-2 successive nodes = $\frac{1}{2}$ wave length ($\frac{1}{2}\lambda$)

-2 successive antinodes = $\frac{1}{2}$ wave length ($\frac{1}{2}\lambda$)

-A node and an antinode = $\frac{1}{4}$ wave length ($\frac{1}{4}\lambda$)

Stationary waves are produced by musical instruments such as

-Guitar -Piano -Harp -Violin

Comparison of standing and progressive waves

Standing wave	Progressive wave
Energy is not carried away from the source	Carries away energy from the source
Amplitude varies	Amplitude is the same for all particles
All particles between two adjacent nodes are in phase	Over one wavelength, all particles have different phases

WAVE PROPERTIES

Waves undergo;

- Refraction
- Reflection
- Diffraction
- Interference

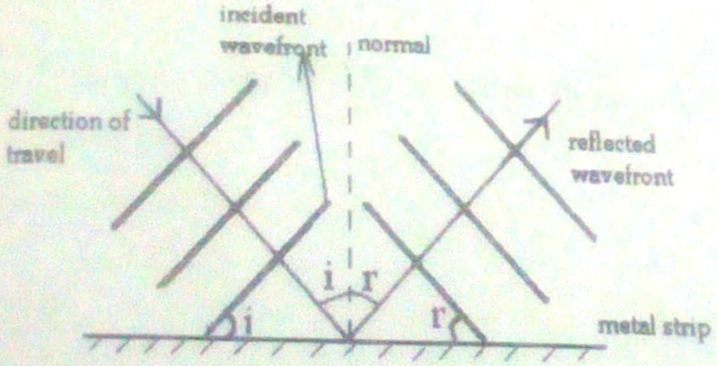
Reflection of waves

A wave is reflected when a barrier/obstacle is placed in its path. The shape of the reflected wave depends on the shape of the barrier.

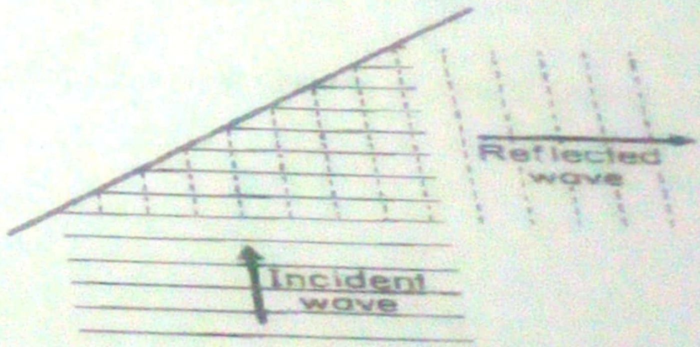
The laws of reflection of waves

1. The incident wave, the normal line and the reflected wave at the point of incidence all lie in the same plane
2. The angle of incidence is equal to the angle of reflection of the wave

Reflection of a wave



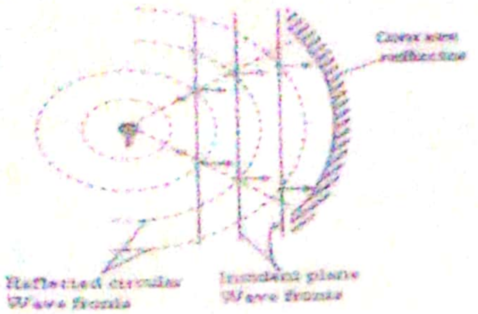
Reflection of plane wave on a plane surface



