays on human tissue.

..... [1]

(ii) The radiographer stands behind a lead barrier while doing the scan.

Explain how the barrier will protect the radiographer.

.....
 [1]

(b) A hospital technician scans the infrared radiation emitted by a patient.

The technician:

- measures the peak wavelength of infrared radiation emitted by the patient
- repeats the measurement 3 times and records the results in **Table 19.1**.

Table 19.1

Measurement	Peak wavelength (μm)
1	9.36
2	9.42
3	9.40

(i) Calculate the mean peak wavelength using the data in **Table 19.1**.

Give your answer in **standard form** in **metres**.

Mean peak wavelength = ... m [2]

(ii) Give **one** reason why the technician repeats the measurements.

.....
 [1]

(iii) The technician scans a different patient and records the results as shown in **Table 19.2**.

Table 19.2

Measurement	Peak wavelength (µm)
1	9.43
2	9.41
3	8.25

What should the technician do with measurement 3 before calculating the mean peak wavelength in **Table 19.2**?

Explain your answer.

.....

.....

..... [2]

(c) Describe **one** other practical use of infrared radiation.

..... [1]

19

- (a) Hydrogen gas is placed in a glass tube in a laboratory.

Fig. 19.1 shows the emission spectrum of hydrogen.

Each line in the emission spectrum has a different colour.

Fig. 19.1



- (i) Complete the sentences to explain the cause of the lines in the emission spectrum.

Use words from the list.

atoms

electrons

light

protons

sound

..... move from a higher energy level to a lower energy level

and emit

[2]

- (ii) There is a potential difference of 3000 V across the tube.

A charge of 0.08 C flows in the tube.

Calculate the energy transferred.

Use the equation: energy transferred = charge $\times$ potential difference

Energy transferred = ... J [2]

- (iii) A special power supply is needed to provide the high potential difference of 3000 V.

Describe **one** risk of using this power supply.

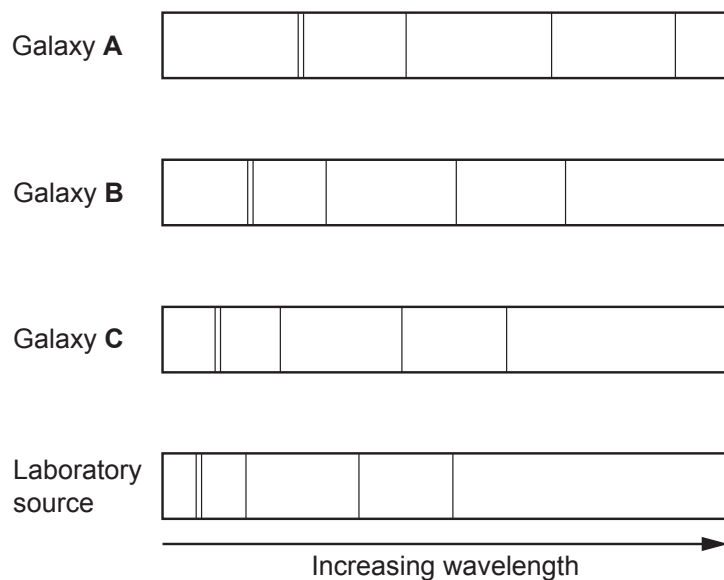
.....

..... [1]

(b) **Fig. 19.2** shows the emission spectrum for each of three different galaxies.

The same emission spectrum is also shown for an equivalent laboratory source on the Earth.

Fig. 19.2



(i) The emission spectrum for each galaxy shows red-shift.

Use **Fig. 19.2** to explain what is meant by the term **red-shift**.

.....
 [1]

(ii) Which galaxy in **Fig. 19.2** is furthest from the Earth?

Give a reason for your answer.

Galaxy

Reason

..... [2]

(iii) State which theory the spectra from each galaxy in **Fig. 19.2** gives evidence for.

..... [1]

16 (a) This question is about electromagnetic waves.

Draw lines to connect each **wave** with its correct **use or property**.

Wave	Use or Property
Gamma-rays	Can cause sunburn
Infra-red	Highest frequency
Radio	Used in TV remotes
Ultra-violet	Longest wavelength

[3]

(b) (i) Which type of wave is the most dangerous?

Tick (✓) **one** box.

Infra-red	☐
Microwaves	☐
X-rays	☐

[1]

(ii) Identify **two** reasons for your answer to **(b)(i)**.

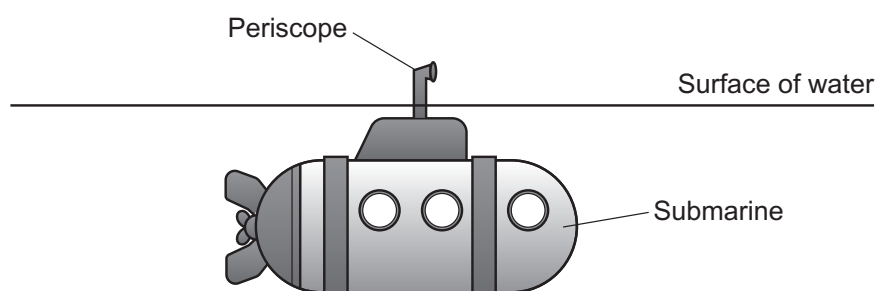
- 1
- 2

[2]



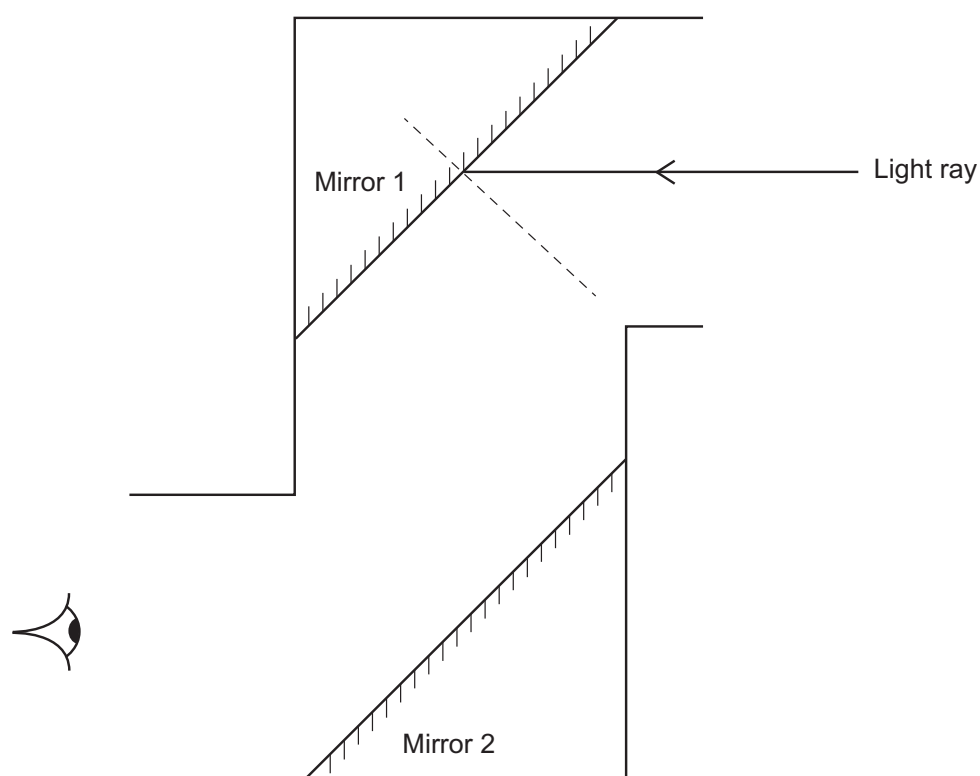
(c) Fig. 16.1 shows a submarine under water.

