JSR IAS ACADEMY

GENERAL SCIENCE

PHYSICS

SOUND - 1

Production of Sound

- Sound is produced when an object is set to vibrate.
- Vibration means a kind of rapid to and fro motion of an object.
- The substance through which sound is transmitted is called medium.

Propagation of Sound:

- Sound travels in water and solids also.
- The speed of sound is more in solids than in liquids and it is very less in gases.
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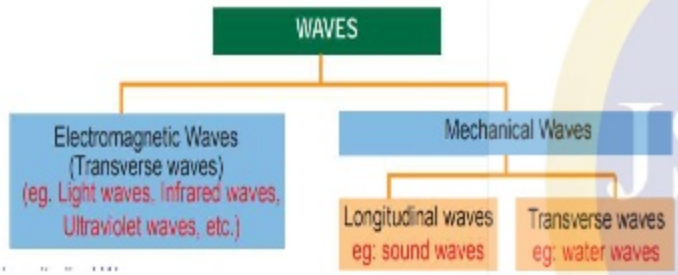
DO YOU KNOW?

Thomas Alva Edison, in 1877 invented the phonograph, a device that played the recorded sound.

CHARACTERISTICS AND TYPES OF WAVES

In general, a wave is a series of disturbances that move through a medium.



Electromagnetic waves.

- Some waves such as electromagnetic waves do not require a medium to propagate and can travel through vacuum.
- Radio waves are an example of electromagnetic waves.

Mechanical waves

- Waves that require a material medium to propagate, such as sound waves, are referred to as mechanical waves.
- Mechanical wave is a disturbance, which propagates in a medium due to the repeated periodic motion of the particles of the medium, from their mean position.
- Mechanical waves are of two kinds - longitudinal waves and transverse waves.

Longitudinal Waves

- "If the particles of a medium vibrate in a direction, parallel to or along the direction of the propagation of wave, it is called a longitudinal wave."
- In a longitudinal wave the particles of the medium vibrate in a direction, which is parallel to the direction of propagation of the wave.
- E.g. Waves in springs, sound waves in a medium. Longitudinal waves are produced in solids, liquids and also in gases.

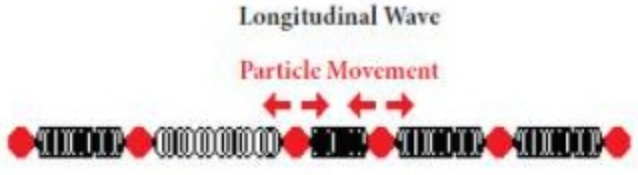
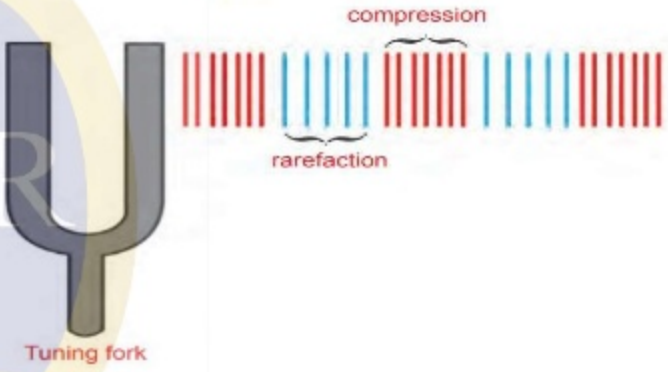


Figure 1.6 Longitudinal wave



- Compression is the area with maximum pressure, rarefaction is the area with minimum pressure.

S.No.	SOUND	LIGHT
1	Medium is required for the propagation.	Medium is not required for the propagation.
2	Sound waves are longitudinal.	Light waves are transverse.
3	Wavelength ranges from 1.65 cm to 1.65 m.	Wavelength ranges from 4×10^{-7} m to 7×10^{-7} m.
4	Sound waves travel in air with a speed of about 340 m s^{-1} at NTP.	Light waves travel in air with a speed of 3×10^{8} m s^{-1}.

Transverse waves

- "If the particles of the medium vibrate in a direction, perpendicular to the direction of propagation, the wave is called a transverse wave."
- Examples of transverse waves are water waves and the vibration of stretched strings.
- E.g. Waves in strings, light waves, etc. Transverse waves are produced only in solids and liquids.