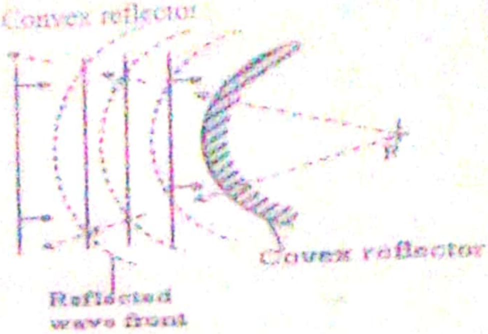
CamScanner

Reflection of plane waves on curved surface

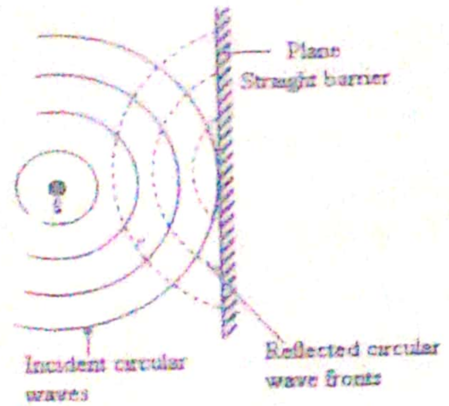
Concave reflector



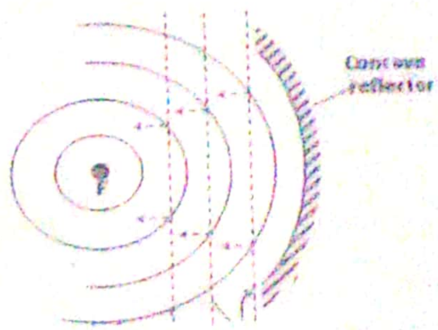
Convex reflector



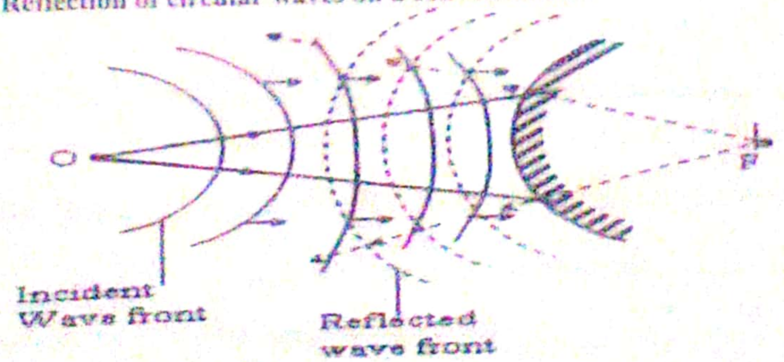
Reflection of circular wave on a plane surface



Reflection of circular waves on a concave surface



Reflection of circular waves on a convex surface



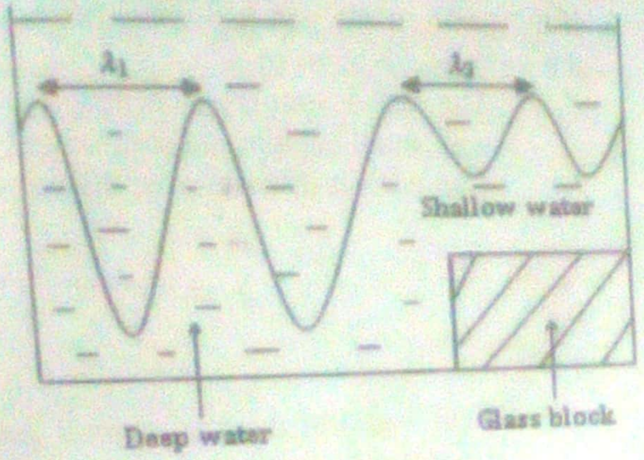
During reflection of water waves, the frequency and velocity of the wave does not change.

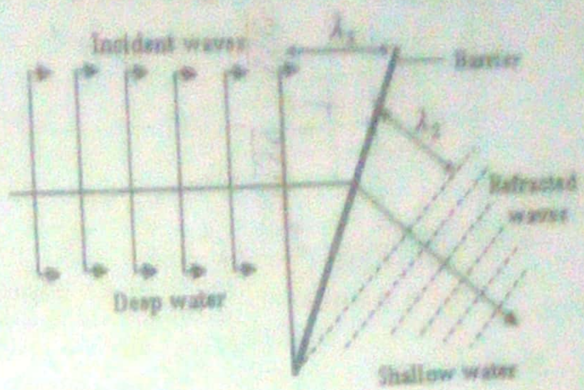
REFRACTION

This is the change of direction of wave travel as it moves from one medium to another.

It is caused in change of wave length and velocity of the wave. However, the frequency and the period are not affected.

In a ripple tank, the change in direction is brought about by the change in water depth.





λ_1 = wave length in deep water

λ_2 = wave length in shallow water

Note (i) $\lambda_1 > \lambda_2$

(ii) $v_1 = f\lambda$ and $v_2 = f\lambda_2$

$v_1 > v_2$ When f – is constant.