Fig. 16.1



A periscope is used to look above the water. Fig. 16.2 shows the periscope.

Fig. 16.2



Complete the ray diagram in Fig. 16.2 to show how light passes through the periscope to the eye.

You must include a normal line in your completed ray diagram on Mirror 2.

[3]

- (d) (i) A sailor uses the periscope to observe some water waves.

Six complete waves pass the periscope in **one** minute.

Calculate the time period for one wave in seconds.

Time period = ... s [2]

- (ii) A different water wave has a frequency of 0.2 Hz.

The wavelength of the wave is 20 m.

Calculate the speed of the wave.

Use the Data Sheet.

Speed of the wave = ... m/s [3]



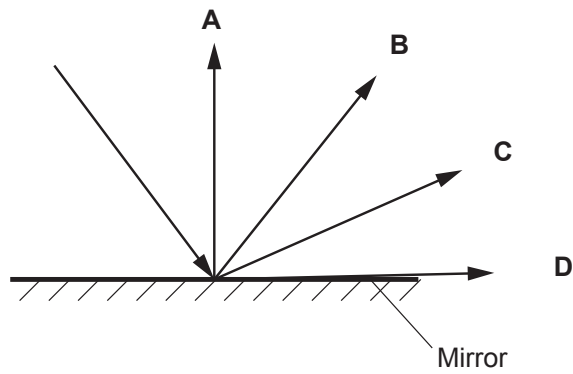
SUB-TOPIC P5.3

WAVE INTERACTION

18 questions in this sub-topic · 50 marks · lowest tariff first



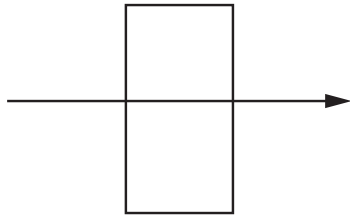
2 Which light ray shows the correct reflection from the plane (flat) mirror?



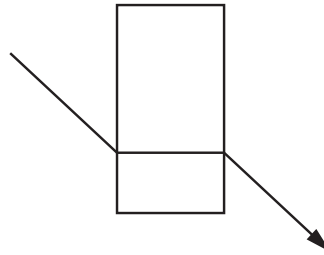
Your answer

[1]

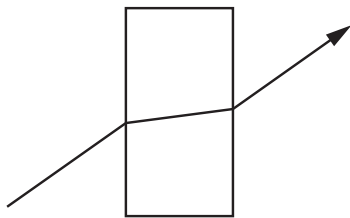
11 Look at the diagrams of a light ray as it passes from air through a glass block.



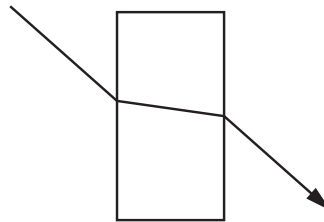
A



B



C



D

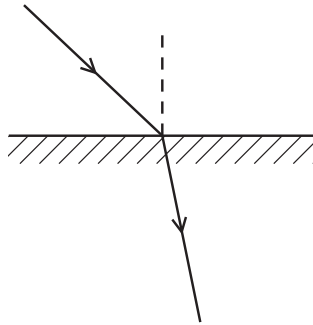
Which diagram shows an **incorrect** refraction?

Your answer

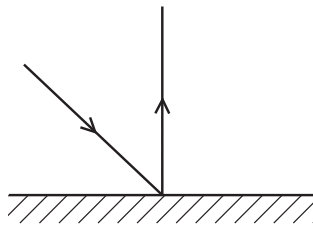
[1]

7 Which diagram shows reflection of a light ray using a plane mirror?

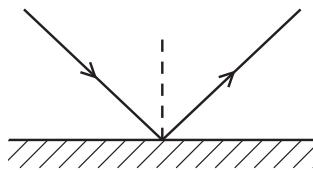
A



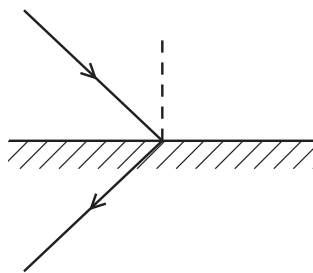
B



C



D

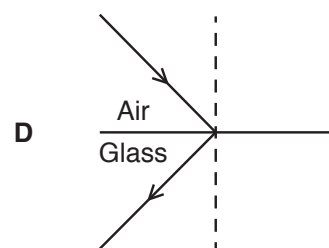
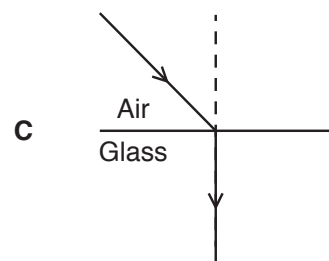
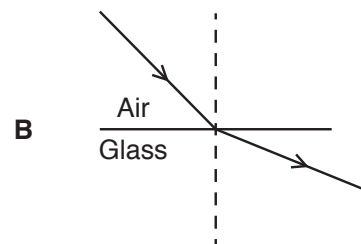
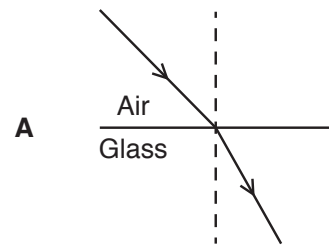


Your answer

[1]

- 5 A light ray passes from air into glass.

Which diagram shows the **refraction** of this light ray?

