CHAPTER EIGHT

WAVES

Introduction:

These are used to carry energy from one point to another, without the movement of particles between these two points. In wave motion, the particles of the medium do not move along with the wave but only vibrates about their mean or equilibrium position.

Classification of waves:

- The mode of classification depends on
(a) the type of medium.
(b) the type of wavefront.
(c) the type of wavelength.
- On the basis of the type of medium involved, waves can be classified into two groups and these are:
(1) Mechanical or elastic waves.
(2) Electromagnetic waves.

Mechanical waves:

- These are waves which require for their propagation a moving or a vibrating source and an elastic medium.
- They are set up in an elastic material by a vibrating source which causes the disturbances of a portion of the medium, which is later on transmitted through the medium.
- There are two types of mechanical waves and these are
(a) transverse waves.
(b) longitudinal waves.
- sound and water waves are examples of mechanical waves.

Electromagnetic waves:

- These are waves which do not need a material medium for their transmission, and do not arise from the vibration of any material medium.
- They travel at the seed of light and can travel through vacuum.
- Radio and light waves are examples of electromagnetic waves.

Longitudinal and transverse waves:

- On the basis of the direction of vibration of the medium`s particles with respect to the direction of motion of the wave, waves can be sub divided into

(a) longitudinal waves. (b) transverse waves.

Longitudinal waves:

- These are waves in which the particles of the medium vibrate to and fro in the same direction, as the direction of propagation of the wave.
- An example of longitudinal wave is sound wave.

Transverse wave:

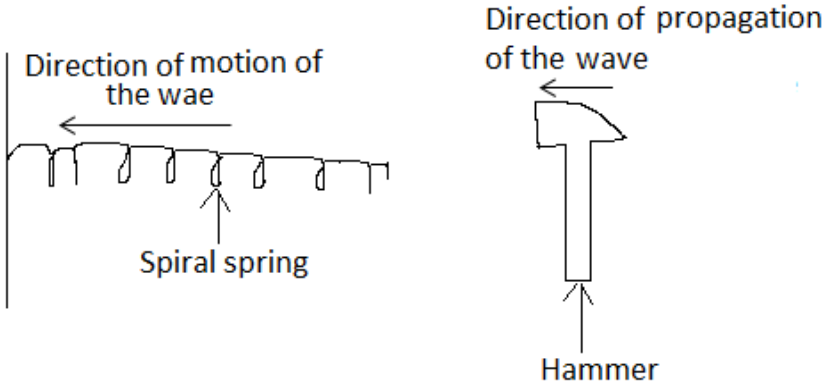
- These are waves in which the particles of the medium vibrate up and down in a direction, which is perpendicular to the direction of propagation of the wave.

- Light and water waves are examples of transverse waves.

Longitudinal and transverse waves from a slinky coil or spiral spring:

(1) **Longitudinal waves:**

- One end of the coil is attached to the wall and the other end is pulled lengthwise or stricken with a hammer so that the coil vibrates in the lengthwise direction.

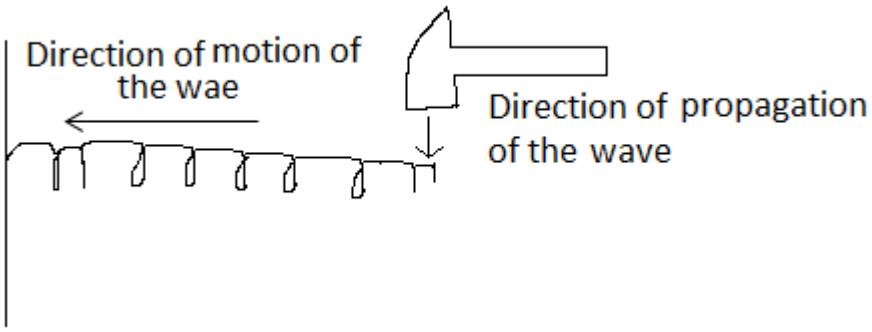


N/B:

- The direction of movement of the hammer, the same as the direction of propagation of the wave.
- After striking the spring in the lengthwise direction asshown in the diagram, it will be noticed that the waves produced in the spring will move in the same direction as the direction of propagation of the wave.

(2) Transverse waves:

- The coil is stricken at right angle or in a perpendicular direction to its length o the free and is pulled alternatively up and down.



Material Medium and the Source of the wave:

The material medium refers to the material through which the wave travels.
For example, which sound wave travels through the medium of air, and water wave travels through the medium of water. The source of the wave refers to the agent which is generating or causing the wave to arise. For example, if we touch the surface of water to generate water waves, then our hand or the finger used in touching the surface of the water is the source of the wave.

Parameters used in describing waves:

- These parameters are

(1) The amplitude (a):

- This is the maximum displacement of an oscillating particle within a wave, from its mean or equilibrium position.
- It determines the amount of energy stored in the wave.

