

WAVES

1.1 Electromagnetic Waves

There are waves made up of electric and magnetic vibrations. They transfer energy from one place to another.

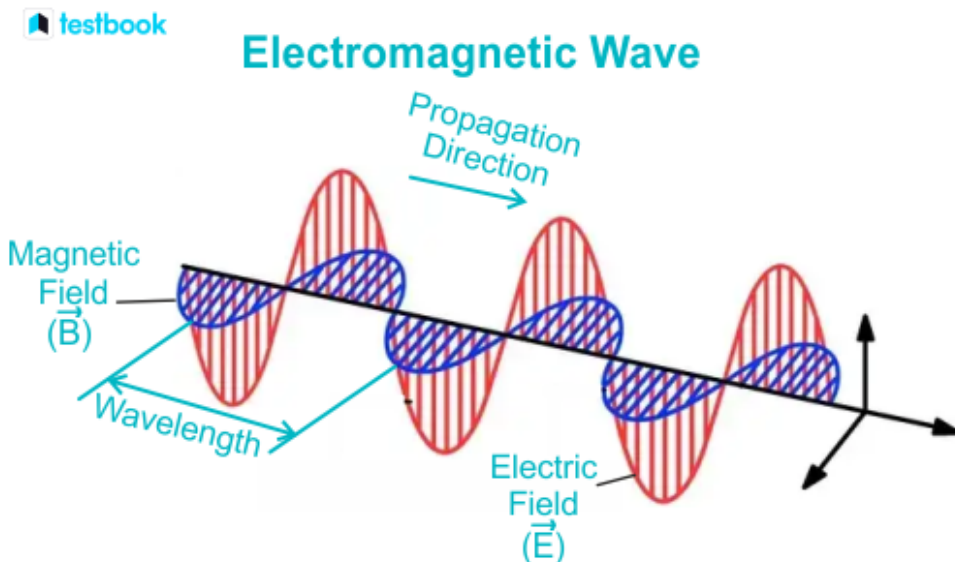
All electromagnetic waves travel through space at the same time.

These waves are created as a result of vibrations between an electric field and a magnetic field.

Properties of electromagnetic waves:

- They travel at the same speed through space.
- They travel at the speed of light which is equal to $3 \times 10^8 \text{ ms}^{-1}$.
- They are transverse waves.
- They obey the wave equation: $v=f\lambda$
- They can be reflected, refracted, and diffracted.
- They can undergo interference.
- They do not transfer matter.
- They transfer energy from one place to another.
- The energy transferred depends on the wavelength of the waves.

The wavelength of the electromagnetic waves has different effects.



How are electromagnetic waves produced?

1. **Charged Particle Acceleration:** The electric and magnetic fields surrounding a charged particle, like an electron, become unstable as it accelerates, decelerates, or changes direction.
2. Electric and magnetic fields that oscillate in response to this disturbance are perpendicular to one another and to the direction in which the wave is propagating.

3. Wave Propagation: These oscillating fields carry energy as they travel over space in the form of electromagnetic waves.

1.2 Electromagnetic Spectrum

The **electromagnetic spectrum** is a band of electromagnetic waves. It is the range of all types of electromagnetic radiation.

The electromagnetic spectrum includes the following waves:

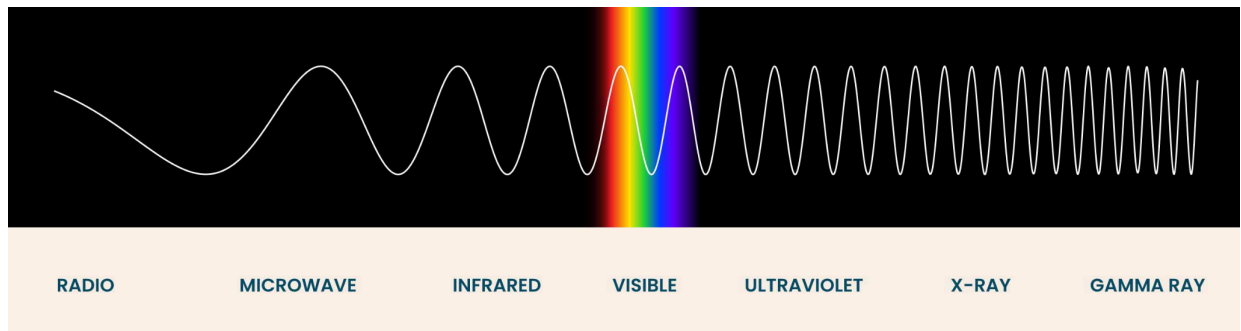


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- Gamma rays have the shortest wavelength and radiowaves have the longest wavelength.
- Gamma rays have the most frequency and radio waves have the least frequency.

Note: The higher the frequency, the shorter the wavelength.

Radiowaves

- They have the largest wavelength.
- These waves can be longer than a football field as short as a football (ranging from about 1m to km).
- Radiowaves do more than just bring music to the radio. They can also carry signals for your television and cellular phones.
- The antenna on your television set receives signals in the form of electromagnetic waves, which are broadcast from the television station. It is played on your television screen.

Main property: They are reflected by metal sheets.

Sources of radiowaves:

- Radio
- TV transmitter

Detectors of radiowaves:

- Receivers with aerials
- Mobile phones

Microwaves

- They have wavelengths that can be measured in centimeters (cm).
- These are waves that can heat food in a microwave oven.
- Microwaves are good for transmitting information from one place to another because microwave energy can penetrate light rain, snow, clouds, and smoke.

Main property: They are reflected by steel and metal sheets. They are absorbed by water.

Sources of microwave:

- Microwave transmitter
- Microwave oven

Uses of microwaves:

- Communication
- Satellite links
- Heating food

Infrared Radiation

- Its wavelength is longer than that of visible light and shorter than that of radio waves.
- It is invisible to the eye but the sensation of warmth on the skin can be detected.

Main property: Heat-inducing property, transverse wave, exhibit refraction.

Sources of infrared radiation:

- Solar radiation
- Fire
- Infrared lamps

Detectors of infrared radiation:

- Thermal detector
- Photonic detector

Light Waves

- Each wave has two parts: An electric part and a magnetic part.
- They have a speed of $3 \times 10^8 \text{ ms}^{-1}$.

Main property: The shorter wavelengths correspond to higher energy (blue and violet light), and the longer wavelengths correspond to lower energy (red and infrared light).

Sources of infrared radiation:

- Sunlight
- Fireflies
- Light bulbs

Detectors of infrared radiation:

- Photo resistors
- Photovoltaic devices
- Photodiodes

Gamma rays

- Gamma rays have the smallest wavelengths and the most energy of any wave in the electromagnetic spectrum.
- They are produced by the hottest and the most energetic objects in the universe such as neutrons, stars and pulsars, supernova explosions, and regions around the black hole.
- Gamma rays are a form of electromagnetic radiation arising from the radioactive decay of an atomic nuclei.

Main property: They do not have mass.

Uses of gamma rays:

- Sterilizing medical equipments
- To kill cancer cells

Detectors of gamma rays:

- Spectrometers
- Imagers

X-rays

- They have high energy and can pass through most objects e.g. human body.
- Medical X-rays generate images of tissues and structures inside the body.

Main property: X-ray photons are highly energetic and have enough energy to break up molecules and hence damage living cells.

Source of x-rays:

- Radioactive elements in Earth
- X-ray machines

Detectors of x-rays:

- Imaging detectors
- X-ray film