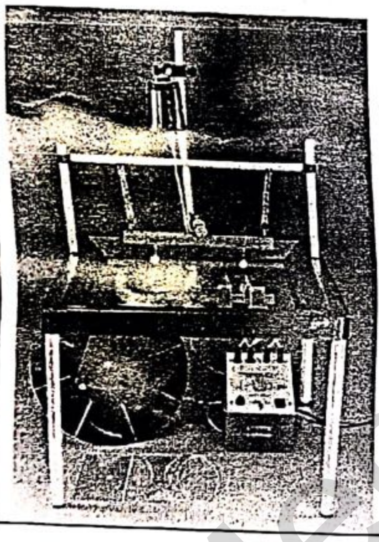
Mustafa
Asif

Abdul Hakeem

O Level Physics Syllabus Content for CAIE 2019-22 Exams

CHAPTER 13:

GENERAL WAVE PROPERTIES



Syllabus Content

9.1 Conduction

9.2 Convection

9.3 Radiation

Learning outcomes

Candidates should be able to:

(a) Describe what is meant by wave motion as illustrated by vibrations in ropes and springs and by experiments using a ripple tank.

(b) State what is meant by the term wavefront.

(c) Define the terms speed, frequency, wavelength and amplitude and recall and use the formula velocity = frequency × wavelength.

(d) Describe transverse and longitudinal waves in such a way as to illustrate the differences between them.

(e) Describe the use of a ripple tank to show

(1) Reflection at a plane surface,

(2) Refraction due to a change of speed at constant frequency.

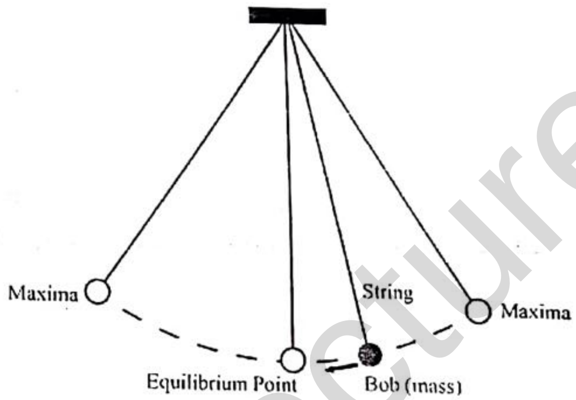
(f) Describe simple experiments to show the reflection of sound waves.

ABDUL HAKEEM
(+92300-4810136)
O / AS & A Level Physics

WAVE MOTION

Vibration of a Body

When a body (like a pendulum or a mass hung from a spiral spring) vibrates, it repeats its motion over and over again. One complete oscillation is the motion from one end to the opposite end then returning back to the same point again.



The **Amplitude** (A) is the maximum displacement of the particle from its rest position. The **Frequency** (f) of oscillation is the number of complete oscillations made in one second. Frequency is measured in Hertz (Hz).

Periodic Time (T) is the time taken by the particle to make one complete oscillation.

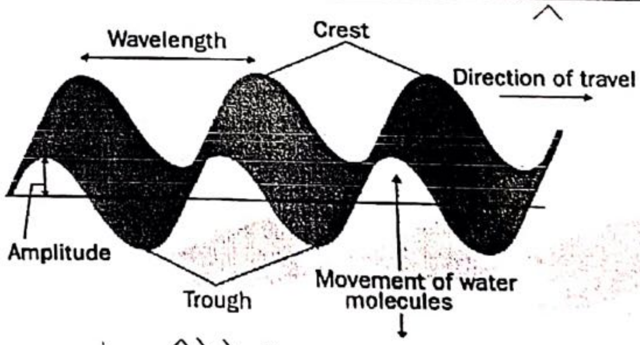
Frequency is measured in Hertz.

Note that: $T = \frac{1}{f}$

Wave Motion

The vibrations of water particles in a ripple tank represent a wave motion. The motion proceeds as a succession of crests and troughs.

The frequency of the wave is equal to the frequency of the vibrator producing the wave.



The **Wavelength** (λ) is the distance between two successive crests or two successive troughs (or two successive points moving at the same phase).

