

## **Sound as a wave motion**

منتدى روضة العلوم الطبيعية

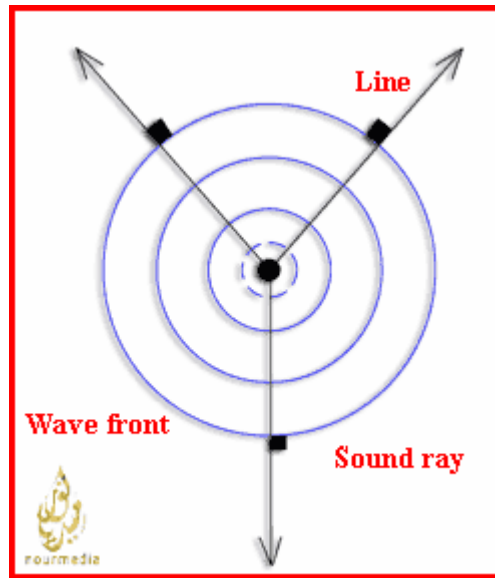
### **Introduction : -**

Sound waves are developed as a result of vibrations of bodies. So, all sounding bodies vibrate, but not all vibrating bodies cause sounds. Because audible sounds are those of frequency between 20 to 20000 Hz. To prove that sound is a wave motion it must have the wave properties: -

- 1 - Propagation in a straight line.
- 2 - Reflect
- 3 - Refract.
- 4 - Interfere.
- 5 - Diffract.

### **1) the propagation of sound in a straight line : -**

In the form of concentric spheres of compression and rarefaction.



### **Wave front- :**

The surface separating the excitable part of the medium and the unexcitable part.

1) Sound ray- :

2) The straight line normal to

- the wave front and show, the
- direction of propagation of the wave.

1) OR: - Is the line indicating the direction of sound waves.

1) reflection of sound wave- :

The echo phenomenon proves the reflection of sound.

**1) Echo- :**

Is the reflection of sound due to reflection.

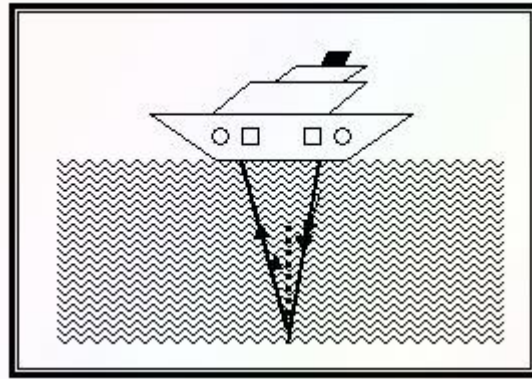
1 Conditions to observe echo- :

A reflecting surface.

A separating distance between sounding source and the reflector is more than 17 cm in air , where our ear drum can not differentiate

between original sound and the reflected one unless the time between

$$\frac{1}{\text{them}} < \frac{1}{10} \text{ sec.}$$



$$S = V \times t$$

$$S = 340 \times \frac{1}{10} = 34 \text{ (m)}$$

S is the distance covered by the sound wave.

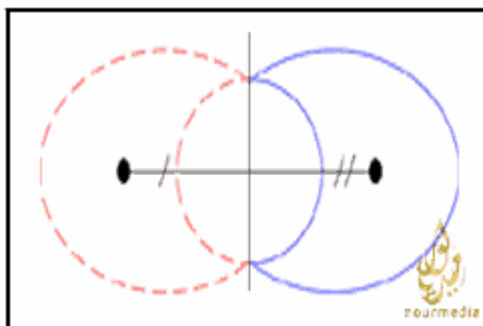
The distance between the source and reflector must be  $> 17 \text{ m}$ .

**Note)** - :the speed of sound(

When the difference in velocity between the two media is high. The separating surface acts reflector more than refractor.

	Medium	Speed
<b>Gases</b> At One atm. Pressure	Air at 0 c	331 m / s
	Air at 20 c	343 m / s
	Helium	965 m / s
	Hydrogen	1284 m / s
<b>liquids</b>	Water at 0 c	1402 m / s
	Water at 20 c	1482 m / s
	Sea water	1522 m / s
<b>solids</b>	Aluminum	6420 m / s
	Steel	5941 m / s
	Granite	6000 – m/s

When spherical waves meet a reflecting surface they are reflected , as compression, and rarefaction, as if they are originating from a point behind the reflecting surface at a distance from it, that is equal to the distance between the source and the reflecting surface.



