Wave motion-

Prepared By: CPS

In order to transfer energy from one point to another, there are different methods involved. In one, there is an actual transfer of the matter carrying the energy as in the case of throwing a stone with some velocity. And in the other, a disturbance is set up into the medium by the body at one point and this disturbance carries the energy forward without the actual transfer of the matter from one point to other. For example when a stone instead being thrown with a velocity is made to strike the surface of water in pond, the energy of stone is carried by the waves setup in the water which moves stedily along the surface carrying the energy from point to point.

Wave is the disturbance that travels onwards through the medium due to the repeated periodic motion of its particles about their mean position. Thus wave transfer energy from one place to another place without bulk motion of their intervening medium. i.e wave tranfer energy and it is the mode of transfer of energy.

* Mechanical wave-

Mechanical waves or elastic wave are governed by Newton's laws of and required a material medium for their propogation. sound waves, seismic waves, water waves are example of mechanical wave.

* Electromagnetic wave -

The waves which do not require material medium to travel onwards are called electromagnetic waves. visible light, radio waves, micro-waves, X-rays γ-rays belong to this category. Electromagnetic waves consists of oscillating electric and magnetic fields and travel with the same speed 'c' in free space

* Matter wave -

Atomic particles exhibit wave properties under cetain conditions. Laws of quantum mechanics govern such matter waves.

* Gravitational wave -

It is suggested that cosmic bodies such as stars, galaxies produce gravitational waves and interact with each other through these waves. The gravitational waves are belived to propagate with the velocity of light.

Two distinct classes of mechanical wave:

1) Transverse wave -

The wave motion in which particles of the medium oscillates up and down about their mean position perpendiculer to the direction of propagation of wave is called transverse wave. Thus it is in the form of crest and trough. Ripples of water surfacess are transverse wave.

2) Longitudinal wave -

The wave motion in which particles of the medium vibrate in a direction parallel to the direction of propagation of wave is called longitudinal wave motion. It is in the form of compression and rarefaction. For example sound waves.

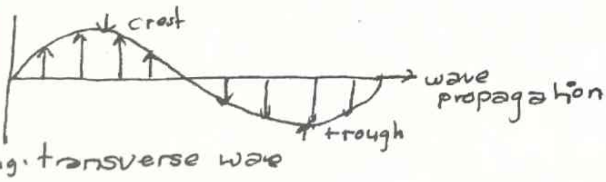


fig. transverse wave

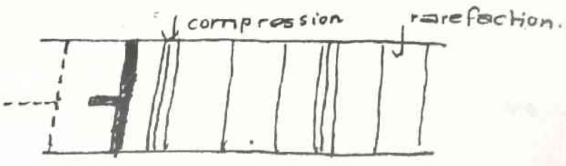


fig. Longitudinal wave.

* Terms associated with wave -

(1) Crest - The maximum displacement of particles of a medium above the equilibrium position is called crest.

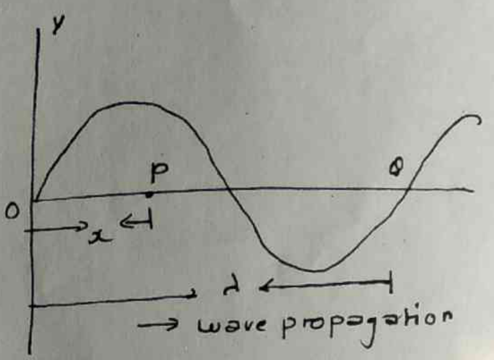
(2) Trough - The maximum displacement of the partcles of the medium below the equillibrium position is called trough.

(3) Amplitude: The maximum displacement of the particles of medium from its equilibrium position when mechanical wave passes through the medium is called amplitude.

(4) wavelength - The distance travelled by the wave during the time at which any particle, of the medium completes one vibration about its meen position is called wavelength. It is denoted by λ. i,e distance between two nearest trough or crest.