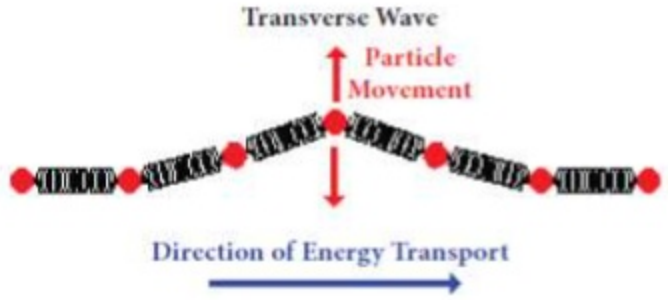
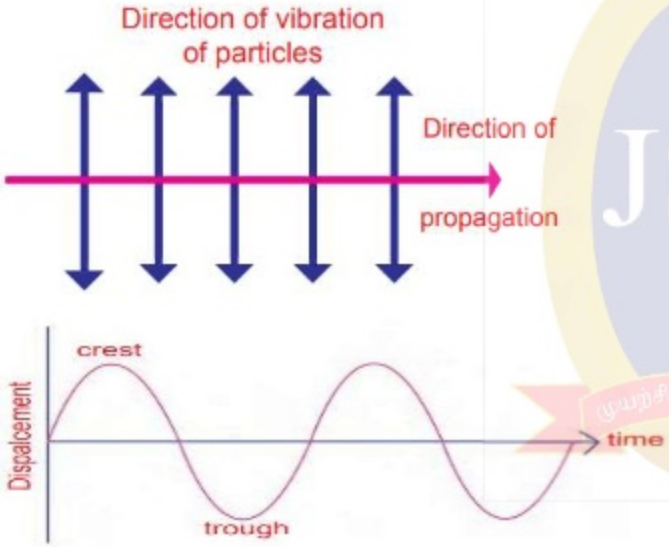


Figure 1.6 Transverse wave



- Transverse waves propagate in a medium in the form of crests

Transverse waves	Longitudinal waves
Particles of the medium vibrate in a direction which is perpendicular to the direction of propagation.	Particles of the medium vibrate in a direction which is parallel to the direction of propagation.
Crests and troughs are formed.	Compressions and rarefactions are formed.
Can travel through solids and surfaces of liquids.	Can travel through solids, liquids and gases.
eg. Water waves	eg. Sound waves.

ELECTROMAGNETIC WAVES

Electromagnetic waves are non-mechanical waves which move with speed equals to the speed of light (in vacuum).

Production and properties of electromagnetic waves - Hertz experiment

- Maxwell's prediction was experimentally confirmed by Heinrich Rudolf Hertz in 1888.
- This confirms that electromagnetic waves are transverse waves as predicted by Maxwell.
- Hertz detected radio waves and also computed the speed of radio waves which is equal to the speed of light (3×10^8 m s^{-1}).

Properties of electromagnetic waves

1. Electromagnetic waves are produced by any accelerated charge.
2. Electromagnetic waves do not require any medium for propagation. So electromagnetic wave is a non-mechanical wave.
3. Electromagnetic waves are transverse in nature.
4. Electromagnetic waves travel with speed which is equal to the speed of light in vacuum or free space,
5. Electromagnetic waves are not deflected by electric field or magnetic field.
6. Electromagnetic waves can show interference, diffraction and can also be polarized.

Electromagnetic spectrum

Electromagnetic spectrum is an orderly distribution of electromagnetic waves in terms of wavelength or frequency