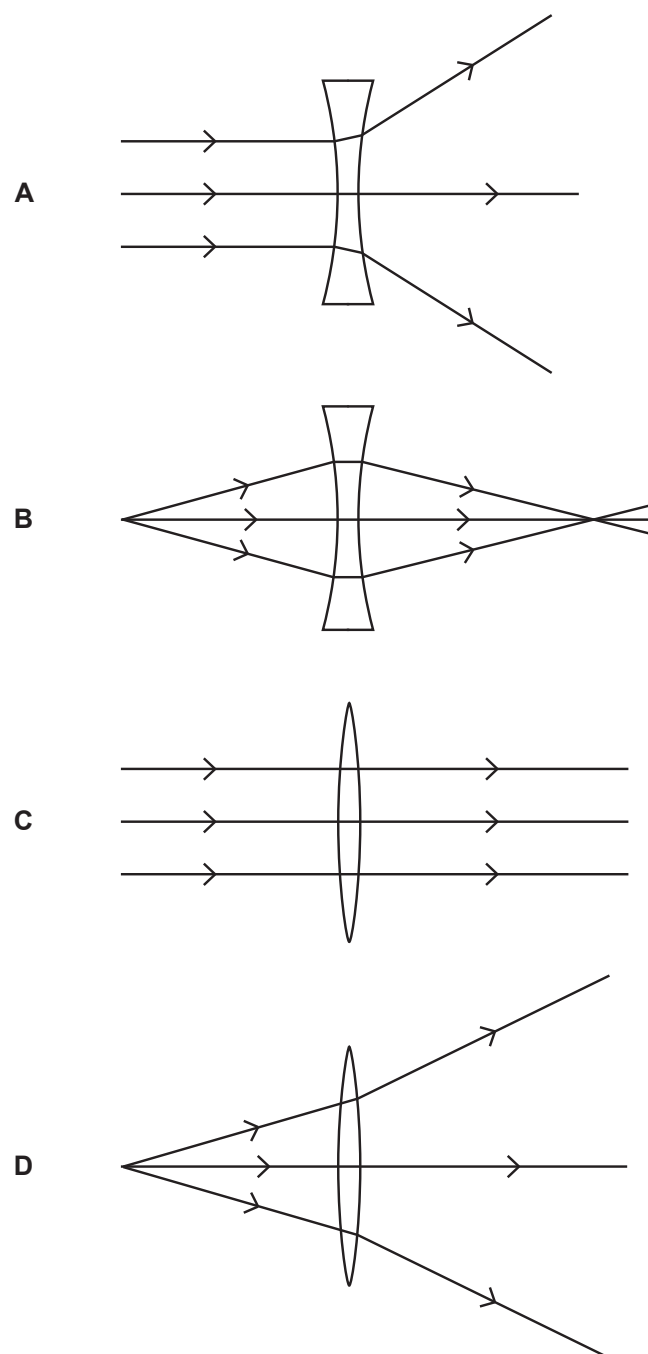


Your answer

[1]

9 A student draws ray diagrams for some lenses.

Which ray diagram is correct?

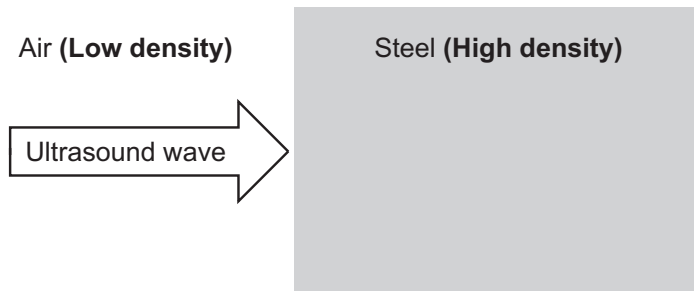


Your answer

☐

[1]

- 2 The diagram shows an ultrasound wave hitting a steel block.



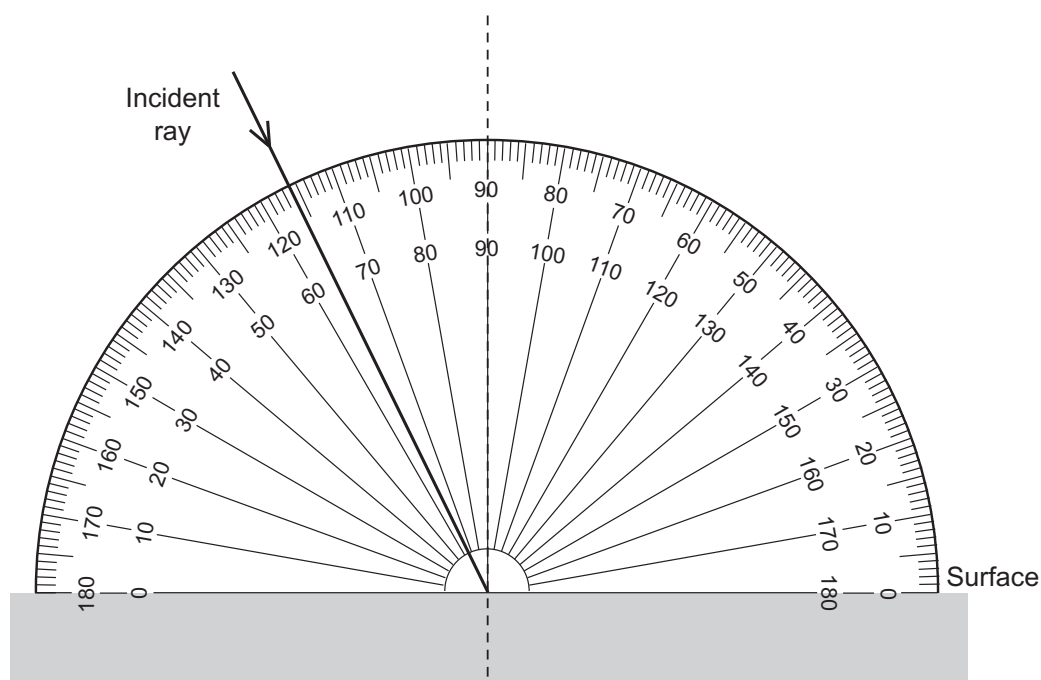
What happens to the ultrasound wave?

- A It is mainly absorbed.
- B It is mainly reflected.
- C It is completely refracted.
- D It is completely transmitted.

Your answer

[1]

6 A ray of light hits a surface.



What is the angle of incidence?

- A 26°
- B 64°
- C 76°
- D 116°

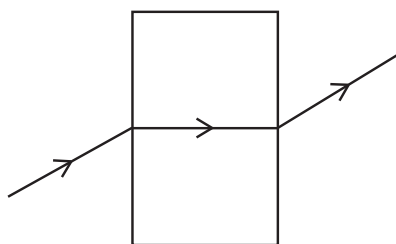
Your answer

[1]

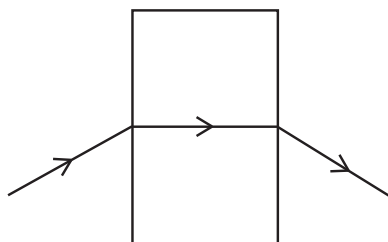
13 A student shines a ray of red light at different shaped glass blocks.

Which diagram shows a correct path for the ray?

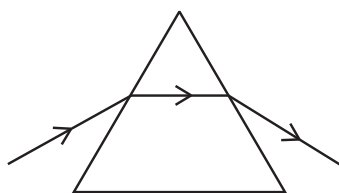
A



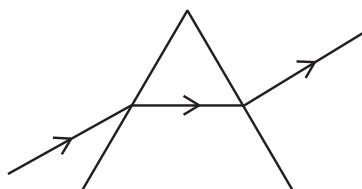
B



C



D

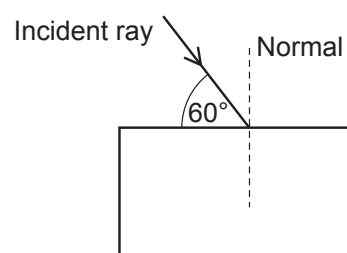


Your answer

☐

[1]

- 3 The diagram shows a ray of light hitting a rectangular glass block.



not to scale

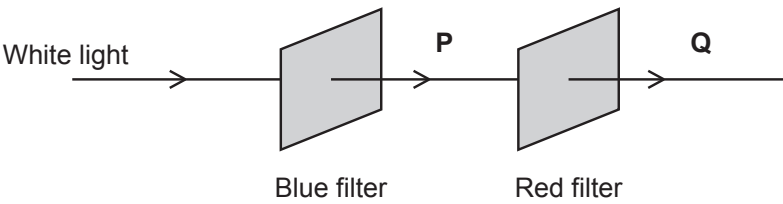
What is the angle between the normal line and the incident ray?