### **Exp- :**

To demonstrate the reflection of sound, 1<sup>st</sup> law and 2<sup>nd</sup> laws of reflection.

### **Steps- :**

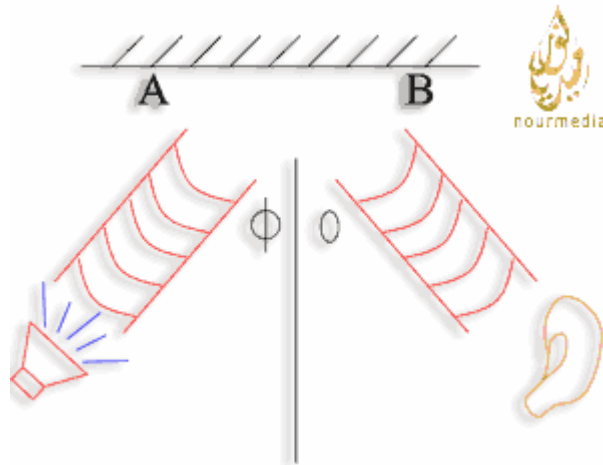
- 1 Put the stopwatch at the end of tube A and put the ear at the end of the tube B.

- 2 Above the tube A to change the angle  $\theta$

Observation and conc.

Clear sound is heard when- :

$$\theta = \phi \quad ; \text{ Law 1<sup>st</sup> }$$



Angle incidence = angle of reflection

1<sup>st</sup> Law- :

The incident ray, the reflected ray and the normal reflecting surface at the point of incidence all lie in one plane, perpendicular to the reflecting surface.

Application of echo- :

To get an unknown distance or unknown depth:

$$d = \frac{V \times t}{2}$$

Where: (d) distance, (V) velocity, (t) time.

**Example- :**

If you stand in desert, between two mountains then you generate sound, where you observe 2 echoes after 4, 6 sec. Find the distance between the two mountains then state if you will observe further echoes or not.

**Solution- :**

$$d = \frac{340 (4)}{2} = 680 \text{ m}$$

$$d_r = \frac{340(6)}{2} = 1020 \text{ m}$$

you will observe a new echo due to the several successive reflections on the two mountains.

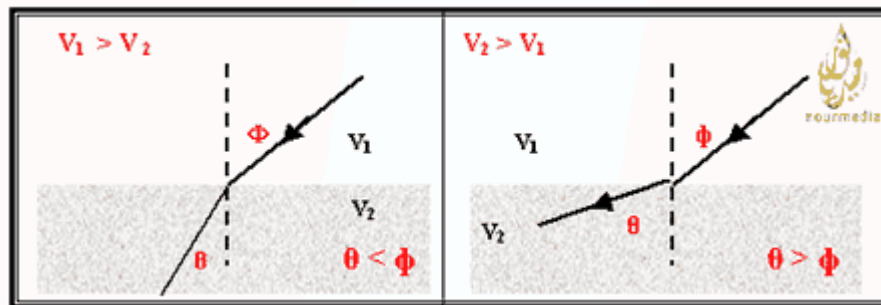
### (~Refraction of sound- : DEFINITION- :

Is the change in the path of the wave, when it travels from a medium into another medium due to the change in velocity.

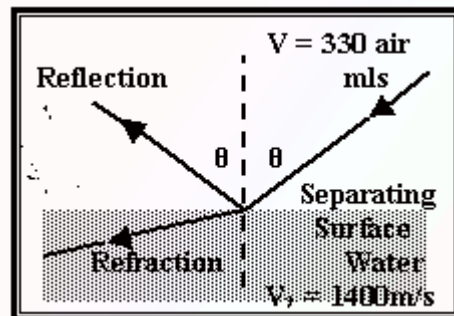
Sound wave refracts such that, it obeys the two Laws of refraction.

