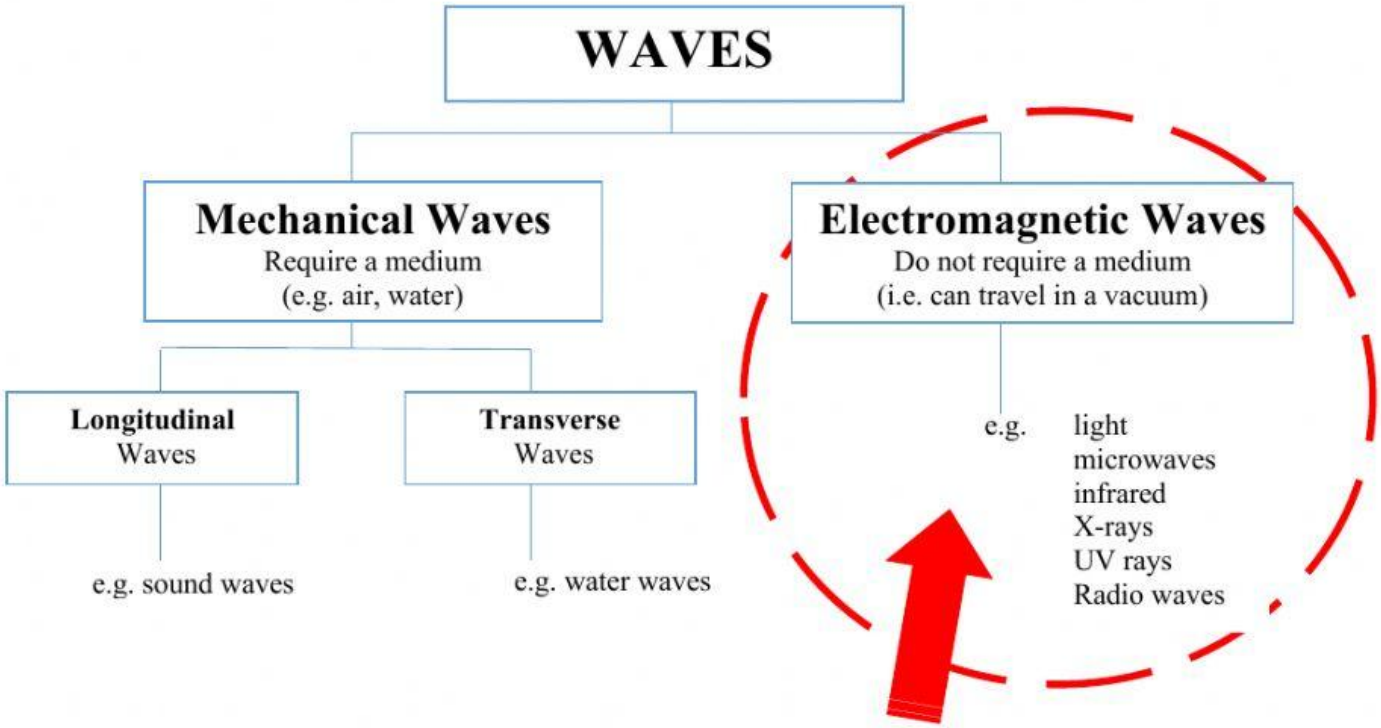
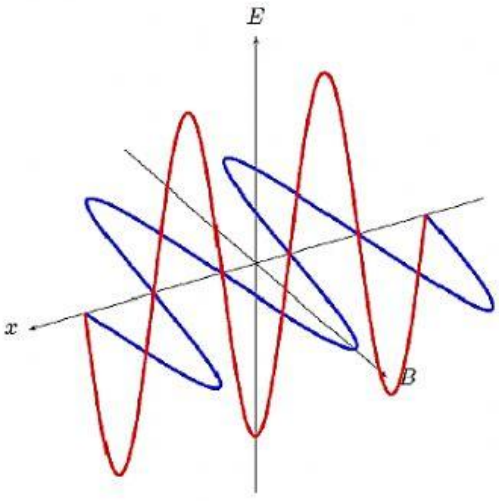
Electromagnetic radiation



- Electromagnetic waves are caused by an accelerating charge. Whenever charges are accelerated they give off (radiate) energy in the form of electromagnetic waves.
- Electromagnetic waves consist of an electric field and a magnetic field that oscillate (moves back and forth) at right angles to each other.
- When current flows it will produce an electric field which oscillates. This changing electric field produces a changing magnetic field that is perpendicular to electric field; which then produces a changing magnetic field at right angles to it, and so it carries on.