Wave Velocity: is the product of frequency and wavelength: V = f.λ

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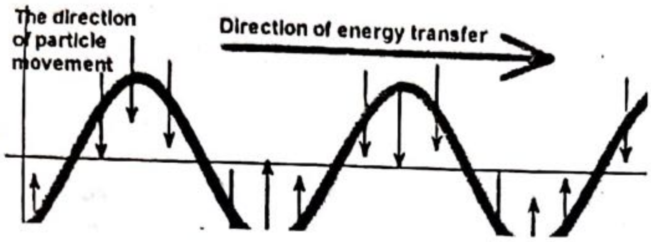
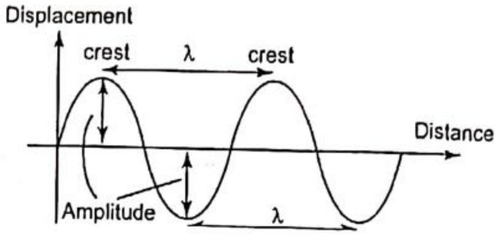
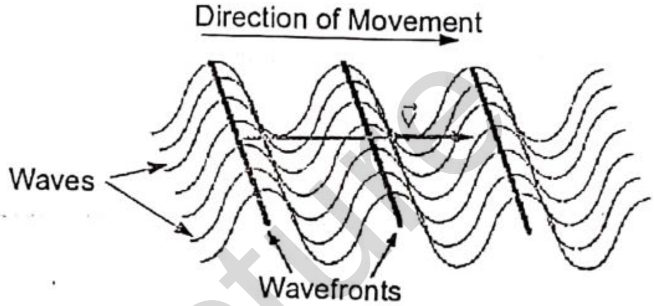




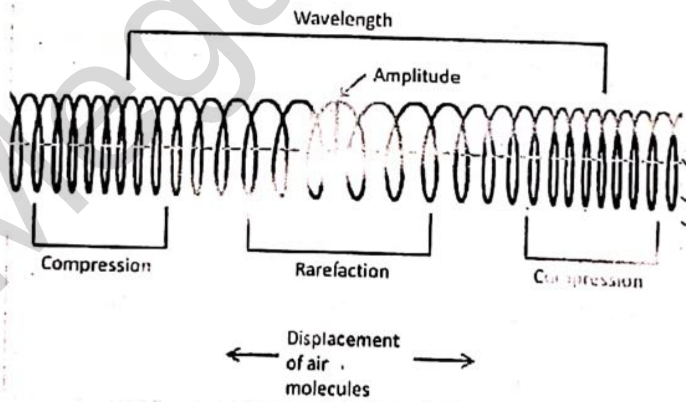
- The wave action is to transfer energy from one place to another.
- When the wave travels in a medium, the particles of the medium vibrate but they do not travel with the wave.
- The frequency of the wave equals the frequency of the vibrating source producing it, but,
- The velocity of the wave depends on the medium in which it is traveling.
- For a given medium, the velocity of the wave is constant, i.e., when f increases, λ decreases and vice versa.
- A wave traveling in a certain direction can be represented either by:



- Rays, which are straight lines representing the direction in which the wave propagates (travels).
- Wave fronts, which are parallel lines perpendicular to the rays. The distance between two successive wave fronts is equal to the wavelength.

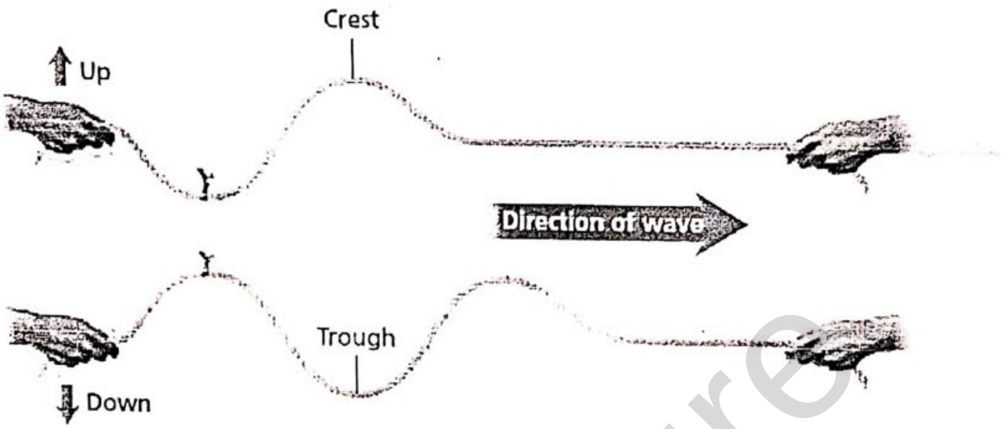
Waves are Two Types: In which the particles of the medium vibrate along (parallel) to the direction of wave motion.

Longitudinal Wave



Sound waves, and waves through a slinky are longitudinal.

Transverse Waves: in which the particles of the medium vibrate in a direction perpendicular to the direction of wave propagation. Water waves, light and all electromagnetic waves are transverse.



