

GCSE Physics (9 – 1)

Electromagnetic Waves

Name:

Group:



Instructions

- Read each question carefully before you begin to answer it.
- Use black ink or black ball-point pen for your answers.
- Fill in the boxes at the top of this page with your name and group.
- Attempt to answer every question in the booklet.
- Answer the questions in the spaces provided – there may be more space than you need in some answer spaces.
- Calculators may be used for this booklet.
- For any calculations, you **must** show all your working.
- Any and all drawings or graphs should be completed in pencil.

For markers use	
Question	Mark
1	/6
2	/9
3	/6
4	/8
5	/10
6	/12
Total	/51
%	
Grade	

Information

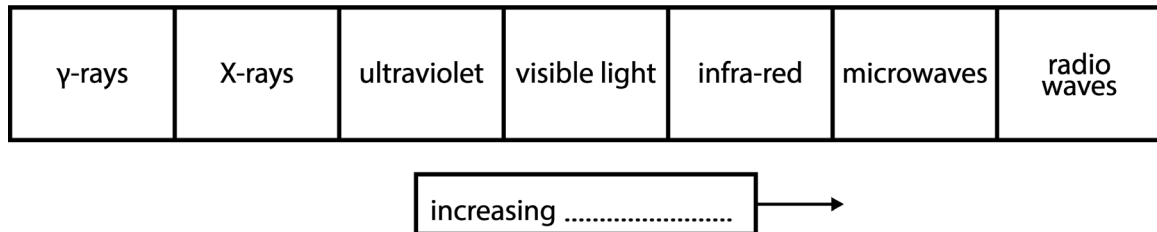
- The maximum mark for this paper is 51 marks.
- The marks for each question are shown in brackets.
- Please be aware that good English and clear presentation are required in your answers.



1. Whether you're texting a friend, changing the channel on your TV, or getting a suntan, you are interacting with this fascinating group of waves. These are electromagnetic waves.

For each of the following questions, **circle** the letter of the correct answer.

- a. The figure below shows the electromagnetic spectrum.



A word is missing from the figure above. Which of the following would best describe the missing word.

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

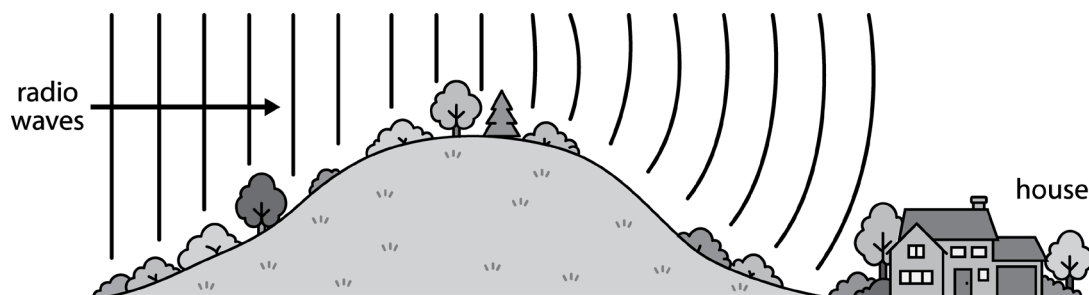
(1 mark)

- b. Which statement about electromagnetic waves travelling through a vacuum is correct?

- A** Gamma rays travel the fastest because they have the highest frequency.
- B** Radio waves travel the fastest because they have the longest wavelength.
- C** Visible light travels faster than infrared but slower than ultraviolet.
- D** All electromagnetic waves travel at the exact same speed.

(1 mark)

- c. Radio waves are emitted by a tower and received at a house on the far side of a hill. The figure below shows this happening.



The waves reach the house because the hill has caused them to be:

- | | | | |
|-----------|-----------|----------|------------|
| A | B | C | D |
| Reflected | Refracted | Sped up | Diffracted |

(1 mark)

- d. Air traffic control uses radar to detect planes.

A pulse of microwaves is transmitted from the radar tower, bounces off a plane, and the echo returns to the tower 0.0002 seconds later.

Given that microwaves travel at 3×10^8 m/s, how far away is the plane?

