4-6 Waves – Physics

1.0 **Figure 1** shows an incomplete electromagnetic spectrum.

Figure 1

A	**microwaves**	**B**	**C**	**ultraviolet**	**D**	**gamma**

1.1 Which position are X-rays found in?

Tick **one** box.

[1 mark]

A ☐

B ☐

C ☐

D ☐

1.2 Which **three** waves can cause ionisation?

Tick **three** boxes.

[1 mark]

Gamma rays ☐

Infrared ☐

Microwaves ☐

Radio waves ☐

Visible light ☐

Ultraviolet ☐

X-rays ☐

1.3 Electromagnetic waves have many practical uses.

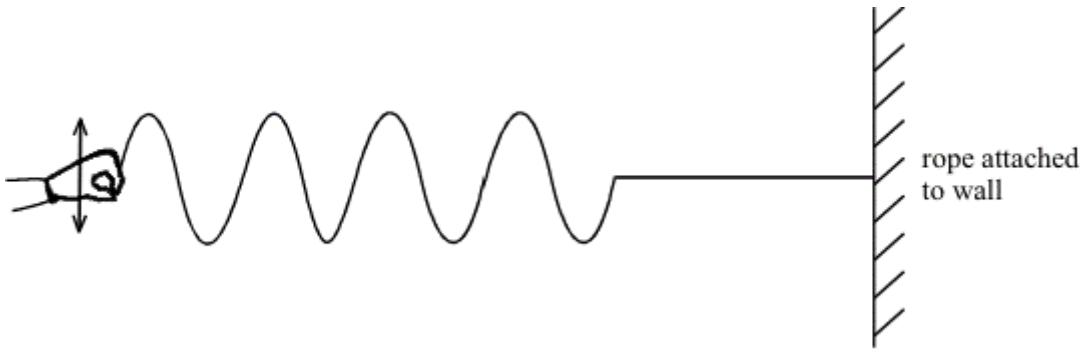
Draw **one** line from each type of electromagnetic wave to its use.

[2 marks]

Electromagnetic wave	Use
Radio waves	Medical treatments
Visible light	Television transmissions
Gamma rays	Fibre optic communications
	Sun tanning

2.0 **Figure 2** shows some waves travelling along a rope.

Figure 2



2.1 Show on the diagram:

The wavelength of one of the waves (labelled with a **W**)

The amplitude of one of the waves (labelled with an **A**)

[2 marks]

2.2 State the type of waves travelling on the rope.

Explain how you can tell.

[2 marks]

Type of wave_____

Explanation _____

2.3 The waves shown in the diagram were produced in two seconds.

Calculate the frequency of the waves.

[2 marks]

Frequency = _____ Hz

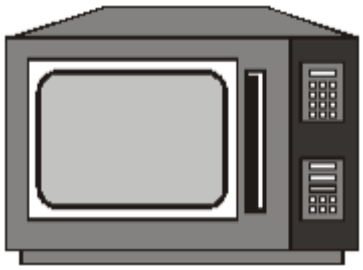
2.4 Calculate the time period of the waves.

State the unit.

[2 marks]

Time period = _____ Unit ____

3.0 Microwave ovens use microwave radiation to cook food.



The instruction manual of a microwave oven stated:

Frequency of microwaves: 10 000 million Hz.

Wavelength 0.02 m.

3.1 Calculate the speed of waves in the microwave according to the information in the instruction manual.

Give your answer in standard form.

[3 marks]

Speed = _____ m/s

3.2 The speed of visible light is 3×10^8 m/s.

Was the information in the instruction manual correct?

Explain your answer.

[1 mark]

_____

3.3 Simon said "When the microwave is working, it lights up. That's the microwaves."

Explain whether Simon was correct.

[2 marks]

3.4 Putting a beaker of water in a microwave and turning it on for a minute or two will increase the temperature of the water.

Describe an experiment to investigate the relationship between the time the microwave is on and the increase in temperature of water in a beaker.

In your answer, include:

- The equipment you will use
- The measurements you will take
- The safety precautions you will take

[6 marks]

4.0 The table gives information about the frequencies in the hearing ranges of three different animals.

Name of mammal	Frequencies in hearing range (Hz)	Wavelength of hearing range (m)
Bat	20 → 160 000	0.0021 → 17.2
Dolphin	40 → 110 000	0.0031 → 8.6
Elephant	5 → 10 000	X → 68.6

4.1 Which animal(s) can hear sounds **higher** than humans?

[1 mark]

Tick **one, two or three** boxes.