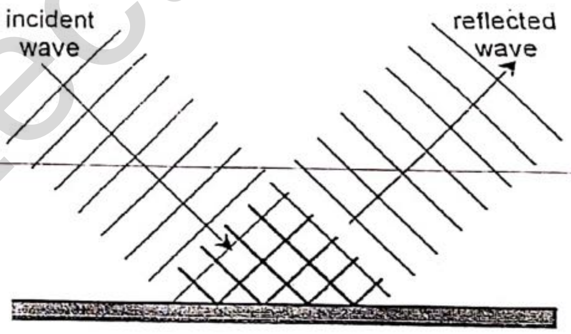
Properties of Waves

Reflection:

When the progressive wave hits an obstacle or a wall, it will be reflected back.

The laws of reflection are:

1. The angle of incidence equals the angle of reflection.
2. The incident ray, the reflected ray and the normal all lie in the same plane.



~~During reflection; the velocity, frequency and wavelength of the wave remain unchanged;~~ only the direction of the wave changes.

Refraction

When the wave travels into a different medium having different density, notice that:

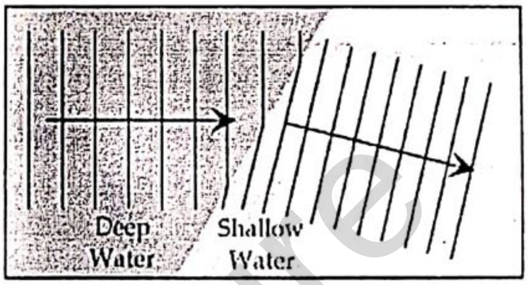
(a) Its direction changes,
(b) it speed changes,
(c) its wave length changes,

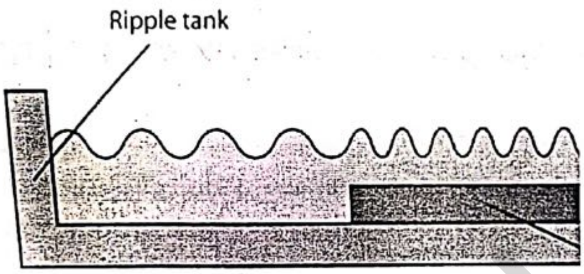
The frequency does not change, because the frequency does not depend on medium, it depends on frequency of the source of vibrations.

Wave going into a Denser medium	Wave going into Rare medium
1. The ray bends towards the normal. 2. Velocity of the wave decreases. 3. Wavelength decreases. 4. The frequency remains constant.	1. It bends away from the normal. 2. Velocity increases. 3. Wavelength increases. 4. The frequency remains constant.

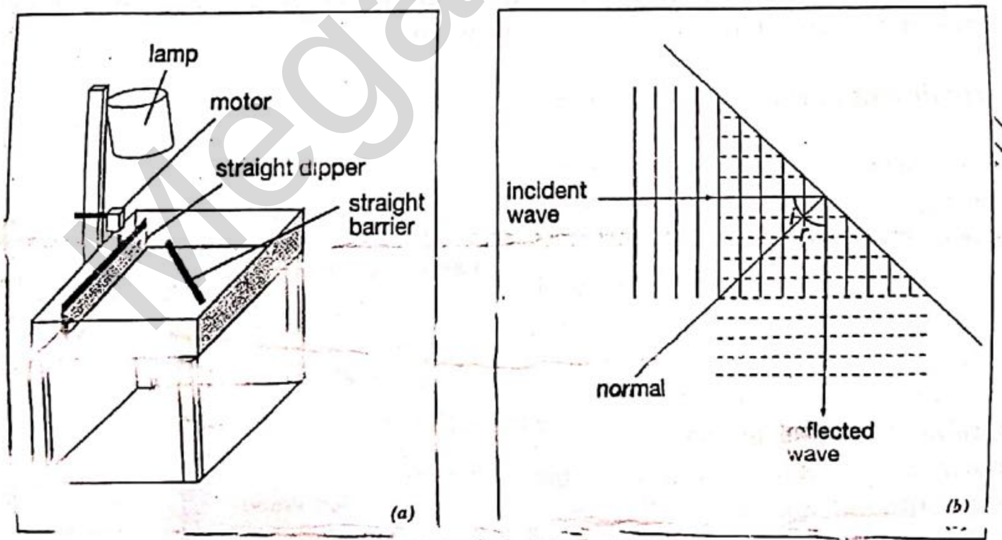
Refraction of Water Waves

When water waves travel into a shallower region, they are refracted (bent) and they are slowed down and the wavelength decreases; but the frequency remains the same.