A	B	C	D
15 000 m	30 000 m	60 000 m	150 000 m

(1 mark)

- e. Compared to an infrared wave, an ultraviolet wave has:

- A** a longer wavelength and a higher frequency.
- B** a shorter wavelength and a higher frequency.
- C** a longer wavelength and a lower frequency.
- D** a shorter wavelength and a lower frequency.

(1 mark)

- f. A laser pointer emits a beam of red light with a wavelength of 6×10^{-7} m.

What is the frequency of the red light? (Speed of light in a vacuum = 3×10^8 m/s)

A	B	C	D
1.8×10^2 Hz	2.0×10^{-15} Hz	5.0×10^1 Hz	5.0×10^{14} Hz

(1 mark)

(Total for Question 1 is 6 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 a vacuum.**

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

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(2 marks)

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?

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(1 mark)

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

A mobile phone network transmits microwaves with a frequency of 1.5×10^9 Hz.

Calculate the **wavelength** of these microwaves.

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

Wavelength = ... Unit:

(3 marks)

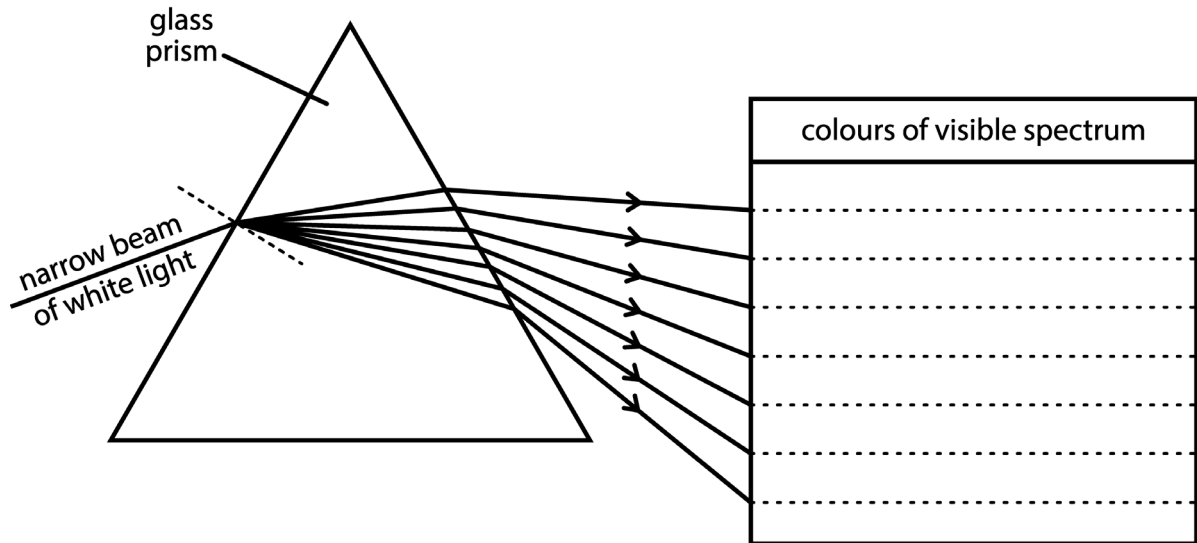
- d. A communications satellite is in orbit 36,000 km above the Earth's surface.

Calculate the **time** it takes for a microwave signal to travel from a transmission dish on Earth to the satellite in space.

Time = ... s
(3 marks)

(Total for Question 2 is 9 marks)

3. A narrow beam of white light is directed at a glass prism.
As the light passes through the prism, it splits into the different colours of the visible spectrum.



- a. The rays leaving the prism represent the seven main colours of the visible spectrum.
Complete the table on the diagram by writing the colours of the visible spectrum in the correct order.
(2 marks)

- b. State the scientific name for the wave behaviour that causes the white light to bend as it enters the glass prism.

