

1 Microwaves are used to transmit signals to the satellite. The microwaves have a wavelength of 0.6 metres (m) and travel through space at a speed of 300 000 000 metres per second (m/s).

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

(1)

- (ii) Calculate the frequency of the microwaves. Show clearly how you work out your answer and give the unit.

Frequency = _____

(3)

(Total 4 marks)

2 Radio waves and microwaves are two types of electromagnetic wave.

Both waves:

- can be used for communications
- travel at the same speed through air.

- (a) Give **two** more properties that are the same for both radio waves and microwaves.

1. _____

2. _____

(2)

- (b) Some satellites are used to transmit television programmes. Signals are sent to, and transmitted from, the satellites using microwaves.

What is the property of microwaves that allows them to be used for satellite communications?

(1)

- (c) Electromagnetic waves travel at a speed of 3.0×10^8 m/s.

A radio station transmits waves with a wavelength of 2.5×10^2 m.

Calculate the frequency of the radio waves.

Show clearly how you work out your answer and give the unit.

Frequency = _____

(3)

(Total 6 marks)

3

- (a) The wavelengths of four different types of electromagnetic wave, including visible light waves, are given in the table.

Type of wave	Wavelength
Visible light	0.0005 mm
A	1.1 km
B	100 mm
C	0.18 mm

Which of the waves, **A**, **B**, or **C**, is an infra red wave?

(1)

- (b) A TV station broadcasts at 500 000 kHz. The waves travel through the air at 300 000 000 m/s.

Calculate the wavelength of the waves broadcast by this station.

Show clearly how you work out your answer.

Wavelength = _____ m

(2)

(c) What happens when a metal aerial absorbs radio waves?

(2)

(d) Stars emit all types of electromagnetic waves. Telescopes that monitor X-rays are mounted on satellites in space.

Why would an X-ray telescope based on Earth **not** be able to detect X-rays emitted from distant stars?

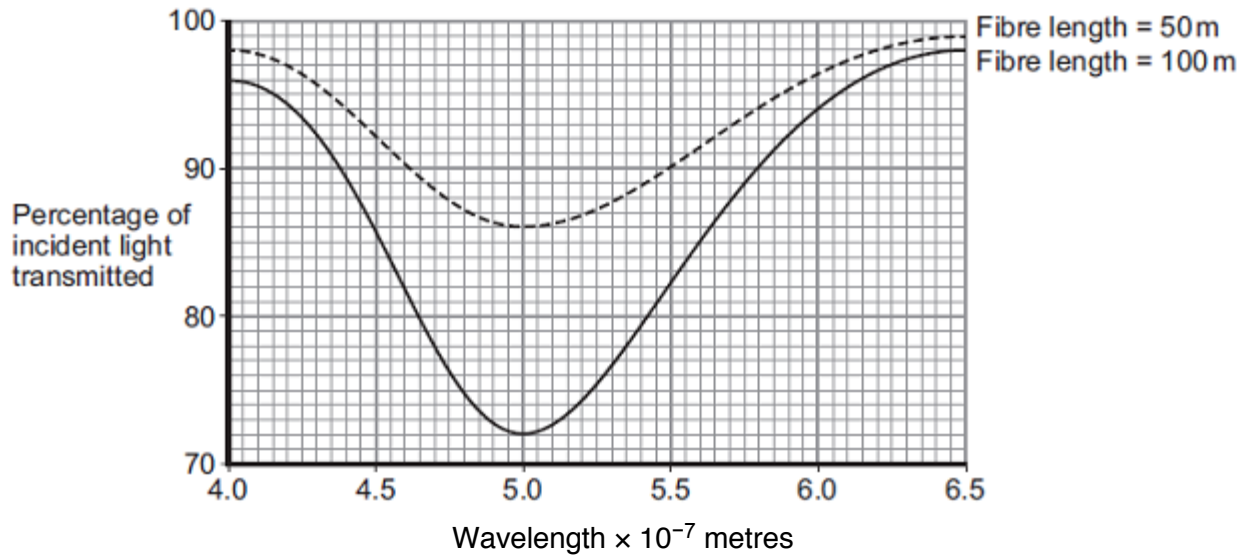
(1)

(Total 6 marks)

4

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

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



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

(Total 3 marks)

5

- (a) Electromagnetic waves form a continuous spectrum with a range of wavelengths.

What is the approximate range of wavelengths of electromagnetic waves?

Tick (✓) **one** box.

10^{-15} metres to 10^4 metres

10^{-4} metres to 10^{15} metres

10^{-6} metres to 10^6 metres

(1)

- (b) Infrared waves and microwaves are used for communications.