- A 30°
- B 60°
- C 90°
- D 120°

Your answer

[1]

10 A student places a blue filter and a red filter in front of a source of white light.



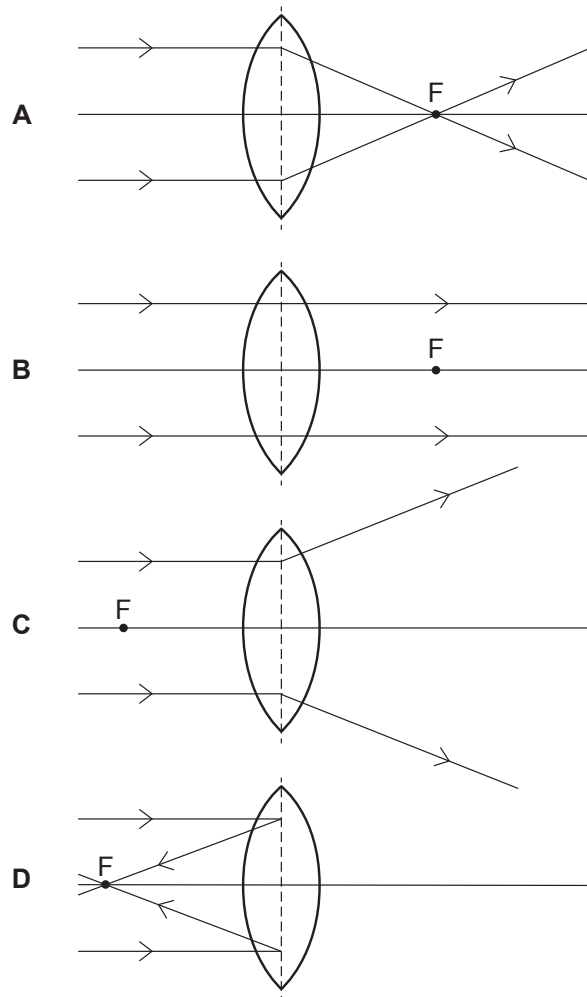
Which row is correct?

	Light seen at P	Light seen at Q
A	blue	no light
B	blue	green
C	red	no light
D	red	green

Your answer

[1]

5 Which ray diagram correctly shows rays of light passing through a lens with principal focus F?



Your answer

☐

[1]

9 A shirt appears green in white light.

Which colour will the shirt appear in **red** light?

A Black

B Blue

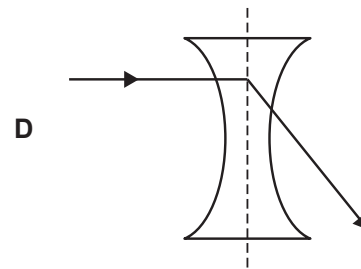
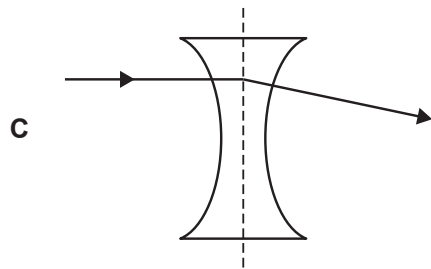
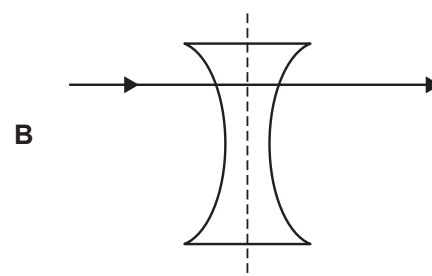
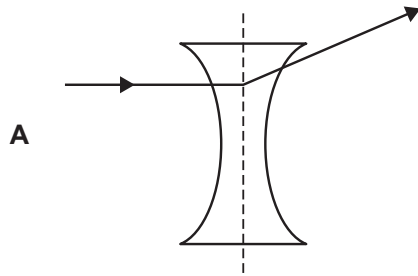
C Green

D Red

Your answer

[1]

11 Which diagram shows a ray of light passing through a **concave** lens?



Your answer

☐

[1]

- 18 (a) Lenses can be used to help people see clearly.

Fig. 18.1 is a diagram of a convex lens.



Fig. 18.1

- (i) A student models the lens using two glass **prisms** and a glass **block**.

Complete the ray diagram **Fig. 18.2** to show how light rays travel through the model lens (glass prism and glass block).

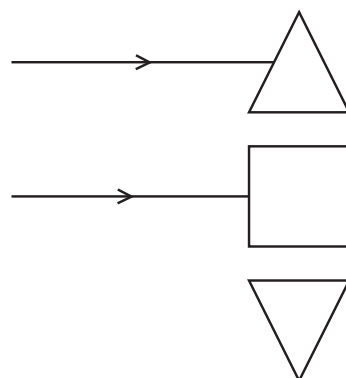


Fig. 18.2

[2]

- (ii) Explain how a convex lens can correct long-sighted vision.

Use the model in **Fig. 18.2** to help you.

.....

.....

.....

..... [2]

(b) A student looks at coloured paper in different coloured light.

Fig. 18.3 is a diagram of her experiment.

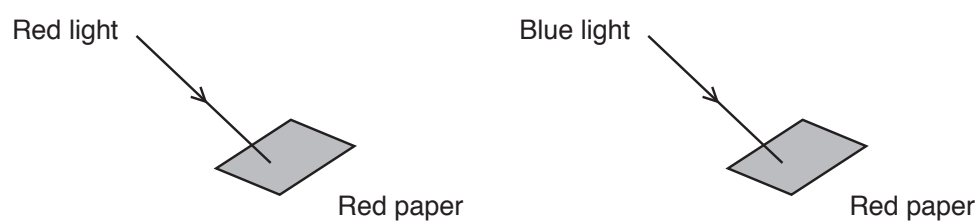


Fig. 18.3

She looks at red paper with red light. The paper appears red.

What colour does the red paper appear in blue light?

Explain your answer.

.....