When a waves move from;

✓ **Deep water to shallow water;**

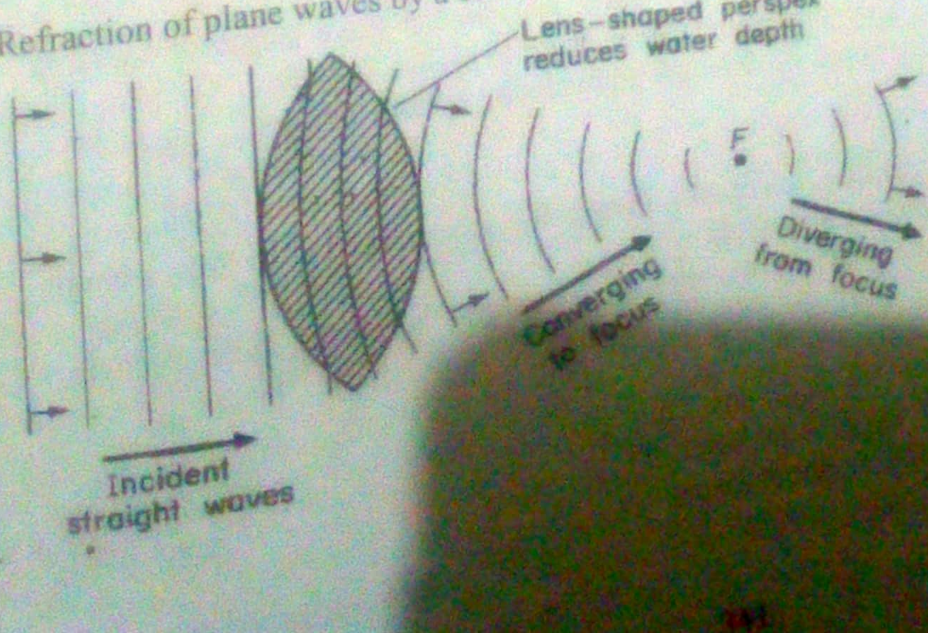
- ✓ Wave speed reduces
- ✓ Wave length reduces
- ✓ The wave bends towards the normal
- ✓ Frequency does not change

(ii) Shallow water to deep water

- ✓ Wave speed increases
- ✓ Wave length increases
- ✓ The wave bends away from the normal
- ✓ Frequency does not change

$$\textbf{Refractive index n} = \frac{\textit{velocity in deep water}}{\textit{velocity in shallow water}} = \frac{v_1}{v_2} = \frac{f\lambda_1}{f\lambda_2} = \frac{\lambda_1}{\lambda_2} = \frac{\textit{wave length in deep water}}{\textit{wave length in shallow water}}$$

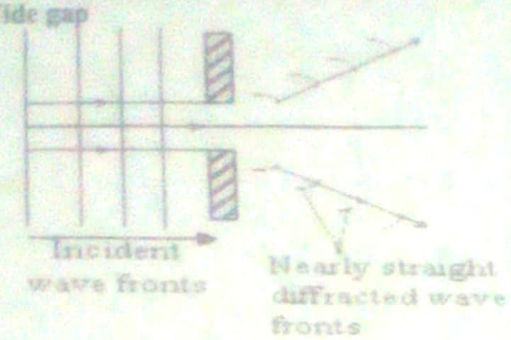
Refraction of plane waves by a convex lens



DIFFRACTION

This is the spreading of waves as they pass through holes, round corners or edges of obstacle. It takes place when the diameter of the hole is in the order of wave length of the wave i.e. the smaller the gap the greater the degree of diffraction as shown below.

✓ **Wide gap**



If the width of the gap is bigger compared to the wave length of wave;

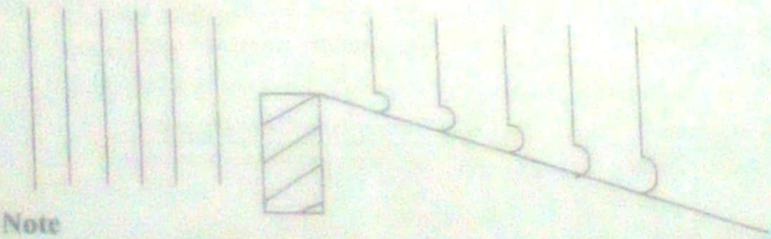
- ✓ The wave immerges nearly straight with small bend round at the edges
- ✓ There is less diffraction of the wave

✓ **Narrow gap**

If the width of the gap is small compared to the wave length;

- ✓ Wave front emerges with a pronounced circular shape
- ✓ There is greater spreading or diffraction of the wave

✓ **Edge of obstacle**



Note

- ✓ Sound waves are more diffracted than light waves because the wave length of sound is greater than that of light. Therefore sound can be heard in hidden corners.
- ✓ When waves undergo diffraction, wave length and velocity remain constant.

