ELECTROMAGNETIC WAVES

Waves are disturbance that travels through media transferring energy from point to another without permanent displacement of the media. We can distinguish two general classes of waves: mechanical and electromagnetic waves.

Mechanic waves requires a material (or tangible) medium for their propagation. Examples are water waves, sound waves, waves on a rope, etc.

The media through which the mentioned waves travel are water particles, air particles, particles of string, respectively.

Electromagnetic waves are those waves that do not require a material medium for their propagation. They arise from vibrations of Electric (E) and Magnet (M) fields. The combination of the electric field and magnetic field waves is called an Electromagnetic (E-M) wave. Examples of E-M are simply members of its spectrum and include Gamma (y) rays, X-rays, Light waves, etc.

Other differences between mechanical and electromagnetic waves are:

- Electromagnetic waves travel at the speed of light (which is 3.0×10^8 ms^{-1}) while mechanical waves travels at speed lesser than that of light.
- Also mechanical waves can either be transverse or longitudinal but electromagnetic waves are always transverse.

History & Development of the Electromagnetic Spectrum

Some scientist studied electromagnetic radiations before the 1860's. They are William Herschel, Johann Rither, and Michael Faraday. During the 1860s James Clerk Maxwell developed four partial different equations for the electromagnetic field. Two of these equations predicted the possibility and behaviour of waves in the field. Analysing the speed of these theoretical waves, Maxwell realized that they must travel at a speed that was about the known speed of light. This startling coincidence in

value led to Maxwell to make the inference that light itself is a type of electromagnetic wave.

Maxwell equations predicted an infinite number of frequencies of electromagnetic waves, all travelling at the speed of light. This was the first indication of the existence of an entire electromagnetic spectrum.

Attempting to prove Maxwell's equations and to detect such low frequency electromagnetic radiation, Heinrish Hertz in 1886 built an apparatus to generate and detect what are now known as radio waves. Hertz found the waves and was able to infer (by measuring their wavelength and multiplying their frequency) that they travel at the speed of light.

In 1895 Wilhelm Röntgen discovered X-rays, Paul Villard, Henry Bragg, Ernest Rutherford, and Edward Andrade all worked to discover, describe, name and confirm gamma rays to be part of the electromagnetic spectrum.

The Electromagnetic Spectrum

The Electromagnetic spectrum is the range of frequencies of electromagnetic radiation and respective wavelengths and photon energies. The EM spectrum includes Gamma rays, X-rays, Ultraviolet rays, Visible light, Infrared rays, Microwaves and Radio waves in order of increasing wavelength.

	Frequency	Wavelength ($\approx m$)
Gamma rays	10^{24}Hz – 10^{22}Hz	10^{-16} – 10^{-14}
X-rays	10^{22}Hz – 10^{18}Hz	10^{-14} – 10^{-10}
Ultra-violet	10^{18}Hz – 10^{15}Hz	10^{-10} – 10^{-7}
Visible light	$7x10^{14}$Hz – $4x10^{14}$Hz	10^{-7} – 10^{-6}
Infra-red	10^{14}Hz – 10^{11}Hz	10^{-6} – 10^{-3}
Microwaves	10^{10}Hz - 10^{7}Hz	10^{-2} – 10
Radio (and TV) waves	10^{8}Hz - 10^{3}Hz	10^{0} – 10^{5}

Note: these values are not very accurate but they give a glimpse of the actual values.

Uses of Electromagnetic Waves

Radio waves have wavelength that lie in the range of 1mm to a few kilometres. They are commonly used in radio transmissions. Radio waves of shorter wavelength (~1cm) are used in radar, that is radio transmission and ranging.

X-rays have wavelengths ranging from 10^{-10}cm to 10^{-7}cm. They have tremendous penetrating power, and are able to penetrate brick, bones, etc. they are therefore used in hospitals to make x-ray pictures or radiographs of the bones and internal organs of the body. They are used to detect flaws in various kinds of materials used in heavy industries. They are used to study the structure of crystals, the structure and properties of atoms and molecules and their arrangements in matter. They are also used at airports as x-rays scanners to detect concealed weapons in luggage.

Gamma rays have wavelength of 10^{-8}cm. Their penetrating power is about 1000 times greater than that of x-rays. They are used in the medical

field to sterilize supplies, like surgical equipment, drug, food, bandages, etc. They are also used to treat cancers and tumours.