

Key Concepts:

- All electromagnetic (EM) waves are **transverse waves** that transfer energy from a source to an absorber.
- They all travel at the **speed of light** in a vacuum (3×10^8 m/s). Their speed decreases in denser media.
- The EM spectrum is a **continuous spectrum** of waves, ordered by wavelength, frequency, and energy.
- **Order:** Radio, Microwaves, Infrared, Visible light, Ultraviolet, X-rays, Gamma rays (RMIVUXG).
- **Trends:** From Radio to Gamma rays: Wavelength **decreases**, Frequency **increases**, Energy **increases**.

Core Equation: Wave speed = Frequency $\times$ Wavelength ($v = f \times \lambda$)

Section A: Key Terms & Spectrum Order

1. Complete the sentences below using the words **transverse**, **light**, **decreases**, **increases**, and **frequency**:

- All electromagnetic waves are _____ waves.
- They all travel at the same speed in a vacuum, which is the speed of _____.
- As you move from radio waves to gamma rays across the spectrum, the wavelength _____.
- As you move from radio waves to gamma rays, the frequency _____.
- The energy carried by an electromagnetic wave is directly proportional to its _____.

2. Label the diagram of the electromagnetic spectrum below with the names of the seven regions and indicate the direction of increasing wavelength and increasing frequency/energy.

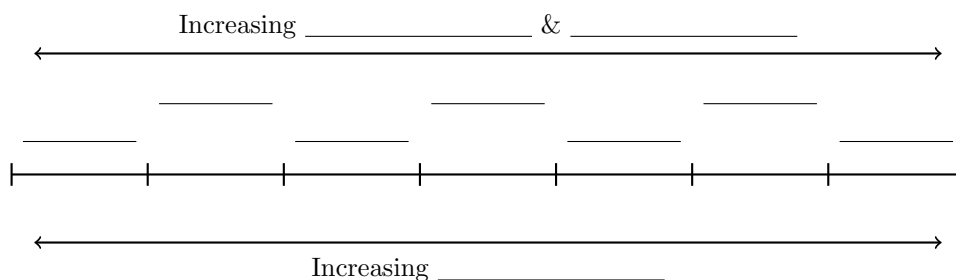


Figure 1: The Electromagnetic Spectrum

Section B: Core Concepts & Explanations

3. Answer the following questions about electromagnetic waves:

- Explain what it means for electromagnetic waves to be *transverse* waves.

- Compare the speed of electromagnetic waves in a vacuum with their speed when they pass through a transparent medium like glass.

- Describe the relationship between the frequency, wavelength, and energy of electromagnetic waves across the spectrum.

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- d) Describe how different types of electromagnetic waves are produced. Give at least three distinct examples from across the spectrum.

Section C: Exam Application & Extended Writing

4. A student is researching the properties and uses of different electromagnetic waves. They find the following information:

EM Wave	Typical Wavelength	Common Use	Associated Danger
Radio waves	> 10 cm	Broadcasting	None (at low intensity)
Microwaves	1 mm – 10 cm	Cooking, Satellite TV	Internal heating of body tissues
Infrared	700 nm – 1 mm	Remote controls, Heaters	Skin burns
Visible light	400 nm – 700 nm	Seeing	Eye damage (at high intensity)
Ultraviolet	10 nm – 400 nm	Sunbeds, Sterilisation	Skin cancer, Eye damage
X-rays	0.01 nm – 10 nm	Medical imaging	Cell mutation, Cancer
Gamma rays	< 0.01 nm	Sterilising medical equipment	Severe cell damage, Cancer

- a) Identify the electromagnetic wave from the table that is used for sterilising medical equipment and can cause severe cell damage.

- b) X-rays and microwaves are both used in various technologies, but they have very different properties and associated dangers. Compare the properties, uses, and dangers of X-rays and microwaves. In your answer, you should refer to their position in the electromagnetic spectrum and the type of radiation they are.