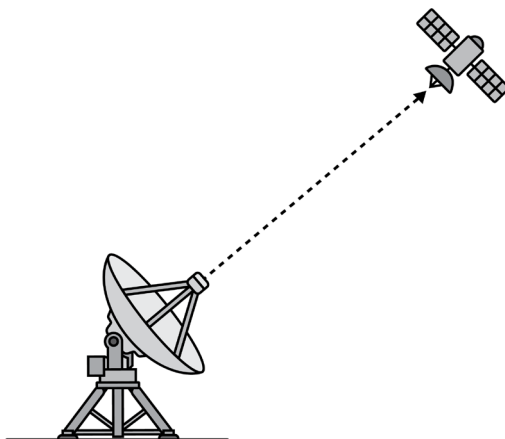
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(1 mark)

- c. The top ray of light leaving the prism has a wavelength of $6.5 \times 10^{-7} \text{ m}$.
The speed of light in the air is $3.0 \times 10^8 \text{ m/s}$.
Calculate the frequency of this ray of light.

Frequency = ... Hz
(3 marks)

(Total for Question 3 is 6 marks)

4. A remote weather station uses a microwave dish to transmit data upwards to a satellite in orbit. Sometimes the signal received by the satellite is very weak.



- a. Suggest what engineers could do to the transmission dish or the signal on Earth to improve the strength of the communication **and** explain why the suggested improvements work.

Suggestion 1:

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Reason:

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Suggestion 2:

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Reason:

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(4 marks)

- b. Look at the information about three different electromagnetic waves used for communication.

Wave	Wavelength	Frequency
X	1500 m	200 kHz
Y	0.03 m	10 GHz
Z	8.5×10^{-7} m	3.5×10^{14} Hz

- i. Which wave is most suitable for sending broadband internet signals down optical fibres?

Answer:

Explain why you chose this wave.

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(2 marks)

- ii. Which wave can be used to broadcast a radio signal over the horizon to a ship at sea, without using a satellite?

Answer:

Explain why you chose this wave.

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(2 marks)

(Total for Question 4 is 8 marks)

- b. A communications tower transmits a radio wave with a wavelength of 1.5 kilometres (km).
The speed of radio waves in the air is 3.0×10^8 m/s.

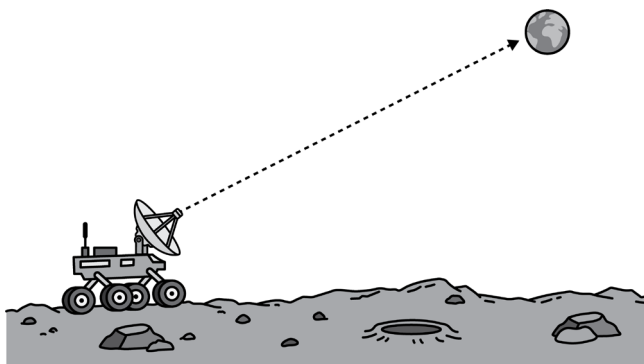
Calculate the frequency of this radio wave.

Give your final answer in kilohertz (kHz)

Frequency = ... Hz
(4 marks)

(Total for Question 5 is 10 marks)

6. A space agency has landed a new rover on the surface of Mars. The rover uses microwaves to communicate with scientists on Earth, and it uses an X-ray spectrometer to analyse the Martian rocks. The figure below shows the rover on the surface of Mars.



- a. Compare the properties of the X-rays used to scan the rocks with the microwaves used for communication. Refer to their frequency and wavelength in your answer.

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(2 marks)

- b. At its current position in orbit, Mars is 2.25×10^{11} m away from Earth.
Electromagnetic waves travel through space at a speed of 3.0×10^8 m/s.
Calculate the **time** it takes for a microwave signal to travel from the rover to Earth.
Give your answer in **minutes**.

Time = ... minutes
(3 marks)

- c. The microwave signal transmitted by the rover has a frequency of 12 GHz
Calculate the **wavelength** of this microwave signal.
Give your answer in **centimetres**.

Wavelength = ...

(3 marks)

- d. The rover is powered by a nuclear battery that emits gamma radiation.

Explain why exposure to gamma rays and X-rays is highly dangerous to human astronauts, but exposure to microwaves is not.

You should refer to the wave properties and their specific effects on human cells.

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(4 marks)

(Total for Question 6 is 12 marks)