HAWASSA CITY ADIMINSTIRATION EDUCATION DEPARITIMENT SECOND SEMESTER COMPESATION LESSON IN 2012E.C

Physics

Grade -9

Unit -8

Wave motion and sound

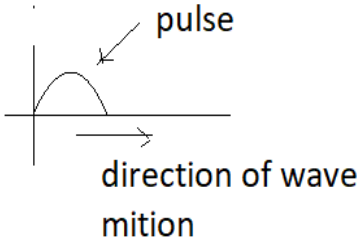
8.1. Wave propagation

What are **waves**? Waves can be thought of as a series of vibrations that travel through a medium.

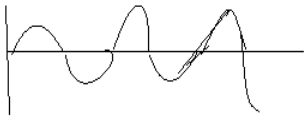
All waves transfer energy from one place to another, there is no transfer of matter.

Wave pulses and continuous waves

Wave pules:- a wave with no repeated vibrations



Continuous Wave:- a wave with repeated vibrations



F.g. A simple continous wave

Longitudinal and Transverse wave

- There are two main types of wave.

These types are classified by the direction of vibrations in relation to the direction of wave movement.

Transverse:-

In Transverse wave the vibrations are at right angles to the direction of wave movement (or energy transfer). This might be up and down or side to side.

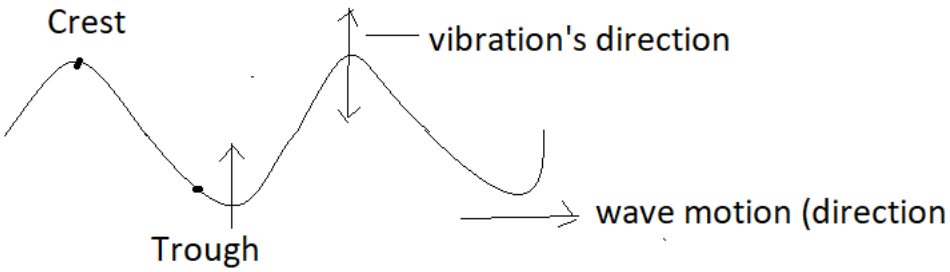


Fig. 8.10 Vibrations in a transverse wave

Examples of transverse waves include:

- All electromagnetic waves:-
  - light
  - microwaves
  - radio wave
  - x – ray etc.

✓ S- waves in earth quakes
✓ Waves on strings
✓ Waves on the surface of deep water.

*All transverse waves comprise a series of crests (or peaks and troughs)

Longitudinal Wave:

In a longitudinal wave the vibrations are in the same direction as the direction of wave movement (or energy transfer)

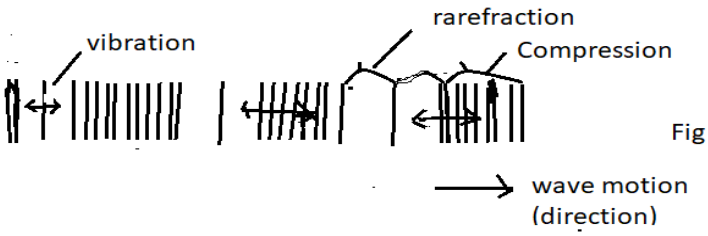


Fig 8.13. vibrations in a longitudinal wave

Examples of longitudinal waves include:-

- Sound waves
- Pressure wave
- Waves forwards and backwards through a spring
- P – waves in earth quakes

✓ Regions where than particles are pushed together are called compressions.

✓ Regions where the particles are more spread out are called rare fractions.

✓ If the longitudinal wave is travelling through a gas then a compression can be thought of an area of higher pressure and a rarefaction an area of lower pressure.

8.2. *Mechanical waves*
Waves characteristics

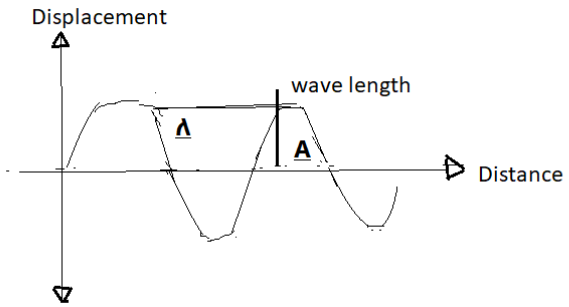


Fig. 8.18 wave length & Amplitude

Wave Speed (V):- is defined as the distance the wave travels in one second or the distance one peak or one compression travels in one second in meter per second.

Amplitude (A):- is the maximum displacement from the equilibrium position. In simple terms it's the maximum height of the wave it is measured (in meter) see fig. 8.18

Wave length (ʌ): is defined as the minimum distance between identical points on adjacent waves. It is measured (in meter) see fig. 8.18 above.