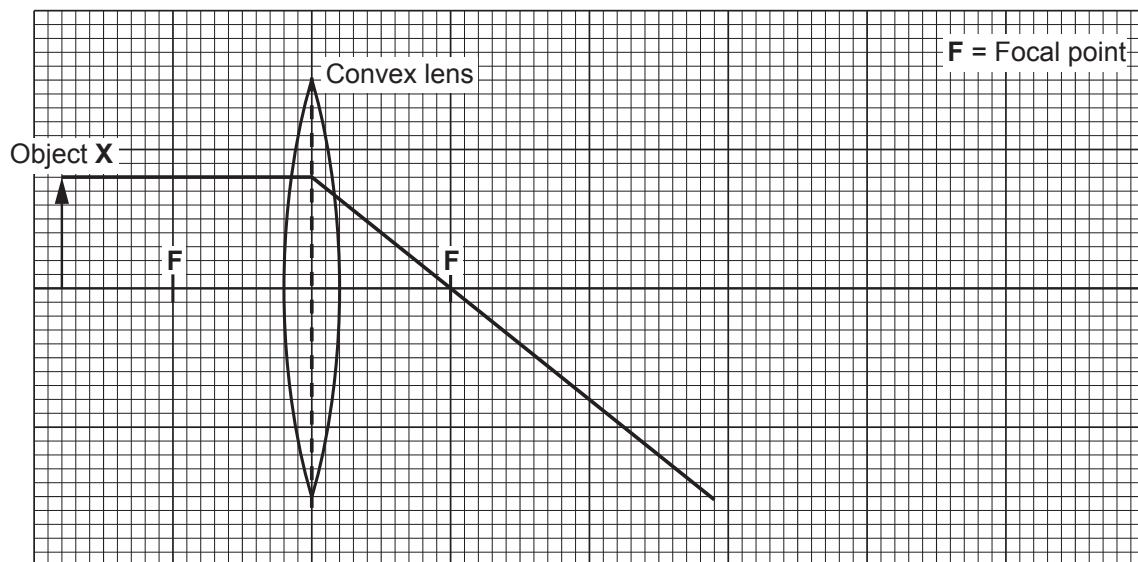
.....

..... [2]

21 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]

22 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. 22.1** shows a ray of light from a fish in a container of water.

Complete the ray diagram in **Fig. 22.1** to show the path of the ray after it leaves the water.

Include a normal line in your diagram.

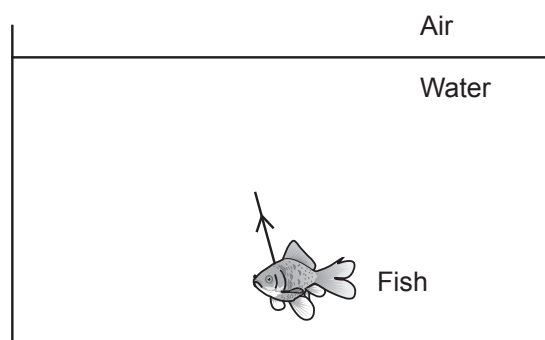


Fig. 22.1

[3]

- (b) Diagram in **Fig. 22.2** shows three incident rays hitting the surface of the fish. Light is scattered from the surface of the fish.

Complete the diagram in **Fig. 22.2** to show the scattered rays.

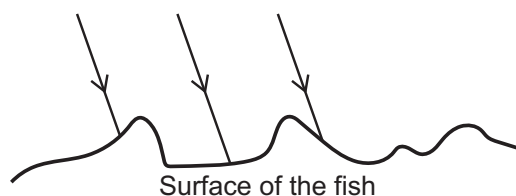


Fig. 22.2

[1]

(c) The fish appears red under white light.

Explain why the fish appears black under green light.

.....

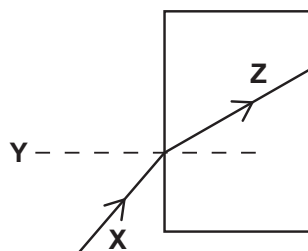
.....

..... [2]



18

(a) A student draws a ray diagram to show the refraction of a light ray through a glass block.



X is the incident ray. What are the names of line Y and line Z?

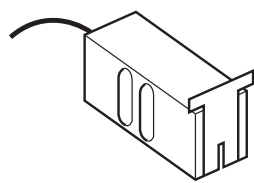
Y

Z

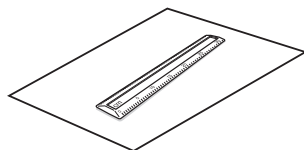
[1]

(b)* The student does an experiment to investigate the reflection of light from a plane mirror.

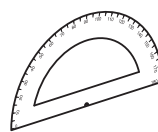
The diagram shows the equipment the student uses.



Ray box with one slit



Ruler and paper



Protractor



Plane mirror

Describe how the student does the experiment.

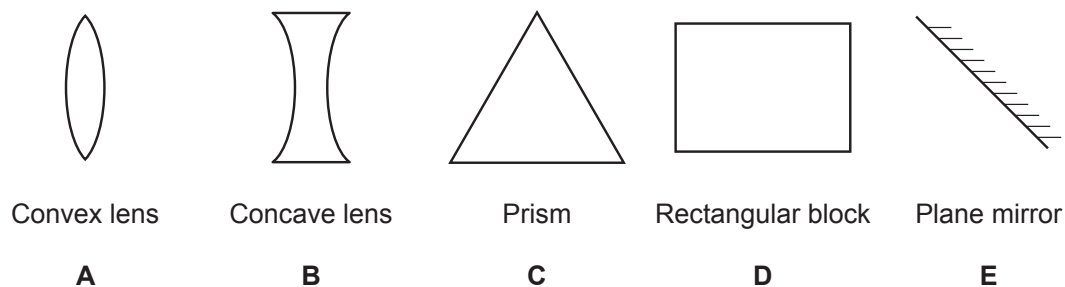
In your answer include:

- how the student sets up the equipment
- what the student will measure
- a prediction of what the student will find out from their results.

You can draw a labelled diagram to support your answer.

- 22 (a)** A student shines three parallel rays of red light at different glass objects. **Fig. 22.1** shows the glass objects.

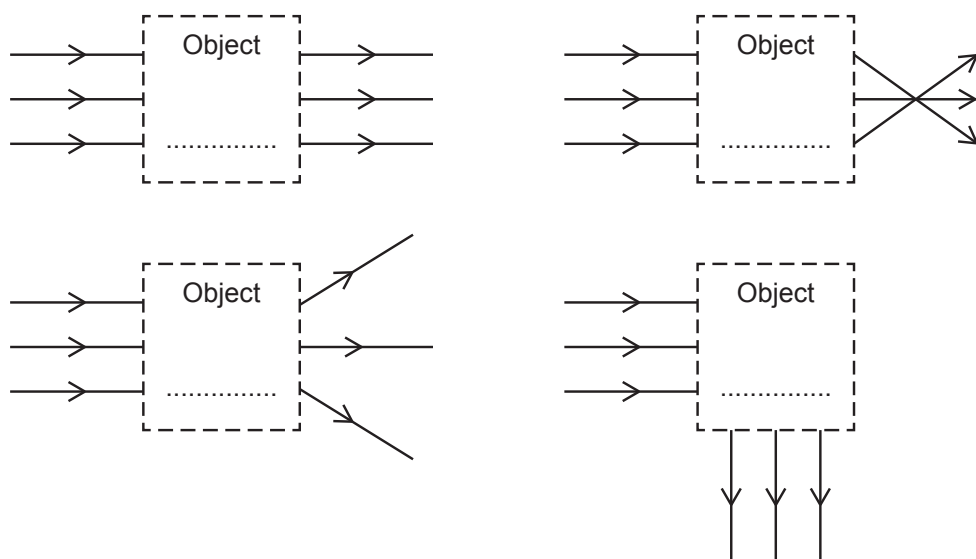
Fig. 22.1



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. 22.2** to identify which glass object produces that ray diagram.

Fig. 22.2



[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 $2.0 \times 10^8 \text{ m/s}$.