- (i) Give **one** example of infrared waves being used for communication.

(1)

- (ii) A mobile phone network uses microwaves to transmit signals through the air. The microwaves have a frequency of 1.8×10^9 Hz and travel at a speed of 3.0×10^8 m/s.

Calculate the wavelength of the microwaves.

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

Wavelength = _____ m

(3)

- (c) Some scientists suggest there is a possible link between using a mobile phone and male fertility.

The results of their study are given in the table.

Mobile phone use in hours per day	Sperm count in millions of sperm cells per cm ³ of semen
0	86
less than 2	69
2 – 4	59
more than 4	50

The results show a negative correlation: the more hours a mobile phone is used each day, the lower the sperm count. However, the results do **not** necessarily mean using a mobile phone causes the reduced sperm count.

Suggest **one** reason why.

(1)

(Total 6 marks)

6

- (a) Microwaves and visible light are two types of electromagnetic wave. Both can be used for communications.

- (i) Give **two** properties that are common to both visible light and microwaves.

1. _____

2. _____

(2)

- (ii) Name **two** more types of electromagnetic wave that can be used for communications.

_____ and _____

(1)

- (b) Wi-Fi is a system that joins computers to the internet without using wires. Microwaves, with a wavelength of 12.5 cm, are used to link a computer to a device called a router. Microwaves travel through the air at 300 000 000 m/s.

Calculate the frequency of the microwaves used to link the computer to the router.

Show clearly how you work out your answer and give the unit.

Frequency = _____

(3)

- (c) Wi-Fi is used widely in schools. However, not everyone thinks that this is a good idea.

A politician commented on the increasing use of Wi-Fi. He said: 'I believe that these systems may be harmful to children.'

However, one group of scientists said that there is no reason why Wi-Fi should not be used in schools. These scientists also suggested that there is a need for further research.

- (i) Suggest what the politician could have done to persuade people that what he said was not just an opinion.

(1)

- (ii) Why did the group of scientists suggest that there is a need for further research?

(1)

(Total 8 marks)

7

Radio waves, ultra-violet, visible light and X-rays are all types of electromagnetic radiation.

(a) Choose wavelengths from the list below to complete the table.

$3 \times 10^{-8} \text{ m}$ $1 \times 10^{-11} \text{ m}$ $5 \times 10^{-7} \text{ m}$ 1500 m

TYPE OF RADIATION	WAVELENGTH (m)
Radio waves	
Ultra-violet	
Visible light	
X-rays	

(4)

(b) Microwaves are another type of electromagnetic radiation.

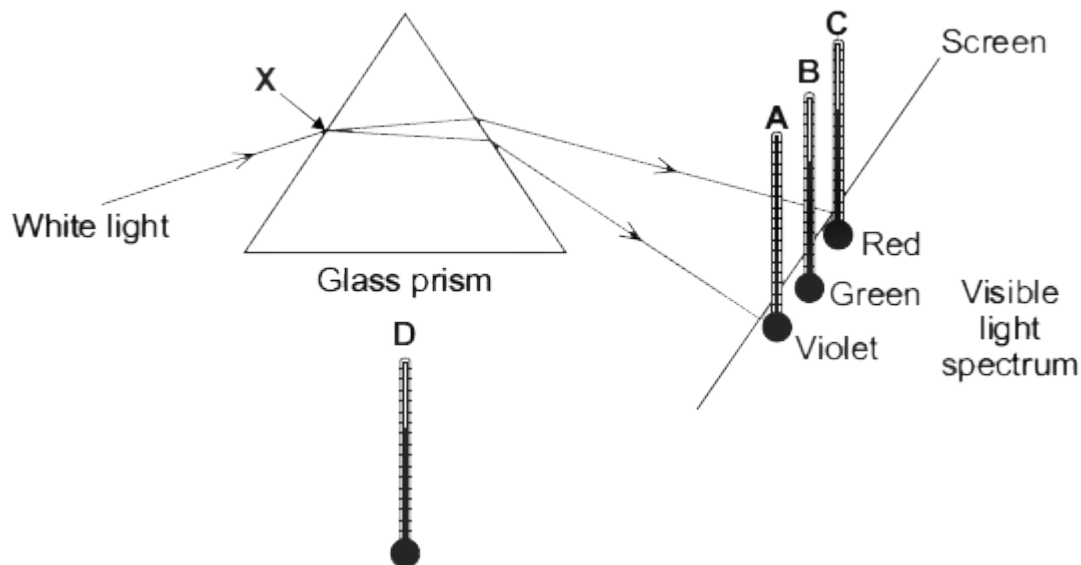
Calculate the frequency of microwaves of wavelength 3 cm.
(The velocity of electromagnetic waves is $3 \times 10^8 \text{ m/s}$.)