Frequency (f):- is the number of complete waves passing a given point per second.

- ✓ This can be determined by the number of crests or compressions that pass a given point per second.
- ✓ The higher the frequency, the greater the number of waves per second. It is measured in hertz (Hz).

Time period (T):- is the time taken for one complete wave to pass a given point.

- ✓ As time period is just measure of duration it is measured in second (s).

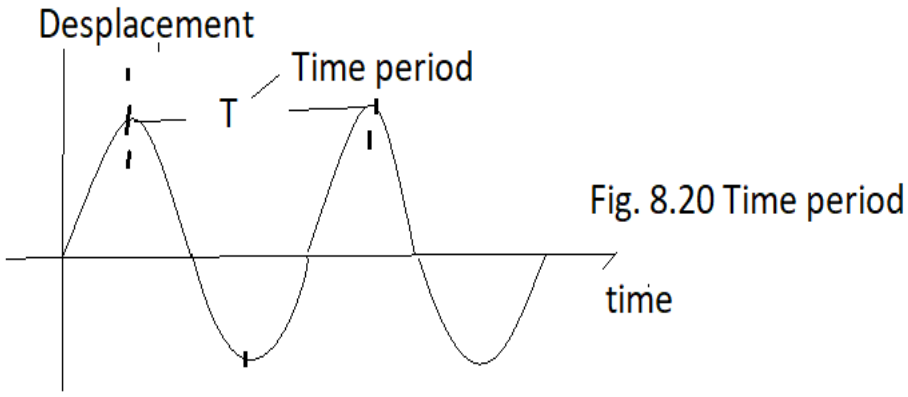


Fig. 8.20 Time period

There are two important equations linking these terms. The first links frequency and time period.

Frequency = $\frac{1}{time\,period}$ $\Rightarrow$ f= $\frac{1}{T}$

This also means T= $\frac{1}{f}$

Wave equation:- It relates wave speed, (v), frequency (f) and wave length (∧)

Wave speed (V)= frequency * wave length…….

$V = f\wedge$

Mechanical Vs electromagnetic waves

We call waves that travel through a material (water, would, air, etc) as vibrations of the material mechanical wave. All mechanical waves require a medium to travel through. They include sound waves, water waves and seismic waves.

Electromagnetic waves:- such as light, radio and x- ray, do not require a medium to travel through. They are comprised of vibrating electric and magnetic fields.

Examples of mechanical waves

Water waves:

Water wave arise due to the surface tension on the water. The speed of water wave depends on the depth of the water. As the depth of the water increase, so does the water speed? In deep water, water waves can travel very fast (in hundreds of km/h).

Tsunamis: are different types of water wave created by changes to the ocean floor or the coastline (often due to earth quakes).

Seismic waves: are produced by earth quakes. They travel out from the focus in all directions throughout the earth.

There are three types of seismic waves:

L- Waves,

p- Waves

S- Waves

L- waves: are complex types of rolling wave, which travel along the surface of the Earth and cause the most damage to buildings.

P- Waves and S-waves travel through the earth.

The p in p- waves stands for primary, or pressure, p- waves are an example of longitudinal wave and travel very fast.

P-waves are able to travel through both the solid and liquid parts of the earth's interior.

The S in S-waves stands for secondary, or sheer. S-waves are an example of transverse waves and still travel test.

8.3. Properties of waves.

The wave equation:- wave speed= frequency x wave length.

Example:- If a wave has a wave length of 3cm and a frequency of 11KHZ –HS speed can be determined.

Soln :- V= f∧ = 11000 Hz * 0.03 m = 330m/s

Wave Behavior:

All types of wave exhibit certain behavior: they exhibit reflection, refraction, diffraction and interference.

Reflection: - Occurs when a wave reaches a fixed surface the wave cannot pass through the surface; instead, it reflects off it, so that its direction changes.

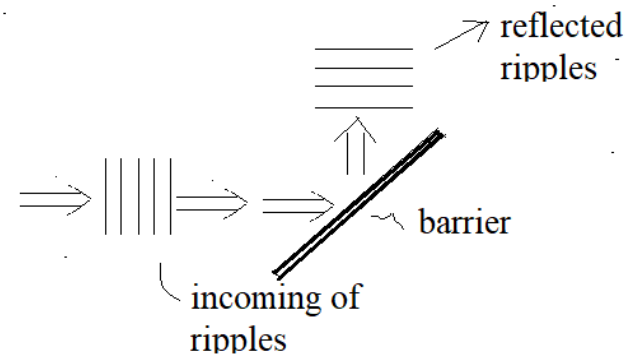
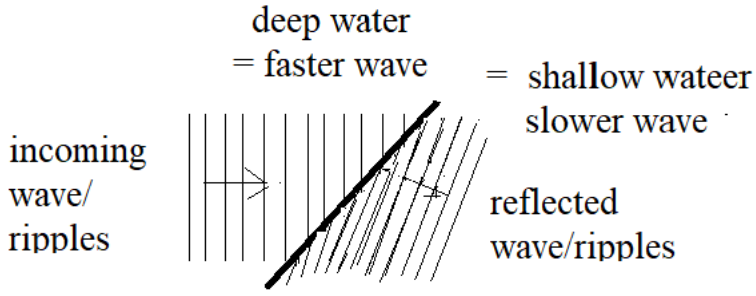


Fig 8.33 The lines are colled wave fronts:
here they are reflecting off a straight barrier.