Bat ☐

Dolphin ☐

Elephant ☐

4.2 Which animal(s) can hear sounds **lower** than humans?

[1 mark]

Tick **one, two or three** boxes

Bat ☐

Dolphin ☐

Elephant ☐

4.3 Calculate the minimum wavelength of sound that elephants can hear (**X**).

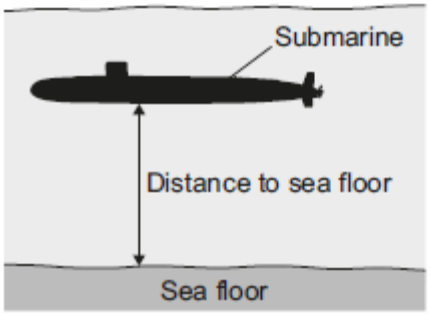
Use information from the table.

[3 marks]

Minimum wavelength = _____ m

5.0 **Figure 3** shows a submerged submarine.

Figure 3



Not to scale

5.1 The submarine sends a pulse of ultrasound to the sea floor.
The pulse returns 0.35 seconds after leaving the submarine.
The speed of sound in water is 1600 m/s.
Calculate the distance from the submarine to the sea floor.
Give your answer to 2 significant figures.

[3 marks]

Distance to sea floor = _____ m

5.2 The submarine moves through the sea and every few seconds sends a pulse of ultrasound to check the distance to the sea floor.

The table shows the time taken for five ultrasound pulses to travel from the submarine to the sea floor and back to the submarine.

Pulse number	Time for pulse to return in seconds
1	0.50
2	0.50
3	0.38
4	0.25
5	0.25

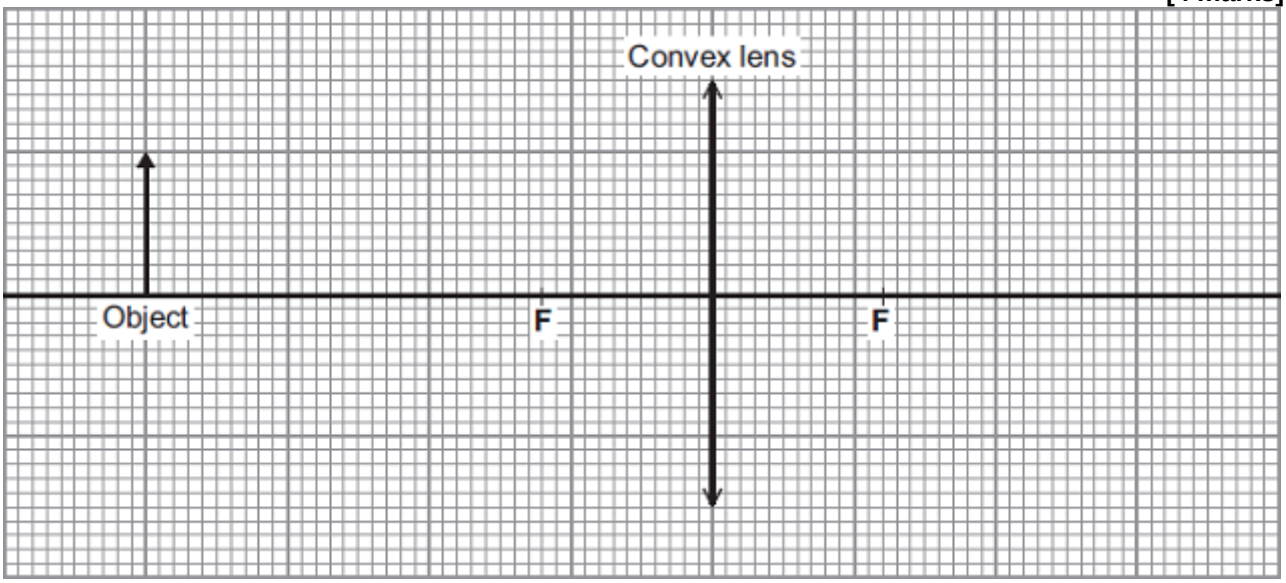
Describe how the distance from the submarine to the sea floor changed over these five pulses.