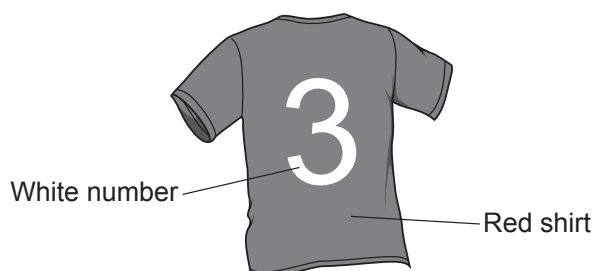
Calculate the frequency of the red light in glass.

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]

MARK SCHEMES

official Pearson Edexcel mark schemes



Question				Answer	Marks	AO element	Guidance
10				C ✓	1	1.2	



Question			Answer	Marks	AO element	Guidance
12			A ✓	1	2.2	



Question	Answer	Marks	AO element	Guidance
2	D ✓	1	1.2	



Question	Answer	Marks	AO element	Guidance
14	D ✓	1	2.2	



Question			Answer	Marks	AO element	Guidance
6			C ✓	1	2.2	



Question			Answer	Marks	AO element	Guidance
15			C ✓	1	1.2	



Question				Answer	Marks	AO element	Guidance
1				B ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
6			B ✓	1	1.2	



Question			Answer	Marks	AO element	Guidance
15			C ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
15			A ✓	1	1.1	



Question	Answer	Marks	AO element	Guidance
2	C	1	1.2	



Question	Answer	Marks	AO element	Guidance
14	B	1	1.1	



Question	Answer	Marks	AO element	Guidance
15	D	1	2.1	



15	D	1	2.1	A: $80 \div 4$ B: $80 \div 2$ C: 80×2 D: 80×4
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19	a	Distance (between source and observer) ✓ Time (for sound to travel between source and observer) ✓	2	2 x 1.1	Do not accept distance / time the ball travels Do not accept metres / seconds
	b	Speed = distance ÷ time ✓	1	1.1	ALLOW distance ÷ time
	c	Takes several readings / take averages / increase distance ✓	1	3.3a	ALLOW no wind IGNORE increase time

Question	Answer	Marks	AO element	Guidance
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18	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer is 0.75 (m) award 3 marks Rearrangement: Wavelength = wave speed $\div$ frequency ✓ (Wavelength =) $330 \div 440$ ✓ (Wavelength =) 0.75 (m) ✓	3	1 $\times$ 1.2 2 $\times$ 2.1	ALLOW $\frac{3}{4}$ (m)
	(b)	Any two from: (Sound) travels as a <u>longitudinal</u> wave ✓ (air) particles / molecules / atoms vibrate / oscillate ✓ <u>parallel</u> to the direction of energy transfer / wave travel / sound travel ✓	2	2 $\times$ 1.1	
	(c)	Wavelength < 100 cm ✓ Amplitude stays at 1mm ✓	2	2 $\times$ 2.2	

20	(a)	(i)	2 (s) ✓	1	1.2	
		(ii)	3 (cm) ✓	1	1.2	
		(iii)	the number of (complete) waves / oscillations in a / per second ✓	1	1.1	ALLOW '2 waves in a second' ✓
	(b)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1.5 (m/s) award 3 marks Wave speed = frequency × wavelength / $v = f \times \lambda$ ✓ = 0.25×6 ✓ = 1.5 (m/s) ✓	3	1.2 2.1 2.1	
	(c)	(i)	(transverse) Wave movement shown  ✓	1	2.2	
		(ii)	Reflection at wall ✓	1	1.2	ALLOW bounces back / comes back towards the hand
		(iii)	The coils / slinky / spring are in the same place (as before the wave) / AW ✓	1	1.1	The coils do not travel from one end to the other Must have reference to coils / slinky / spring

21	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer is 6.6 (s) award 2 marks Mean = $(6.7 + 6.3 + 6.7 + 6.6) \div 4$ ✓ (Mean =) 6.6 (ms) ✓	2	2 × 1.2	ALLOW one mark for 6.575 (ms) ALLOW candidate's average roundly correctly to 2 s.f. for one mark
	(b)	Any one from: The timer would start and stop at (roughly) the same time ✓ The time would not be the time for the sound to travel from mic 1 to mic 2 ✓	1	2.2	ALLOW the time measurement would be incorrect
	(c) (i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer is 320 (m / s) award 4 marks 7.5 ms = 0.0075 s ✓ Rearrangement: speed = distance ÷ time ✓ (Speed =) $2.4 \div 0.0075$ ✓ (Speed =) 320 (m / s) ✓	4	1.2 1.2 2 × 2.1	
	(ii)	With a tape measure / (several) metre-rule(s) ✓	1	1.2	DO NOT ALLOW with a ruler
	(iii)	Any one from: Errors / Uncertainty in measuring time ✓ Errors / Uncertainty in measuring distance ✓ Value on the website might be for different conditions (air temperature etc) ✓	1	3.2a	DO NOT ALLOW the value on the website could be incorrect.

18	(a)	Speed of light is (much) higher than speed of sound / AW ✓	1	1.1	
	(b)	Longitudinal ✓ Parallel ✓	2	2 × 1.1	
	(c)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 140 (m) award 4 marks distance travelled = speed × time ✓ (distance travelled =) 330×0.42 ✓ (distance travelled =) 138.6 or 139 ✓ (distance travelled =) 140 (m) (to 2sf) ✓	4	1.2 2.1 2.1 1.2	
	(d)	Idea time measured is incorrect ✓ due to child's reaction time / distracted / child hears a different firework / sound cannot be heard clearly / wind may have an effect ✓ OR Idea speed of sound varies ✓ Air is different temperature / density ✓	2	3.2b 3.2a	DO NOT ACCEPT faulty stopwatch ALLOW different altitudes

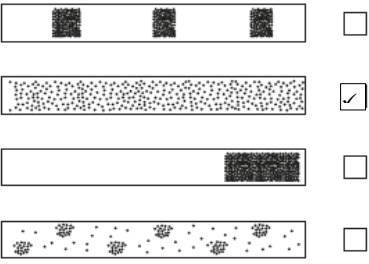
22	(a)	<table><tr><td></td><td>Type of wave</td><td>Direction of particle vibration</td></tr><tr><td>Sound</td><td>longitudinal ✓</td><td>Particles vibrate parallel ✓ to wave direction</td></tr><tr><td>Water ripples</td><td>transverse ✓</td><td>Particles vibrate perpendicular ✓ to wave direction</td></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
22	(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



16	a	i	3.5 (cm) ✓	1	1.1	ALLOW 3.4 to 3.6
		ii	2.4 (cm) ✓	1	1.1	
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.5 (m/s) award 2 marks 2 x 25 OR 2 x 0.25 ✓ 0.5 (m/s) ✓	2	2 x 2.1	ALLOW 50
	b	i	(Particles move) up and down / oscillate/vibrate vertically/at right angles to the direction of the wave ✓	1	1.1	
		ii	(Particles move) forwards and backwards / oscillate/vibrate parallel to the direction of the wave / AW ✓	1	1.1	
	c	i	Radio / infra-red / microwave ✓	1	1.1	
		ii	Ultra-violet / X-rays / gamma-rays ✓	1	1.1	
		iii	Any two from: Radiotherapy / killing cancer cells ✓ Irradiating food / sterilisation of instruments ✓ Tracer / medical imaging ✓ Scanning metals / non-destructive testing (NDT) ✓	2	2 x 1.1	ALLOW tumours / treatment of cancer ALLOW killing bacteria / (harmful) microorganisms / sterilising food