Refraction: means **breaking**.

Refraction can be shown using a ripple tank. Ripples travel move slowly in shallower water than in deeper water because they drag on the bottom.



- ✓ The ripples change direction as they enter the shallower water.
- ✓ The ripples are closer together in the shallower water chair wave length has decreased.

Introduction to diffraction and interference

Diffraction:- occurs when a wave passes the edge & an obstacle, or through a gap.

- ➢ The ripples spread out in to the space beyond the gap.

The narrow gap has more effect than the wide one- there is more spreading out with the narrower gap.

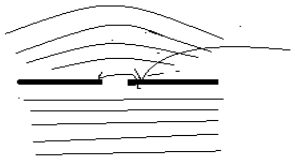
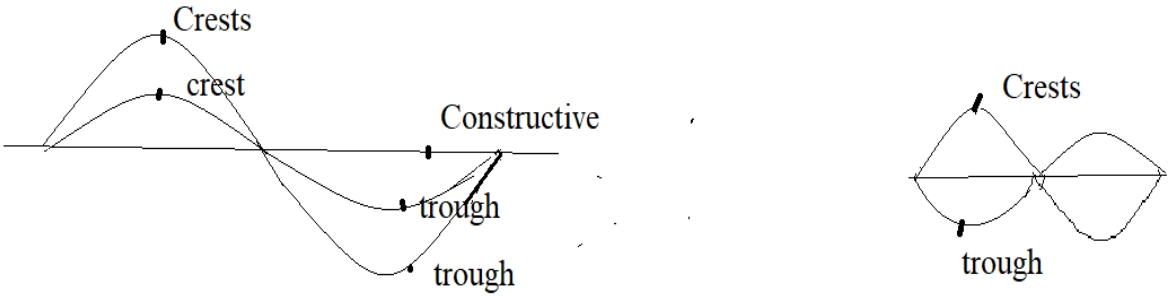


Fig 8.36
Diffraction of ripples as they pass through a gap.

Interference:- Is a phenomenon that occurs when two or more waves propagate through the same medium simultaneously.

Constructive Interference:- occurs when compressions/ crests/ of one wave coincide with completion /crests/ of another wave, or rarefaction / troughs/ of one coincide with rarefactions / troughs/ of the other.



Destructive interference: Occurs when compressions of one wave coincide with rarefaction of the other.

8.4. Sound wave

Sound is longitudinal mechanical wave which created by vibrating objects and is audibly perceived through sense of heaping.

Hearing

When vibration reaches our ears they travel down our ear canal and make our ear drums vibrate.

When we are young we can detect arrange of frequencies from around 20HZ to 20kHZ. This is returned to as our **audible range.** This is referred to as our **audible range**

- Any sound frequency be low 20HZ is known as infrasound or infrasonic. .
- Any sound when a frequency above 20kHZ is known as ultrasound or ultrasonic.

The speed of sound

Sound travels at different speeds through different materials. The speed of sound through air is around 340m//s. the speed of sound through water is around five times faster than in air and in metals like iron it is faster still (around 15 times).

In **general**:- the denser the material, the faster the speed of sound.

The density of the gas has an effect, and if two gases were at the same temperature then sound would travel faster through the denser gas. However, the temperature of the gas has a significant effect. When a gas is at a higher temperature the average kinetic energy of the particles is higher.

Speed of sound: $V=\sqrt{rR*T}$

where: r - the adiabatic index of the gas (a constant for the gas)
For air, r = 1.4

R* - another constant for the gas /Molar gas constant/ moar mass

(R/M) For air, this is 286 m^2/s^2k

$$V=\sqrt{\left(r\left(\frac{R}{M}\right)T\right.}$$

T= the temperature in k

$V=\sqrt{(KT)}$ where: $k=rR^* = 1.4 * 286 m^2/s^2k = 400\ m^2/s^2k$

and so: $V = \sqrt{400 * T}$

Example: At 25°c the speed of sound through air may be calculated using this equation:

$V=\sqrt{400*T}$

Given: T=25°c = (25-1273) k = 298k

$V=\sqrt{(400 * 298\ m^2/s^2\ k^{-1} *k)}$ = 345m/s

Describing sound wave

Terms such as loudness, pitch, timbre etc are used to describe sound.