[3 marks]

6.0 A camera was used to take a photograph. The camera contains a convex (converging) lens.

6.1 Complete the ray diagram to show how the lens produces an image of the object.

[4 marks]



6.2 Calculate the magnification of the image.

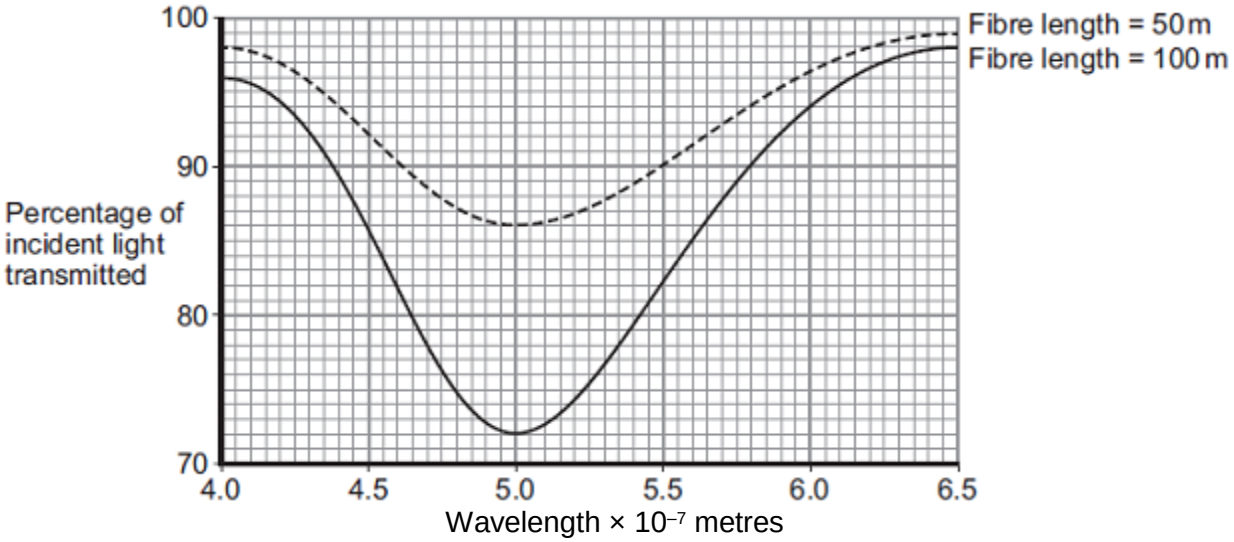
[2 marks]

Magnification = _____

7.0 Different wavelengths of light can be used to transmit information along optical fibres.

Figure 4 below shows how the percentage of incident light transmitted through a fibre varies with the wavelength of light and the length of the fibre.

Figure 4



7.1 Compare the percentages of incident light transmitted through the two different fibres over the range of wavelengths shown.

[3 marks]

_____

_____

_____

7.2 The speed of light is 3×10^8 m/s.

Calculate the frequency of light that is absorbed the most by the 100m length of fibre.

Give your answer in standard form.

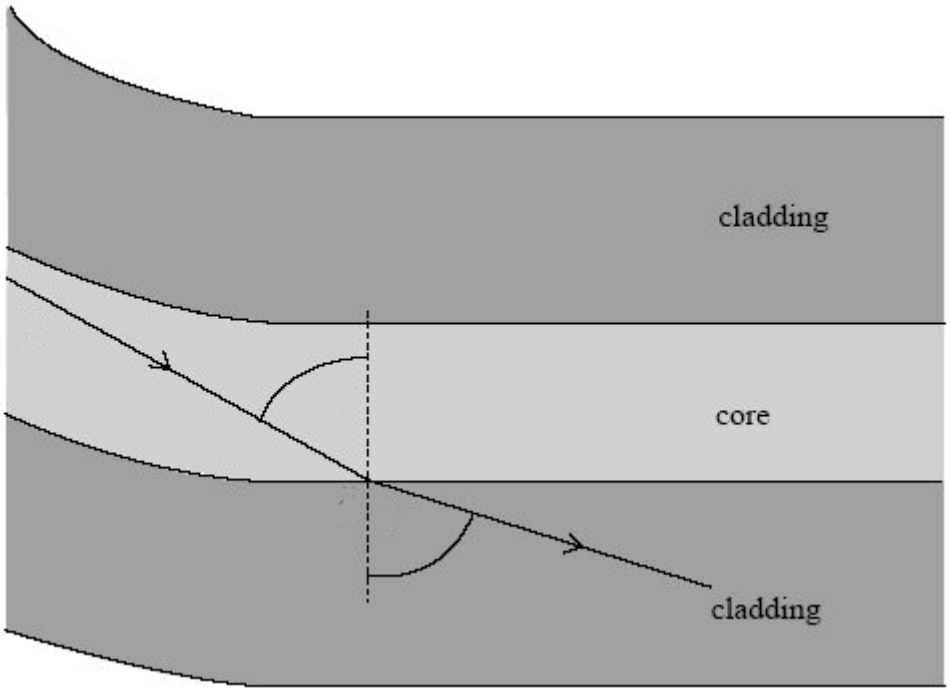
[2 marks]

Frequency = _____ Hz

7.3 The inside of optical fibres consists of two layers of glass, core and cladding.

Figure 5 shows how light travels between these two layers.