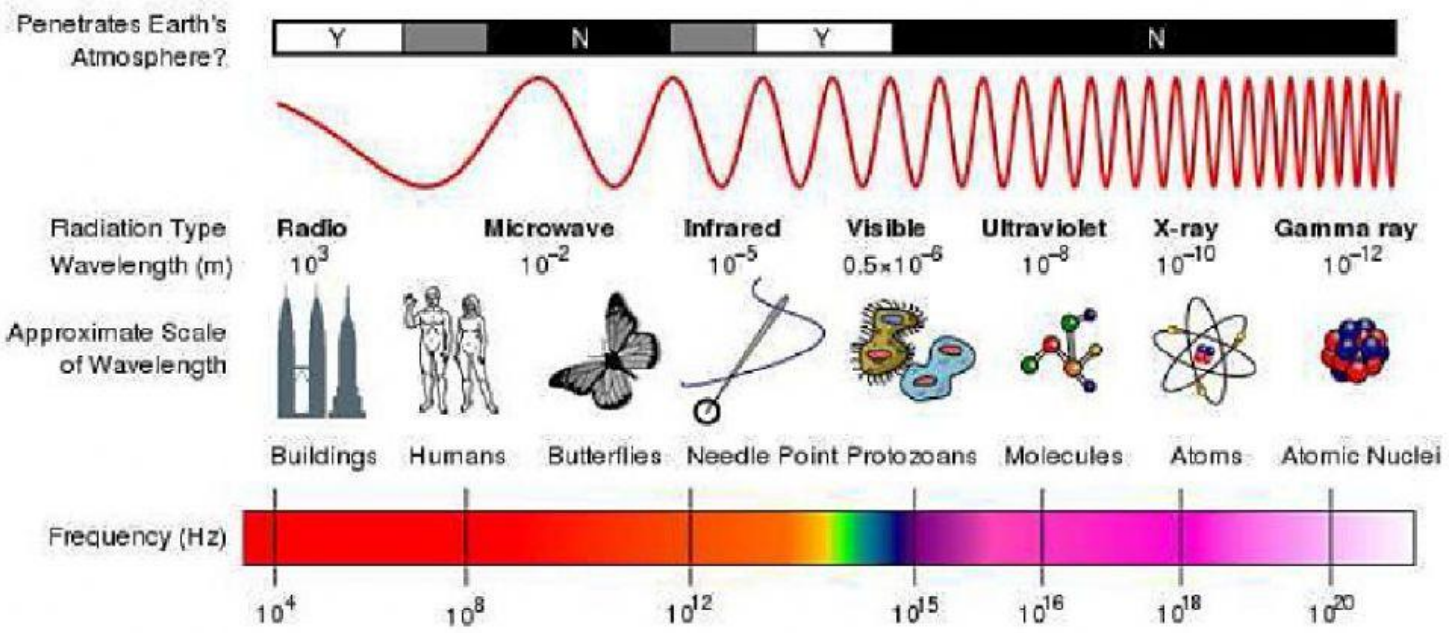


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- Electromagnetic waves travel through space at a constant speed of 3×10^8 m.s^{-1} (symbol used for the speed is c).

- We can arrange the different types of EM radiation in order of frequency or wavelength.

- Longest to shortest wavelength (or from lowest to highest frequency): Radio waves, microwaves, infrared, visible light, ultraviolet, x-ray and gamma rays.