(4)

(Total 8 marks)

8

The diagram shows the apparatus that a student used to investigate the heating effect of different wavelengths of light.



- (a) (i) The student put thermometer **D** outside of the light spectrum.

Suggest why.

(1)

- (ii) The table gives the position and reading of each thermometer 10 minutes after the investigation started.

Thermometer	Position of thermometer	Temperature in °C
A	in violet light	21
B	in green light	22
C	in red light	24
D	outside the spectrum	20

What should the student conclude from the data in the table?

(2)

- (b) A similar investigation completed in 1800 by the scientist Sir William Herschel led to the discovery of infrared radiation.

Suggest how the student could show that the spectrum produced by the glass prism has an infrared region.

(2)

- (c) A person emits infrared radiation at a frequency of 3.2×10^{13} Hz.

Calculate the wavelength of the infrared radiation that a person emits.

Take the speed of infrared radiation to be 3.0×10^8 m/s.

Show clearly how you work out your answer.

Wavelength = _____ m

(2)

- (d) A thermal imaging camera detects infrared radiation. Electronic circuits inside the camera produce a visible image of the object emitting the infrared radiation.

At night, police officers use thermal imaging cameras to track criminals running away from crime scenes.

Thermal imaging cameras work better at night than during the day.

Explain why.

(2)

(Total 9 marks)

9

Galaxies emit all types of electromagnetic wave.

- (a) (i) Which type of electromagnetic wave has the shortest wavelength?

(1)

- (ii) State **one** difference between an ultraviolet wave and a visible light wave.

(1)

- (b) Electromagnetic waves travel through space at a speed of 3.0×10^8 m/s.

The radio waves emitted from a distant galaxy have a wavelength of 25 metres.

Calculate the frequency of the radio waves emitted from the galaxy and give the unit.

Frequency = _____

(3)

- (c) Scientists use a radio telescope to measure the wavelength of the radio waves emitted from the galaxy in part (b) as the waves reach the Earth. The scientists measure the wavelength as 25.2 metres. The effect causing this observed increase in wavelength is called red-shift.

- (i) The waves emitted from most galaxies show red-shift.

What does red-shift tell scientists about the direction most galaxies are moving?

(1)

- (ii) The size of the red-shift is **not** the same for all galaxies.

What information can scientists find out about a galaxy when they measure the size of the red-shift the galaxy produces?

(2)

- (iii) What does the observation of red-shift suggest is happening to the Universe?

(1)

(Total 9 marks)

10

Different parts of the electromagnetic spectrum have different uses.

(a) The diagram shows the electromagnetic spectrum.

Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays
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(i) Use the correct answers from the box to complete the sentence.

amplitude	frequency	speed	wavelength
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The arrow in the diagram is in the direction of increasing _____
and decreasing _____ .

(2)

(ii) Draw a ring around the correct answer to complete the sentence.

The range of wavelengths for waves in the electromagnetic

spectrum is approximately

10^{-15} to 10^4
10^{-4} to 10^4
10^4 to 10^{15}

metres.

(1)

(b) The wavelength of a radio wave is 1500 m.
The speed of radio waves is 3.0×10^8 m / s.

Calculate the frequency of the radio wave.

Give the unit.

Frequency = _____

(3)

(c) (i) State **one** hazard of exposure to infrared radiation.

(1)

- (ii) State **one** hazard of exposure to ultraviolet radiation.

(1)

- (d) X-rays are used in hospitals for computed tomography (CT) scans.

- (i) State **one** other medical use for X-rays.

(1)

- (ii) State a property of X-rays that makes them suitable for your answer in part **(d)(i)**.

(1)

- (iii) The scientific unit of measurement used to measure the dose received from radiations, such as X-rays or background radiation, is the millisievert (mSv).

The table shows the X-ray dose resulting from CT scans of various parts of the body.

The table also shows the time it would take to get the same dose from background radiation.

Part of the body	X-ray dose in mSv	Time it would take to get the same dose from background radiation
Abdomen	9.0	3 years
Sinuses	0.5	2 months
Spine	4.0	16 months

A student suggests that the X-ray dose and the time it would take to get the same dose from background radiation are directly proportional.

Use calculations to test this suggestion and state your conclusion.

(3)
(Total 13 marks)