1<sup>st</sup> Law

$$\frac{\sin \phi}{\sin \theta} = \frac{V_1}{V_2}$$

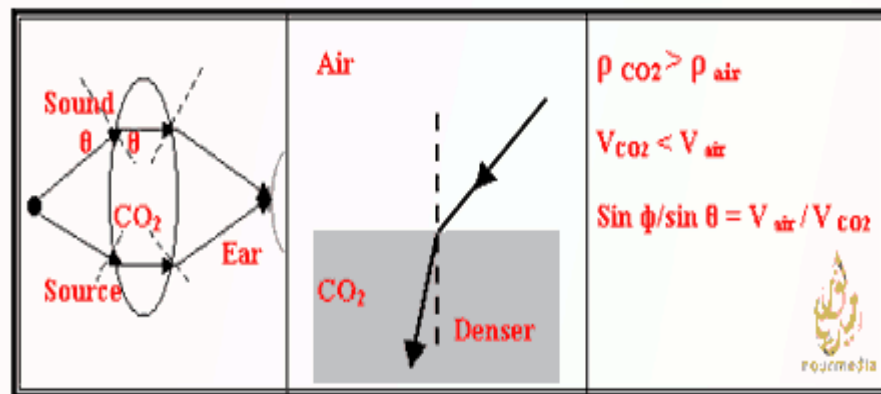


If the difference in velocity is very large like water and air.



The major part of sound energy is reflected and when the wave velocity of sound in the first medium  $V_1$  is greater than  $V_2$  the sound ray bends towards the normal  $\theta_1$  (is bigger than  $\theta_2$ ).

**To demonstrate refraction of sound- :**



-Use a thin balloon filled with  $\text{CO}_2$  having the shape of converging lens.

$$V_{\text{CO}_2} > V_{\text{air}} \text{ because } V \propto \frac{1}{\sqrt{\rho}}$$

$$\text{And } \rho_{\text{CO}_2} < \rho_{\text{air}}$$

-A very clear sound is heard at B, Where sound collects as a result of the lens.

**Note- :**

-A thin bladder filled with  $\text{CO}_2$  acts as a converging lens for sound.

(For homogeneous system only (or for the same state)  $V \propto \frac{1}{\sqrt{\rho}}$ )

$$\rho_{\text{air}} < \rho_{\text{water}}$$

$$V_{\text{air}} > V_{\text{water}} \quad \text{:But}$$

### (**Interference of sound- :**

Interference of sound takes place when two sound waves act on the same medium.

#### **DEFINITION- :**

It is the superposition of two waves or more having the same amplitude to reinforcing each other at some points, or weakened each other at another points.

Conditions of interference- :

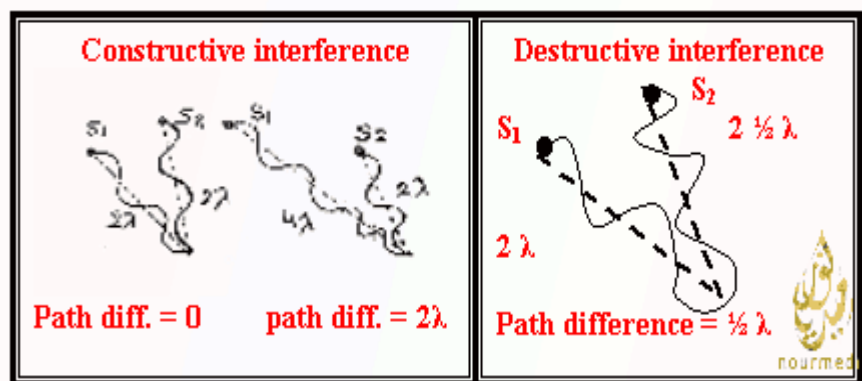
- ١ The two waves must have the same frequency and the same amplitude.
- ٢ The angle between their directions must be small.
- ٣ Constructive interference takes place when the path difference