(2) The frequency (f):

- This is the number of complete oscillations made per second, by an oscillating particle in the wave.
- Its unit is the hertz Hz).

(3) The wavelength (λ):

- The wavelength which is represented by the symbol λ or lamda, is the distance between two successive particles which are in phase.
- In other words, it is the distance between two successive crests or troughs.
- Its unit is the metre.
- Two particles in a wave are said to be in phase when they have the same amplitude.
- For example, when one is at the highest amplitude, the other is also at the same amplitude.

- And also, if one of the particles is at its lowest amplitude, then the other must also be at the same lowest amplitude.

(1) The period:

- This is the time taken by an oscillating particle in a wave to complete one oscillation.
- Its unit is the second.

(2) The speed of propagation (transmission) of a wave (v):

- This is the distance travelled by the wave in one second.
- V = fλ, where V = the speed of propagation, and λ = the wavelength.

Differences between longitudinal waves and transverse waves:

Longitudinal wave	Transverse wave
(1) The particles of the medium, vibrate parallel to the direction of motion of the wave.	(1) The particles of the medium vibrate in a perpendicular direction, to the direction of motion of the wave.
(2) It consists of compressions and rarefactions.	(2) It consists of crests and troughs.
(3) The distance between two successive compressions is a wavelength.	(3) The distance between two successive crests or troughs, is a wavelength.

The differences between mechanical (sound) wave, and electromagnetic (light) wave:

Mechanical Wave e.g sound wave	Electromagnetic wave e.g light wave
(1) They require a material medium, for their transmission or propagation.	(1) They do not require a material medium, for their transmission or propagation.
(2) They can either be transverse or longitudinal.	(2) They can only be transverse.
(3)They have longer wavelengths.	(3. They have shorter wavelengths.
(4)They travel at a very low velocity.	(4) They travel at very high velocity.

The electromagnetic spectrum:

- This is a kind of spectrum, in which the various electromagnetic waves have been arranged according to their various frequencies or wavelengths.
- The electromagnetic spectrum consists of the following radiations:

(a) Gamma rays.

(b) X – rays.

(c) Ultra violet rays.

(d) Visible light.

(e) Infrared rays.

(f) Radio waves.

Gamma rays:

- This is produced when energy changes occur within the nucleus of the atom.
- Gamma rays are used for sterilization purposes.

X – rays:

- X – rays is produced when fast moving electrons are brought to a halt or a stop in a target material.
- It is mainly used in medicine for the diagnosis and treatment of diseases.

Ultra – violet rays:

-This is produced when electrons change their energy levels within an atom.
- It is used for the brightening of dyes and paints.

Visible light:

- This is produced in the same manner as ultra violet rays, and it is used for illumination.

Infrared rays:

- This is also produced in the same way as ultra violet or light rays, and it is used for warming and heating.

Radio waves:

- These are produced by the oscillation of electrons within an area, and are used for the transmission of information.

Factors affecting the velocity of sound in air:

- The factors which affect the velocity of sound in the air or a gas are:

(1) The type of gas:

- The velocity of sound is determined by the type of gas, through which sound is travelling.

(2) Temperature:

- The velocity of sound in gas increases as the temperature of the gas is travelling through increases.

(3) Wind:

- The velocity of sound in air, increases in the direction of the wind.

(4) Humidity:

- The velocity of sound in air increases as the humidity of the air increases.

Wave characteristics and some properties of waves:

- Waves in general behave in certain typical ways, and these typical ways are known as wave characteristics.
- Some of the properties of wave are:

(1) Refraction.
(2) Reflection.
(3) Diffraction.
(4) Interference.

Refraction of waves:

This refers to the change in the direction of a wave when it travels from one medium into another. For example, refraction will occur when the wave moves from the medium of air into the medium of water. Refraction is due to the change in the velocity of the wave, when it moves from one medium into another.

Reflection of waves:

Reflection of sound wave occurs, when sound wave moving in a particular direction comes into contact with an obstacle, and the direction of movement of the wave is reversed in the opposite direction. A reflected sound wave is called an echo, and they

are produced by the reflection of sound waves from a hard surface, such as a wall or a cliff.

The importance or uses of echo:

- Used to determine the depth of oceans and for oil exploration.
- Used to determine the velocity of sound in air.
- Used to determine the distance between two objects.
- Fishermen use the soner or echo sounder which depends on echo to determine and locate shoals of fishes.

Diffraction of waves: This refers to the spreading out of waves when they pass through a small gap or opening.

Sound waves require a material medium:

- Unlike light wave which is an electromagnetic and as such can travel through vacuum sound wave cannot travel through vacuum.
- Sound wave can only travel through a material medium.
- To demonstrate this, a glass bottle containing a clockwork bell which is producing sound is taken.
- The air within the glass bottle is gradually pumped out using an air pumped out using a vacuum pump.
- It will be noticed that as the air is pumped out, the sound steadily gets weaker and weaker till it disappears.