ELECTROMAGNETIC SPECTRUM

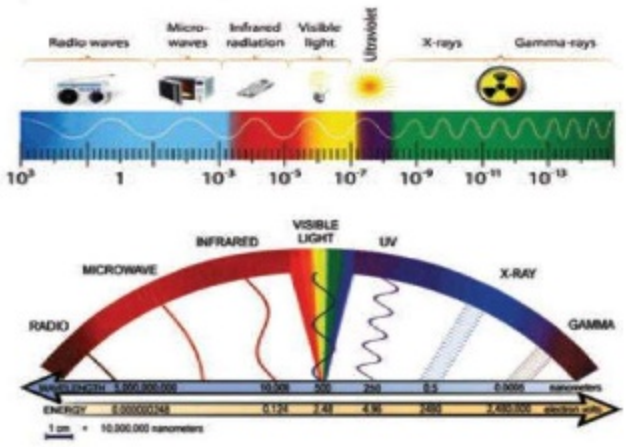


Figure 5.10 Electromagnetic spectrum -

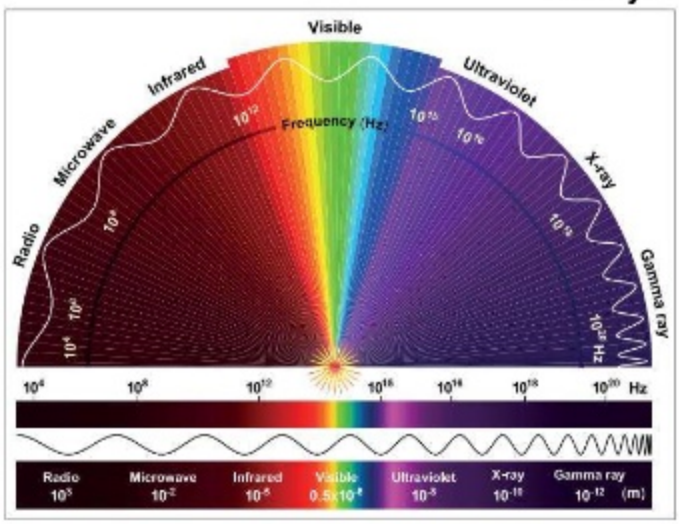
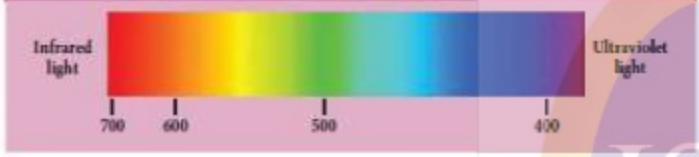


Table 5.1 visible region, frequency and wavelength of different types of radiation



Type of Radiation	Frequency Range (Hz)	Wavelength Range
gamma-rays	10^{20}-10^{24}	$<10^{-12}$m
x-rays	10^{17}-10^{20}	1 nm - 1pm
ultraviolet	10^{15}-10^{17}	400 nm - 1nm
visible	$4 - 7.5 \times 10^{14}$	750 nm - 400nm
near-infrared	1×10^{14}-4×10^{14}	2.5 μm - 750nm
infrared	10^{13}-10^{14}	25 μm - 2.5μm
microwaves	3×10^{11}-10^{13}	1 mm - 25 μm
radio waves	$< 3 \times 10^{11}$	> 1 mm

Radio waves

- It is produced by oscillators in electric circuits.
- It obeys reflection and diffraction.
- It is used in radio and television communication systems and also in cellular phones to transmit voice communication in the ultra high frequency band.

Microwaves

- It is produced by electromagnetic oscillators in electric circuits.
- It obeys reflection and polarization.
- It is used in radar system for aircraft navigation, speed of the vehicle, microwave oven for cooking and very long distance wireless communication through satellites.

Infrared radiation

- It is produced from hot bodies (also known as heat waves) and also when the molecules undergo rotational and vibrational transitions.
- It provides electrical energy to satellites by means of solar cells.
- It is used to produce dehydrated fruits, in green houses to keep the plants warm, heat therapy for muscular pain or sprain, TV remote as a signal carrier, to look through haze fog or mist and used in night vision or infrared photography.

Visible light

- It is produced by incandescent bodies and also it is radiated by excited atoms in gases.
- It obeys the laws of reflection, refraction, interference, diffraction, polarization, photo-electric effect and photographic action.
- It can be used to study the structure of molecules, arrangement of electrons in external shells of atoms and sensation of our eyes.

Ultraviolet radiation

- It is produced by Sun, arc and ionized gases.
- It has less penetrating power.
- It can be absorbed by atmospheric ozone and harmful to human body.
- It is used to destroy bacteria, sterilizing the surgical instruments, burglar alarm, detect the invisible writing, finger prints and also in the study of molecular structure.

X-rays

- It is produced when there is a sudden deceleration of high speed electrons at high-atomic number target, and also by electronic transitions among the innermost orbits of atoms.
- X-rays have more penetrating power than ultraviolet radiation.
- X-rays are used extensively in studying structures of inner atomic electron shells and crystal structures.

- It is used in detecting fractures, diseased organs, formation of bones and stones, observing the progress of healing bones.
- Further, in a finished metal product, it is used to detect faults, cracks, flaws and holes.

Gamma rays

- It is produced by transitions of atomic nuclei and decay of certain elementary particles. They produce chemical reactions on photographic plates, fluorescence, ionisation, diffraction.
- Gamma rays have high penetrating power than X-rays and ultraviolet radiations; it has no charge but harmful to human body.
- Gamma rays provide information about the structure of atomic nuclei.
- It is used in radio therapy for the treatment of cancer and tumour, in food industry to kill pathogenic microorganism.