INTERFERENCE

This is the superposition of two identical waves travelling in the same direction to form a single wave with a larger amplitude or smaller amplitude.

Interference is the effect which occurs when two separate waves overlap of the same frequency and amplitude

Conditions for interference to occur

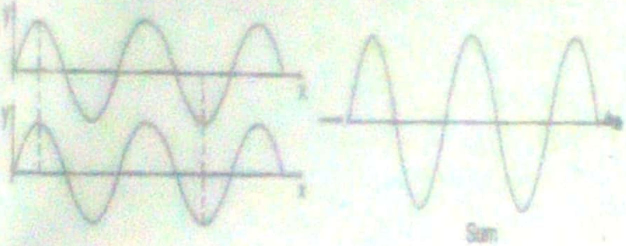
- ✓ The two waves must be travelling in the same direction
- ✓ The two waves must be having the same amplitude
- ✓ The two waves must be having the same frequency
- ✓ The two waves should be in phase (matching)

A coherent source: is a source which produces waves of the same frequency and a constant phase difference between them

Superposition of waves: This is the ability of waves to combine together

Constructive interference

Constructive interference occurs when waves from two coherent sources are superposed in the same phase. It occurs when a crest from one wave source meets a crest from another source or a trough from one source causing reinforcement of the wave i.e. increased disturbance is obtained. The resulting amplitude is the sum of the individual amplitudes.



Conditions for constructive interference

Waves must be in phase

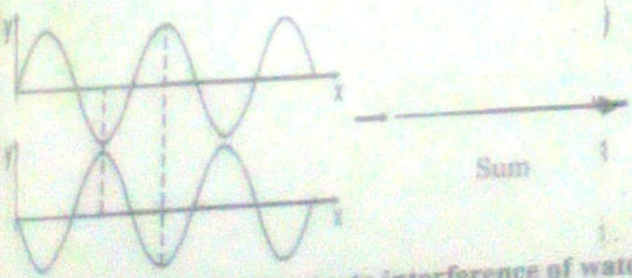
Waves must be of the same frequency

Waves must be of the same amplitude

Destructive interference

Destructive interference occurs when waves from two coherent sources, with the same amplitude and 180^0 out of phase superpose

This occurs when the crest of one wave meets a trough of another wave resulting in wave cancelling i.e.



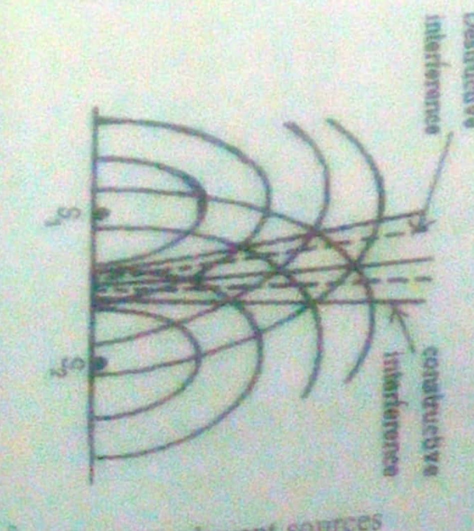
Conditions for destructive interference

Waves must be out of phase

Waves must be of the same frequency

Waves must be of the same amplitude

Experiment to demonstrate interference of water waves in a ripple tank



S_1 and s_2 are coherent sources

- Two ball ended dippers are attached to the vibrator of the ripple tank
- Two sets of circular ripples are sent out which pass through one another as shown in the diagram
- Where a crest from s_1 meets a crest from s_2 or a trough from s_1 meets a trough from s_2 constructive interference occurs
- Where a crest from one of the source meets a trough from the other source destructive interference occurs