- For calculations with Mechanical Waves we used the formula **v = fλ**

- For Electromagnetic Radiation, wave speed is **c** not **v** but the formula remains the same:

$$\mathbf{c = f\lambda}$$

c = speed of EM waves (3×10^8 m.s^{-1})
f = frequency of wave (Hz)
λ = wavelength of wave (m)

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Question 1

Calculate the frequency of an electromagnetic wave with a wavelength of $4,2 \times 10^{-7}\ m$.

$$c = f\lambda$$

$$3 \times 10^{8}\ \text{m} \cdot \text{s}^{-1} = f \times 4,2 \times 10^{-7}\ \text{m}$$

$$f = \square \times 10^{14}\text{Hz}$$

Question 2

An electromagnetic wave has a wavelength of 200 nm. What is the frequency of the radiation?

$$c = f\lambda$$

$$\square\ \text{m} \cdot \text{s}^{-1} = f \times \square \times 10^{-9}\ \text{m}$$

$$f = \square \times 10^{15}\ \text{Hz}$$

Examples of each type of EM radiation:



- **Gamma rays:**
  Emitted by radioactive substances (like Uranium and Radium). This radiation can cause mutations, cancer and even cell death.
  Uses: kill cancer cells in tumours (radiation), kill bacteria and sterilise medical instruments. Some foods are irradiated by gamma rays to keep them fresh for longer.

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- **X-rays:**
  Are produced when fast-moving electrons are brought to a sudden stop as they hit a metal target.
  Uses: X-rays can pass through skin and flesh, but not through bones and teeth. The differences in penetrating ability are used to create an image on photographic film.
  Security checks at airports use X-ray machines to identify objects in luggage.

- **Ultraviolet light**:
  the sun emits UV light (but the ozone layer absorbs 97-99%). UV rays cause skin to tan by stimulating a dark pigment called melanin. Over-exposure to UV radiation causes redness, blisters and increases the risk of skin cancer. (sunscreen contains chemicals that absorbs the UV rays).
  Uses: UV rays are needed to form vitamin D in our skin. Many insects, such as bees and moths and some bird species can see UV light. Bees follow the UV patterns on the flowers to reach the nectar. UV light (also called black light) can be used to attract insects, which are then electrocuted by high-voltage wires near the lamp. Hospitals use UV lights to sterilise equipment, forensics use UV light to look for clues at crime scenes.

- **Visible light:**
  The visible spectrum contains seven colours (ROYGBIV).
  Uses: We are able to see objects, because they reflect visible light.

- **Infrared rays**:
  Infrared rays are given off by hot objects, like heaters or fires. (They radiate from all objects that are warmer than their surroundings).
  Uses: conventional ovens use infrared waves to cook food.
  Photographers use night-vision cameras when there is not enough

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visible light. Police and military use thermal images to "see" in the dark. Infrared light used in remote controls.

- **Microwaves:**
  The sun emits microwave radiation, but most of it is blocked by Earth's atmosphere.
  Uses: microwave ovens produce waves that transmit energy to food. Microwaves are also used in satellite communication systems. (Microwaves are good transmitters because they are not affected by snow, clouds, haze etc.) Telephone messages are transmitted when microwaves are sent from the ground up to communication satellites that are linked around the earth. Television programmes are beamed to television satellites and down to earth again. Radar speed-trapping devices use microwaves to measure the speed of vehicles.

- **Radio waves:**
  Radio waves are made by lightning or astronomical objects like stars and galaxies.
  Uses: Man- made radio waves are used for radio communication, broadcasting radar and navigation systems.

Exercise 11-1:

1. Arrange the following types of EM radiation in order of increasing frequency: infrared, X-rays, ultraviolet, visible, gamma.

2. Calculate the frequency of an EM wave with a wavelength of 400 nm.

3. Give an example of the use of each type of EM radiation, i.e. gamma rays, X-rays, ultraviolet light, visible light, infrared, microwave and radio and TV waves.

Do Question 3 in the back of your physics note book.

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