Loudness:

The loudness of a sound depends on the amplitude of the sound wave the larger the amplitude, the louder the sound.

Pitch:- The pitch of sound depends on the frequency of the sound wave the higher the frequency, the higher the pitch.

Timber:- The timber of sound tells the quality of the sound quantity does mean good or bad. It just refers to the difference is sound.

Echo:- is the reflection of sound from surfaces.

Intensity of sound wave is the energy received by each square meter per second. A higher intensity would mean more energy per second falling on each square meter.

Intensity = $\frac{energy/time}{Area}$, where: $\frac{Energy}{time}$ = power

Intensity = $\frac{Power}{Area}$ A= $4\pi^2$

Since sound is transmitted in all direction, then the area cover by the sound wave is spherical.

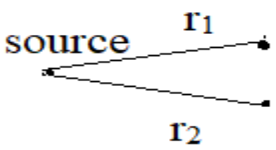
$$I=\frac{P}{4\pi r^2}$$

Example:- A speaker produces a sound with a power of 440W. Calculate the intensity of the sound at a distance of 5m from the speaker.

Solution: I= $\frac{P}{A} = \frac{P}{4*\pi r^2} = \frac{440W}{4*3.14*¿¿} = 1.4 W/m^2$

The intensity of sound at two difference distances r_1 and r_2 from a given source can be related as follows:-

$$I_1 = \frac{P}{4\pi r_1^2} \Rightarrow I_2 = \frac{P}{4\pi r_1^2}$$



We get $I_1 = r_2^2$

$I_2 = r_1^2$

$$\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$$

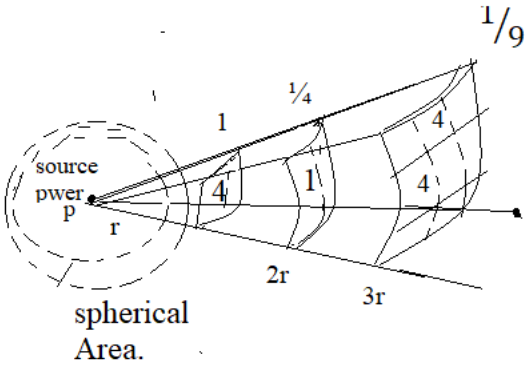


Fig 8.59 Intensity againsts distance.

Example:- By what factor will the intensity of a sound wave change as the distance from the source is doubled.

Soln :- $\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$, Here, $r_2 = 2\,r_1$

$$I_2 = I_1 \left(\frac{r1^2}{r2^2}\right) = I_1 \left(\frac{r1^2}{(2r1)^2}\right) = \frac{I_1}{4}$$

$I_2 = ¼\ I_1$

Thus, as the distance from the sound source is doubled the intensity decreases by a factor of ¼ .

Uses of sound waves: Sound waves have many uses, in addition to the obvious uses in communication and music.

Most of these uses depend on the behavior of the sound waves when they reflect or refract sound, like all waves, reflects off surfaces, but sound waves also reflect of the boundary between materials.

Summery

In this unit you have learn that:

- A wave transfers energy from one place to another as a series of vibrations.
- In a transverse wave the vibrations are perpendicular to the direction of wave motion.
- In a longitudinal wave the vibrations are parallel to the direction of wave motion.
- When waves bounce off a surface, this is called reflection.
- When waves travel from one medium to another, their speed may change and so they may bend. This is called refraction.
- Diffraction is the spreading out of waves when they pass through a gap or around an obstacle.
- Interference is when two or more waves pass through the same point and either add up or cancel each other out.
- In general, sound travels faster in denser materials; however the warmer the gas the faster the speed of sound through it.
- The amplitude of a sound wave affects its loudness and the frequency of the sound wave its pitch.
- The intensity of a sound wave is the energy received per square meter of a surface per second.

Work sheet

1. A water wave travels at a speed of 80m/s with a wave length of 20m. Calculate the time period of the wave and the time period.
2. A wave has a period of 20Ns (micro seconds) what is its frequency.
3. A radio station broad casts an FM signal with a wave length of 2.85m. if the speed of radio waves is $3x10^8$m/s. what is frequency of the FM signal?
4. A sound source produces a 1.5J of energy every second. What is the intensity of this sound at a distance of 10m from the source?
5. In no 4, if the power from the source is constant, at watt distance from the source does the intensity of the sound equal to:-
   a) The threshold of hearing?
   b) The threshold of pain?
6. The intensity of sound at a distance of 100m away from a certain source is $1x10^{-10}$ w/m^2. At what maximum distance from the source can this sound be heard by a normal human ear? (Assume a constant power).