$$= n\lambda$$

Where  $n = 0, 1, 2, 3, 4, \dots$  ,

- ٤ Destructive interference takes place when path difference

$$= n\lambda \left( n + 0.5 \right)$$



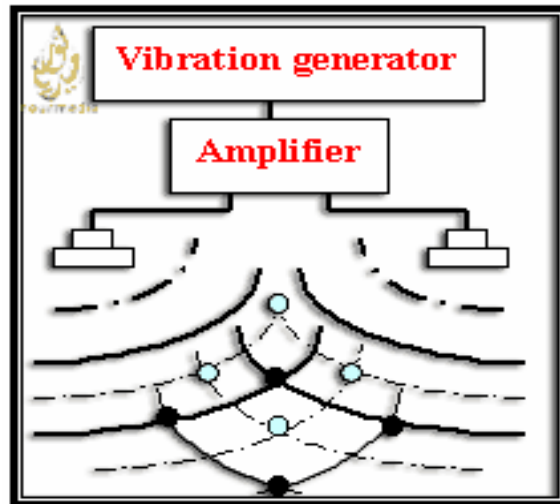
#### **To demonstrate interference- :**

Exp. (1- : (



(١) Connect two loudspeakers to the same oscillator as shown in the figure.

(٢) The continuous arcs indicate the maximum compression and the dotted curves represent the maximum rarefaction.



(٣) The two waves having the same frequency and the same amplitude.

(٤) At some points compression from the first source meets compression from the second source or rarefaction meets rarefaction.

They reinforce each other.

(٥) Constructive interference takes place and clear sound is heard where  
path difference =  $m \cdot \lambda$ .

(٦) At other points compressions from first source meet rarefaction from the sound source.

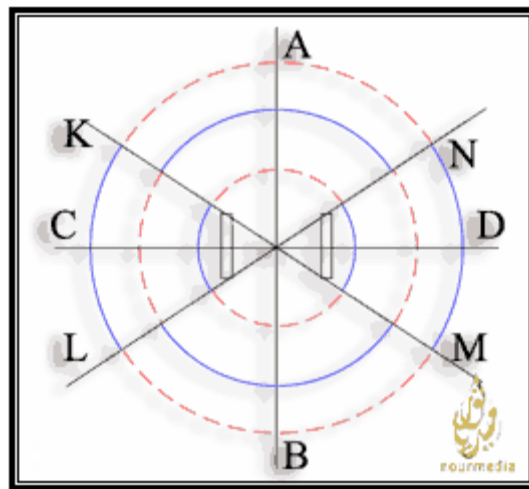
Destructive interference takes place and clear sound is heard where path difference =  $(m + 0.5) \lambda$

**Exp. (2- ):**

Cause a Vibration of a tuning fork and turn it around its vertical axis near your ear.

Observation- :

Along to AB, CD normal clear sound is heard along KM, NL Sound vanishes due to the destructive interference.



**Note- :**

The two prongs of the tuning fork move inward to produce compression between them and rarefaction outside and move outward to produce compression outside and rarefaction inside.

The vibrating tuning fork acts as two sources one from outside and the other from inside.

**G.R- :**

-Sound vanishes 4 successive times around its vertical axis near the ear.

- At KN and LN compressions from between meet rarefaction from outside  
and path difference =  $(m + 0.5) \cdot \lambda$
- Therefore interference takes place and sound vanishes.

### - : Diffraction of sound (°)

#### - : DEFINITION

ve in the same medium when it's the changing in the path Of sound wave  
passes near a sharp edge or through an opening  
The diameter of the opening is less than the wavelength  
Diffraction of sound is familiar to use in our daily life more than that of light

#### - : (°)Example

nd a tuning fork you find that a smallests Tube a'On using Quink  
displacement for one tube between two successive loudness  
Find the frequency of .sec/m 336cm taken velocity of sound in air 336  
.tuning fork

#### - : Solution

.cm 336 =Distance  $\lambda = 336 \times 2 = 672$   $S = 336$

$$\text{Hz } 500 = \frac{336}{0.64} = \frac{V}{\lambda} = u \quad u \cdot \lambda = V$$

#### - : (°)Example

336 if you repeat using a tuning fork of frequency 500 In the previous problem  
loudness and a followed weakness 500 Find the displacement between 336 Hz  
in intensity

#### - : Solution

$$\text{m } 1.0 = \frac{336}{320} = \frac{V}{u} = \lambda \quad u \cdot \lambda = V$$

$$.cm \ 02,0 = \frac{1.05}{2} = \frac{\lambda}{2} = \text{Path difference}$$

$$.cm \ 26,0 = \frac{\lambda}{4} = \text{Displacement}$$