The use of a ripple tank to show reflection at a plane surface



- A ripple tank as shown in Fig. (a) is set up and a straight barrier is placed in the water.
- The waves are reflected as shown in Fig. (b).
- The angle of incidence, I, is found to be equal to the angle of reflection, r.

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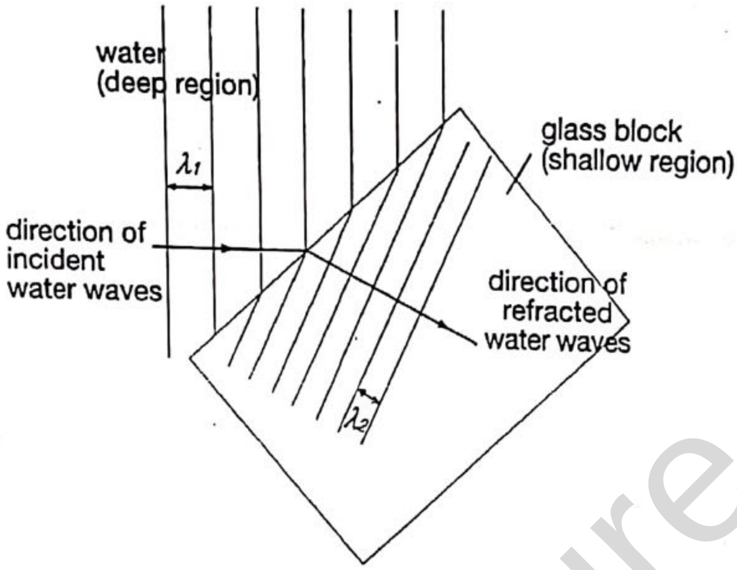
The use of a ripple tank to show refraction due to a change of speed



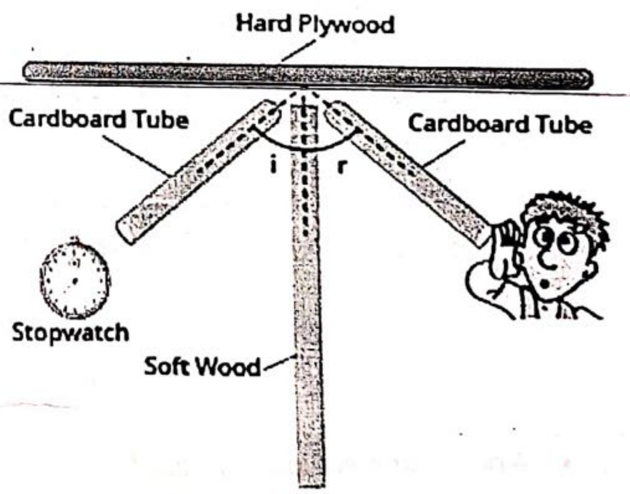
- A glass block is placed in the ripple tank. The water waves are refracted as the waves travel from a deep region to a shallow region (difference in depth of water).
- The table below shows the differences between the water waves in the deep region and those in the shallow region.

Wavefront

An imaginary line joining all points at the front of the wave which are in phase is called wavefront. It is used to represent crest of a wave.

Experiment of reflection of sound

The concept of reflection of sound is familiar to everyone. Let's understand this by a small activity. If we take two tubes and position them against a wall, as shown in the figure below, upon placing a speaker or any other source of sound near one end of the tube, we receive the sound at the end of the other tube. This activity proves that the surface of wall reflects the sound wave. In this section we shall learn more about the reflection of sound and its application in day-to-day life.



Sound: Definition

Sound is defined as oscillations or auditory sensation evoked by oscillations in particle displacement or velocity, propagated in a medium with internal force. Sound propagates as a mechanical wave, through a medium such as air or water.

Reflections of sound

Just like reflection of light, the reflection of sound is similar as it follows the laws of reflections, where the angle of reflection is equal to the angle of incidence and the reflected sound, the incident sound, and the normal sound belong in the same plane. Sound bounces off the surface of medium which can be a solid or a liquid. In order to make reflection of sound to occur, the surface can be of large size and can be either rough or polished.

Laws of Reflection of Sound

- The angle of reflection is always equal to the angle of incidence .
- The reflected sound, the incident sound, and the normal sound belong in the same plane.

Echo:

The sound heard after reflections from a rigid surface such as a cliff or a wall is called echo creating a persistence of sound even after the source of sound has stopped vibrating. Echo is used by bats and dolphins to detect obstacles or to navigate. The same principle is used in SONAR (Sound Navigation and Ranging technique), used in oceanographic studies. SONAR is used for the detection and location of unseen underwater objects, such as submerged submarine, sunken ships and ice-bergs. In SONAR, ultrasonic waves are sent in all directions from the ship and the received signal is analysed.