Figure 5

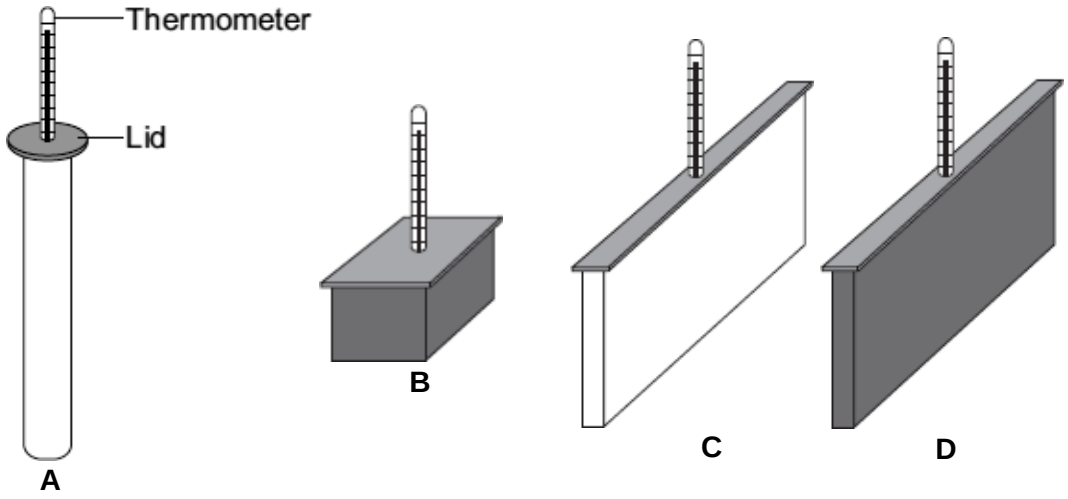


Suggest why the light travels in this way in the optical fibre.

[2 marks]

8.0 A student investigated the effect of shape and colour on heat transfer.

The student used metal containers with the same volume but with different shapes and outside colour. The containers were each filled with water at 100 °C.
After 20 minutes the temperature of the water inside each container was measured.



The results from the investigation are given in the table.

Container	Colour	Temperature after 20 minutes in °C	Temperature fall in °C
A	White	86	14
B	Black	86	14
C	White	73	27
D	Black	60	40

8.1 The student uses the results in the table to see if **shape** has affected heat transfer.

State which containers the student should compare to do this.

Give a reason for your answer.

[2 marks]

Containers to compare: _____

Reason: _____

_____

8.2 Explain why the temperature of the water in both containers **A** and **B** fell by the same amount.

[2 marks]

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	D		1
1.2	Gamma rays Ultra violet X-rays	All three required for the mark	1
1.3	Radio waves – Television transmissions Visible light – Fibre optic communications Gamma rays – Medical treatments	All three correct – 2 marks Two correct – 1 mark If more than one line from any wave, deduct a mark, minimum of zero marks.	2

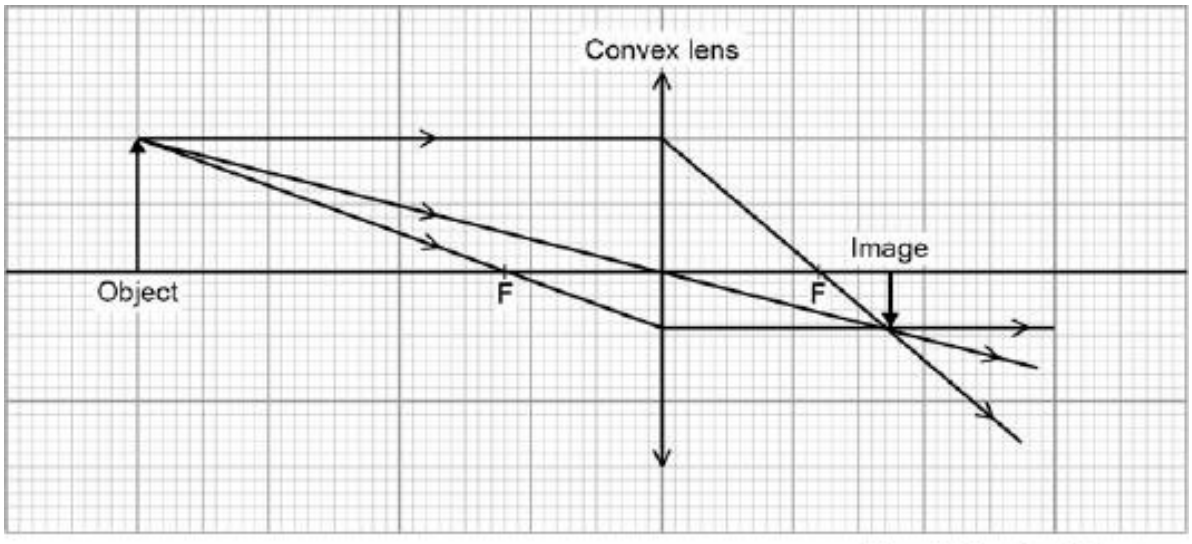
Qu No.		Extra Information	Marks
2.1	**W** Horizontal distance labelled between two identical points on adjacent waves **A** Vertical distance from peak or trough to mean		1 1
2.2	Transverse waves Wave moving up and down while moving from left to right		1 1
2.3	4 waves / 2 seconds = 2 (Hz)		1 1
2.4	0.5 s / seconds	Allow ecf rom 2.3 if T = 1/f clearly used	1 1