17	(a)	(i)	Transverse ✓	1	1.1	
		(ii)	Molecules/Particles move <u>perpendicular/ right angles</u> (to the direction of energy transfer/water surface) ✓	1	1.1	ACCEPT at right angles/ 90° (to direction of travel) ACCEPT up and down1
		(iii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.5 (Hz) award 2 marks Frequency = number of waves per second / = $10 \div 20$ ✓ $f = 0.5$ (Hz) ✓	2	2 × 2.1	ACCEPT ½
	(b)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.06 (m / s) award 3 marks Speed = 0.6×0.1 ✓ Speed = 0.06 (m / s) ✓	2	2 × 2.1	
		(ii)	Distance is measured with a metre-rule OR tape measure ✓ Time is measured with a stop-watch ✓	2	2 × 1.2	ACCEPT metre-ruler DO NOT ALLOW ruler
		(iii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.08 (m / s) award 3 marks Speed = distance ÷ time ✓ = $2.4 \div 30$ ✓ = 0.08 (m / s) ✓	3	1 × 1.2 2 × 2.1	
		(iv)	Uncertainty/difficulty in measuring distance ✓ OR Human reaction time in starting/stopping stopwatch ✓	1	3.2a	ALLOW AW

16	(a)	(i)	Longitudinal ✓	1	1.1	
		(ii)	 ✓	1	2.1	
	(b)		(frequency) stays the same (velocity) increases (wavelength) increases ✓✓	2	2 × 1.1	All 3 correct = 2 marks Any 1 or 2 correct = 1 mark

Question	Answer		Marks	AO element	Guidance
(c)		Start Amplitude Light Wavelength End is an electromagnetic wave. is the maximum displacement of a wave. is the distance between one peak and the next. ✓✓	2	2 × 1.1	All 3 correct for 2 marks Any 1 or 2 correct for 1 mark
(d)	(i)	(ultrasound pulse) may reflect off fish or different layers / rocks in seabed or named object in sea ✓	1	3.2a	ALLOW not smooth (surface of seabed)
(d)	(ii)	First check the answer on the answer line If answer = 450 (m) award 3 marks Time = 0.3 (s) (to the seabed) ✓ (distance =) 1500×0.3 ✓ (distance =) 450 (m) ✓	3	1.2 2.1 2.1	ALLOW 1500 × 0.6 for 1 mark ALLOW 900 (m) for 2 marks
(e)		First check the answer on the answer line If answer = 0.66 (m) award 3 marks ($\lambda =$) $v \div f$ ✓ ($\lambda =$) $330 \div 500$ ✓ ($\lambda =$) 0.66 (m) ✓	3	1.2 2.1 2.1	ALLOW 1 mark for correct substitution into given equation

Question				Answer	Marks	AO element	Guidance
1				D ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
7				D✓	1	2.2	



Question	Answer	Marks	AO element	Guidance
3	D ✓	1	1.1	



Question	Answer	Marks	AO element	Guidance
4	C ✓	1	1.1	



Question	Answer	Marks	AO element	Guidance
8	B ✓	1	1.1	



Question	Answer	Marks	AO element	Guidance
15	A ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
13			A ✓	1	1.1	



Question	Answer	Marks	AO element	Guidance
4	C	1	1.1	



Question	Answer	Marks	AO element	Guidance
10	C	1	1.1	



Question	Answer	Marks	AO element	Guidance
11	A	1	1.2	



Question	Answer	Marks	AO element	Guidance
3	D	1	1.1	



Question	Answer	Marks	AO element	Guidance
14	A	1	1.1	



19	(a)	spoon A AND (More radiation emitted) at higher temperature / hotter objects (emit more radiation) / spoon A is hotter / AW / ORA✓	1	1.1	ALLOW spoon A is heated (more)
	(b)	Any one from: Eye can only detect visible light / eye cannot detect IR ✓	1	1.1	ALLOW see for detect ALLOW spoon is not hot enough for a change in colour AW

22	(a)	Any two from: Electron absorbs or gains energy / AW ✓ Electron becomes 'excited' / moves to a higher energy level / moves to outer path / AW ✓ Electron escapes / leaves the atom / AW ✓	2	2×1.1	ALLOW atom becomes ionised / charged
	(b) (ii)	Any two from: Electromagnetic radiation is being absorbed by electrons not nucleus ✓ Alpha emitted from the nucleus / electrons not present in the nucleus / AW ✓ Alpha emitted from unstable radioactive nuclei ✓ Alpha does not have electrons / has protons and neutrons only / AW ✓	2	2×1.1	

19	(a)	(i)	ultra-violet X-ray gamma rays ✓✓	2	2 x 2.1	All three correct = 2 marks One (or two) correct = 1 mark ALLOW UV for ultra-violet
		(ii)	Decreases ✓	1	1.1	
	(b)		First check the answer on answer line If answer = 0.5 (μm) award 2 marks Vertical line drawn on graph (in approximately correct position) ✓ $\lambda = 0.5 \text{ (}\mu\text{m)}$ ✓	2	2 x 3.1a	
	(c)	(i)	Microwaves ✓	1	3.2b	
		(ii)	Big bang (theory) / expanding universe ✓	1	1.1	

17	(a)	visible (light) ✓	1	1.1	
	(b)	First check the answer on the answer line If answer = 5.7×10^{14} award 3 marks Rearrange: frequency = wave speed ÷ wavelength ✓ substitution: (frequency =) $3.0 \times 10^8 \div 5.3 \times 10^{-7}$ ✓ evaluation: 5.7×10^{14} (Hz) ✓	3	1.2 2 × 2.1	ALLOW 5.66 for 5.7 ALLOW standard symbols ALLOW correct substitution into unrearranged equation for this mark ALLOW any answer that rounds to 5.7×10^{14} ALLOW 5.7×10^n for 2 marks
	(c)	absorb ✓ higher and lower ✓ emit ✓	3	3 × 2.1	In this order only

16	(a)	Any one from: Similarity Both transverse waves ✓ Both electromagnetic waves ✓ Both travel at the same speed/speed of light (in a vacuum) ✓ Both can travel through space / vacuum ✓ Any one from: Difference X-ray has higher frequency / shorter wavelength / ORA ✓ X-rays have higher energy / ORA ✓ X-rays are more penetrating / ORA ✓	2	2 × 1.1	1 DO NOT ALLOW we can see visible light/we cannot see X-rays
	(b)	(i) 86 (%) ✓	1	2.2	ALLOW 85-87 %
		(ii) FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 14 (%) award 2 marks 100 – 86 ✓ = 14 (%) ✓	2	2 × 2.2	ALLOW ECF from (b)(i)
	(c)	Big Bang ✓ Red shift ✓ Expanding ✓	3	3 × 1.1	

