CHAPTER FOUR

WAVES:

INTRODUCTION:

A wave is that form of energy which flows from one point to another within a medium, such that the particles of the medium do not travel between the two points but only vibrate about equilibrium position. In wave motion, the particles of the medium do not move along with the wave, but merely vibrate about their mean or equilibrium position. It is only the shape of the wave (i.e. the crests and troughs), which move forward with a definite speed. A familiar example of wave motion is that of ripples which occur on the surface of water, when a point in it is disturbed. When a disturbance is initiated, the particles of the medium vibrate periodically about their mean or equilibrium position, and this periodic disturbance is propagated through the medium at a definite speed.

Classification of waves:

-The mode of classification depends on :

(a) the type medium.

(b) the type of wavefront.

- 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.

-In short, mechanical waves originate in an elastic or deformable medium, by the onset of the vibration of a source, which causes a displacement or disturbance of

some portion of the medium, which in turn enables the disturbance to be transmitted through the medium.

- Examples are sound wave and water wave.

Electromagnetic waves:

- These are waves which do not arise from the vibration of any material medium, and do not need or depend on any material medium for its transmission.
- It consists of waves of energy associated with electric and magnetic fields, vibrating at right angles to each other and to the direction of propagation.
- This type of wave consists of visible and non visible radiation and travel at the speed of light.
- Examples are light waves, ultra – violet waves, radio waves, x – rays and gamma rays.

Longitudinal and transverse waves:

- On the basis of the direction of the vibration of the mediums particles and with respect to the direction of motion of the wave, waves can be sub divided into:
(i) longitudinal waves.
(ii) 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 is sound wave.

Transverse waves:

- 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 waves.
- Examples are water waves and light 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 pulled length wise or stricken with the a hammer, so that the coil vibrates in the length wise manner.

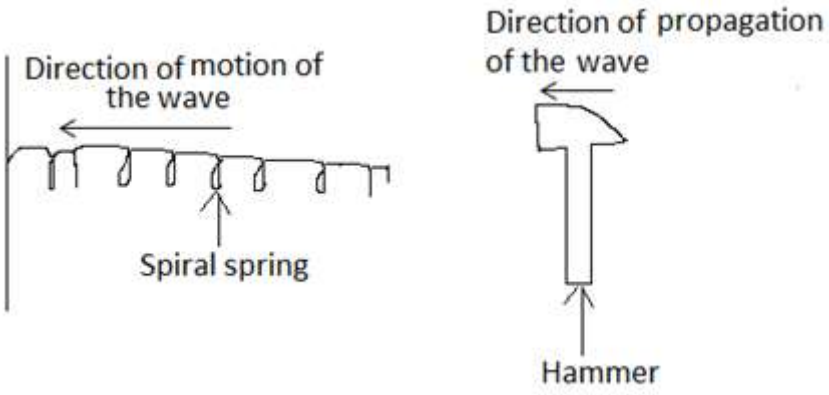
(2) Transverse waves:

-The coil is stricken at right angle to its length, or the free end is pulled alternatively up and down.

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.



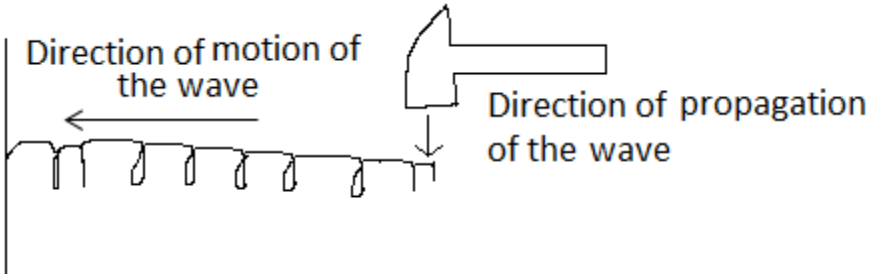
N/B:

-The direction of movement of the hammer is the same as the direction of propagation of the wave.

- After striking the spring in the lengthwise direction as shown 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, or the free end 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 while sound waves travel through the medium of air, water waves travel 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 in a wave, from its mean or equilibrium position.

-The amplitude determines the amount of energy stored in the wave.

(1) The frequency (f):

-This is the number of complete oscillations made per second, by an oscillating particle in the wave.

- It represents the number of waves which passes a particular point per second, or the number of waves produced per second by the source of the wave.

- Its unit is the hertz (Hz) or cycle per second i.e. cycle/ S

(2)The wavelength (λ):

-The wavelength which is referred to as 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 with metres being its unit.

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 perpendicularly 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.

Differences between mechanical and electromagnetic waves:

Mechanical waves	Electromagnetic waves
(1) They require a material medium for their propagation.	(1) They do not require a material medium for their 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 i.e. about 330m/s.	(4) They travel at very high velocity i.e. 3×10^8m/s.
(5) They cannot undergo polarization.	(5) They undergo polarization.
(6) They are due to the vibration of the particles of the medium concerned.	(6) They are due to electric and magnetic vectors.

N/B: When asked to differentiate or list the differences between sound waves and light waves, we only list the differences between mechanical and electromagnetic waves, since sound wave is mechanical wave and light wave is electromagnetic wave.

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.

The radar:

The radar has both transmitting and receiving equipments. The transmitting equipment within the radar sends out electromagnetic waves, which are reflected back when they hit an obstacle, and are received by the receiving equipment found within the radar. By making use of the time taken for the waves to return, the location or the distance the object is away from the radar can be calculated. Radars on planes enable the pilot to know whether he is going to crush into an obstacle, which can be another plane or not. They also assist the pilot to pilot the plane safely when the weather is bad, and as such cannot see ahead of him. Radars mounted on ships also prevent them from crushing into or colliding with other ships or icebergs. Lastly, radars installed at airports help in the detection of approaching aircrafts.