Qu No.		Extra Information	Marks
3.1	V = f λ = 10 000 000 000 x 0.02 = 200 000 000 = 2×10^8 m/s		1 1 1
3.2	(No) as all electromagnetic waves have the same speed.	Ignore reference to speed changing in air.	1
3.3	(No) as the eye cannot see microwaves The light is visible light (from a bulb)		1 1
3.4			
Level 3:	A detailed and coherent description of how to carry out a safe investigation including clear description of equipment to use and explanation of the measurements to take.		5-6
Level 2:	A detailed and coherent description which may be lacking in some details or includes elements which are unlikely to work well (for example lengths of time over 5min).		3-4
Level 1:	A description of an experiment which is lacking in detail or us inherently unsafe.		1-2
	No relevant content		
Indicative content			
	Equipment used (does not need to be in a list): - Beaker - Measuring cylinder - Water - Thermometer - Stop watch / use of microwave to time - Microwave Investigation - Pour ~200ml cold water into a beaker - Measure temperature - Put in microwave for 30 seconds - Stir then measure the temperature after - Repeat for a range of times up to 3 mins - Plot a graph of the results		

Qu No.		Extra Information	Marks
4.1	Bat Dolphin	Both required for the mark	1
4.2	Elephant		1
4.3	Use of speed = frequency x wavelength to calculate speed of sound Speed of sound = 343 Use of speed of sound calculated and 10 kHz to calculate shortest wavelength of elephant's hearing.	Allow any pair of frequencies and wavelengths from a single animal (eg allow 20 x 17.2 = 344 m/s for first marking point) Value calculated will be 336 to 344 depending on pair used Answer in range 0.0336 to 0.0344 m	1 1 1

Qu No.		Extra Information	Marks
5.1	1600 x (0.35/2) = 280 (m)		1 1
5.2	Pulse 1 and pulse 2 – stayed the same depth Pulse 3 to pulse 4 – got shallower Pulse 4 and pulse 5 – stayed the same depth		1 1 1

Qu No.		Extra Information	Marks
6.1	any **two** correct construction lines: line passing straight through centre of lens (& out other side) • line travelling parallel to principal axis & then being refracted through principal focus (on RHS) • line travelling through principal focus (on LHS) & then being refracted to be parallel to principal axis (on RHS) inverted image drawn (with arrow) in correct location one arrowhead from object to image on any construction ray [Complete diagram below]		2 1 1
6.2	Magnification = 0.8 cm / 2.0 cm =0.4 cm		1 1



F = Principal focus

Qu No.		Extra Information	Marks
7.1	(for both fibres) increasing the wavelength of light decreases and then increases the percentage / amount of light transmitted (for both fibres) the minimum transmission happens at 5 (x 10^{-7} metres) the shorter fibre transmits a greater percentage of light (at the same wavelength)		1 1 1
7.2	f = c / λ = 6 x 10^{14} Hz		1 1
7.3	Light refracts at boundary between cladding and core Light changes speed/ slows down in cladding	Do not allow speeds up	1 1

Qu No.		Extra Information	Marks
8.1	A and C **or** B and D Only one (independent) variable **or** different shapes but the same colour		1 1
8.2	**B** radiates faster / **B** is a better emitter (of heat) But **B** has a smaller (surface) area **/ B** has a smaller (surface) area: volume ratio		1 1