19	(a)	(i)	Any one from: cause cell mutation / damage ✓ cause cancer ✓	1	1.1	ALLOW death of tissue / kill cells
		(ii)	X-rays absorbed / stopped by lead / barrier OR X-rays do not reach radiographer / penetrate lead ✓	1	2.1	ALLOW less exposed
	(b)	(i)	First check the answer on the answer line If answer = $9.39(3) \times 10^{-6}$ (m) award 2 marks $((9.36+9.42+9.40) \div 3) = 9.39(3) \text{ (}\mu\text{m)} \checkmark$ Conversion to m: $9.39(3) \times 10^{-6} \text{ (m)} \checkmark$	2	2×1.2	ALLOW 9.393 for 9.39 IGNORE 9.4 ALLOW $9.39(3) \times 10^0$ for 1 mark ALLOW 9.4×10^{-6} for 1 mark
		(ii)	To check for anomalies / outliers ✓	1	3.3a	ALLOW to make results more precise IGNORE accurate
		(iii)	Any two from: Idea of measurement 3 being an anomalous result ✓ Discard measurement 3 ✓ Re-take measurement 3 ✓	2	3.3a	ALLOW outlier for anomalous / not similar to measurements 1 and 2
	(c)		Toaster / oven / heater / motion detector / (tv) remote / infra red thermometer / thermal imaging camera ✓	1	1.2	IGNORE night vision ALLOW security beams

19	(a)	(i)	Electrons✓ Light✓	2	2 × 1.1	
		(ii)	First check the answer on the answer line If answer = 240 (J) award 2 marks (E ⇒) 0.08×3000 ✓ (E ⇒) 240 (J) ✓	2	2 × 2.1	
		(iii)	(Risk of) an (electric) shock / electrocution / AW ✓	1	3.2a	IGNORE dangerous / injury / death unqualified
	(b)	(i)	Increase in wavelength (of light) ✓	1	1.1	
		(ii)	A ✓ greater red-shift ✓	2	2 × 2.1	dependent on first mark wavelengths are further apart / longest / wavelengths move further to the right ALLOW lines for wavelengths
		(iii)	Big-Bang (model / theory) or expanding Universe ✓	1	1.1	



16	(a)		3	3 × 1.1	Award 2 marks for 2 or 3 correct Award 1 mark for 1 correct
	(b) (i)	X-rays ✓	1	1.1	
	(ii)	Any two from: It has the highest frequency / energy / shortest wavelength ✓ It is ionising (radiation) ✓ It can cause cancer / damage cells / kill cells ✓	2	2 × 1.1	ALLOW these marks if answer to 16(b)(i) is incorrect. IGNORE harmful IGNORE radiation sickness

Question	Answer	Marks	AO element	Guidance
(c)	Angle of reflection = angle of incidence at mirror 1 (by eye) ✓ Light ray carries on in a straight line to mirror 2 and reflects from the surface of mirror 2 into the eye ✓ Correct normal drawn at ~90° to the mirror at point ray reflects from mirror 2 (by eye) ✓ 	3	3 × 1.2	DO NOT ALLOW if arrow pointing from eye
(d) (i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 10 (s) award 2 marks Unit conversion: 1 minute = 60 s ✓ Time period = 60 ÷ 6 = 10 s ✓	2	1.2 2.2	ALLOW one mark for anything that rounds to 0.17
(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 4 (m / s) award 3 marks wave speed = frequency × wavelength ✓ (wave speed =) 0.2 × 20 ✓ (wave speed =) 4 (m / s) ✓	3	1.2 2.1 2.1	

Question				Answer	Marks	AO element	Guidance
2				B ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
11				B ✓	1	2.2	



Question	Answer	Marks	AO element	Guidance
7	C ✓	1	1.2	



Question				Answer	Marks	AO element	Guidance
5				A ✓	1	2.2	



Question			Answer	Marks	AO element	Guidance
9			A ✓	1	1.2	



Question				Answer	Marks	AO element	Guidance
2				B ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
6				A ✓	1	1.2	



Question				Answer	Marks	AO element	Guidance
13				C ✓	1	1.2	



Question	Answer	Marks	AO element	Guidance
3	A	1	1.2	



Question	Answer	Marks	AO element	Guidance
10	A	1	2.1	



Question	Answer	Marks	AO element	Guidance
5	A	1	1.2	

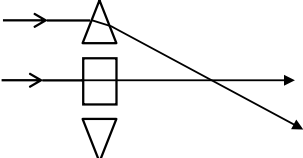


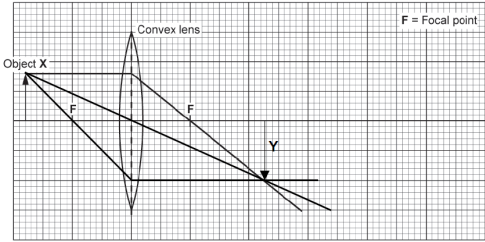
Question	Answer	Marks	AO element	Guidance
9	A	1	2.1	



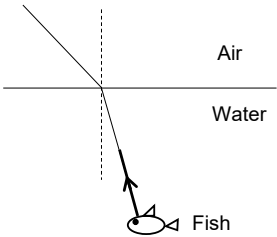
Question	Answer	Marks	AO element	Guidance
11	A	1	1.1	



18	(a)	(i)	Ray from prism: straight line (by eye) towards focal point ✓ Ray from block: continues straight ✓	2	2×1.2	IGNORE ray in prism IGNORE other rays 
		(ii)	(in long sight) rays focused <u>behind</u> retina / eye (ball) / AW ✓ Convex lens refracts light inwards / focuses light on the retina / AW ✓	2	2×1.1	ALLOW near object focussed <u>behind</u> the retina / eye (ball) or eye (ball) is too short ALLOW converges / meet for focuses
	(b)		Black ✓ AND Any one from: Black because blue light absorbed by red paper ✓ Black because red paper only reflects red light ✓ Black because red paper absorbs all colours except red ✓ Black because no light reflected from paper ✓	2	2×2.2	ALLOW dark without any colour

21	(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
21	(c)	(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

22	(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	

18	(a)	Y: normal Z: refracted (ray) ✓	1	1.2	BOTH answers needed for 1 mark ALLOW refraction for refracted
	(b)	* 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) Prediction of the results AND a detailed method / diagram OR Detailed prediction of results AND a basic method / diagram <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) Prediction of the results AND a basic (workable) method / diagram. OR Detailed prediction of the results OR Detailed method / diagram. <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 prediction OR a basic (workable) method / diagram.	6	2 × 1.1 4 × 3.3a	AO1.2 – Demonstrate knowledge and understanding of ray diagrams and reflection • Prediction made e.g., both angles are equal • Angle of incidence = angle of reflection • Law of reflection mentioned for all angles • Marks can be awarded from labelled diagram showing the mirror with the normal, angle of incidence and angle of reflection • As i increase r increases AO3.3a – Analyse information and ideas to develop experimental procedures • Use of a darkened room • Use ray box (and slit) to produce ray of light. • Place mirror onto paper • Draw position of mirror • Shine ray of light at mirror • Draw normal at 90 degrees to the mirror • Trace rays by drawing crosses / marks on the paper. • Use ruler to join up crosses / marks • Measure angle between normal and incident ray / angle of incidence • Measure angle between normal and reflected ray / angle of reflection • Repeat for different angles of incidence • Marks can be awarded from labelled diagram
		<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 or no response worthy of credit.			

22	(a)	D ✓ A ✓ B ✓ E ✓	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.)	
	(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