* progressive wave or travelling wave -

The wave which travels onwards through the medium in a given direction without attenuation .i,e with constant amplitude is called progressive wave. It may be transverse or longitudinal.



As the oscillations are communicated from point to point, the points are in different state of oscillations at different times. Therefore displacement of particle in the medium is function of space-coordinate and time.

We denote the displacement by

$$y = f(x,t) \quad \cdots (1)$$

It is called wave function.

Let a wave travels in positive x- direction. consider a particle at 'o' executes simple harmonic motion. Then equation of particle displacement will be

$$y = f(t) \quad \cdots (2)$$

Interms of trigonometric function,

$$y = A \sin \omega t \quad \cdots (3)$$

since the successive particles to the right of 'o' receive and repeats its moments after definite interval of time, the phase lags goes on increasing as we proceed away from 'o' towards right. Let us consider a particle at point 'p' at a distance x from origin.

Let ϕ be the phase lag then at point p,

$$y = A\sin(\omega t - \phi) \quad \cdots (4)$$

In one complete oscillation total phase difference $= 2\pi$

$\therefore$ when path difference is λ, then phase difference $= 2\pi$

" " " is 1 then, " $= 2\pi/\lambda$

Therefore, for x displacement, phase difference $= \frac{2\pi}{\lambda} x$

$$\therefore \phi = \frac{2\pi}{\lambda} x \quad \cdots (5)$$

om (4) and (5)

$$y = A\sin(\omega t - \frac{2\pi}{\lambda}x)$$

$$\Rightarrow y = A\sin(\omega t - kx) \quad \cdots (6) \qquad [\because \frac{2\pi}{\lambda} = k]$$

This is a progressive wave equation. If the particle is in negative x-direction then,

$$y = A\sin(\omega t + kx) \quad \cdots (7)$$

* phase velocity (wave velocity) and particle velocity -

The distance travelled by wave in unit time is called phase velocity. It is denoted by u and given as

$$u = \frac{dx}{dt} \quad \cdots (1)$$

As we know that the wave travelling in positive x-direction is represented as $y = A\sin(\omega t - kx)$ ... (2)

where 'y' is the displacement of particle along y-direction in time 't'.

For a given wave,

$$\omega t - kx = \text{constant}$$

Differentiating w.r. to t we get

$$\Rightarrow \omega\frac{dt}{dt} - k\frac{dx}{dt} = 0$$

$$\Rightarrow \omega - ku = 0$$

$$\Rightarrow \omega = ku$$

$$\Rightarrow u = \frac{\omega}{k}$$

$$\Rightarrow u = \frac{2\pi f}{2\pi/\lambda}$$

$$\Rightarrow u = f\lambda \quad \cdots (3)$$

,e wavevelocity = frequency x wavelength.

The rate of change of displacement of a particle with time is called particle velocity. It is denoted by v and given by

$$v = \frac{dy}{dt} \quad \cdots (4)$$

ifferentiating eqn (2) w. r. to time,

$$\frac{dy}{dt} = A\omega\cos(\omega t - kx)$$

$$\Rightarrow v = A\omega\cos(\omega t - kx) \quad \cdots (5)$$

gain, differentiating eqn (2) w. r. to x

$$\frac{dy}{dx} = -Ak\cos(\omega t - kx)$$

$$\Rightarrow A\cos(\omega t - kx) = -\frac{dy/dx}{k} \quad \cdots (6)$$

CPS

From (5) and (6)

$$v = -\frac{\omega (dy/dx)}{k}$$

$$\Rightarrow v = -u\frac{dy}{dx}$$

$$\Rightarrow v = u\left(-\frac{dy}{dx}\right)$$

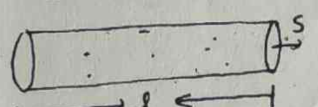
$\Rightarrow$ particle velocity = wave velocity times the slope (negative) of displacement.

* Intensity of wave –

The total energy flowing per sec per unit area is called intensity.

i.e intensity = $\frac{\text{total energy}}{\text{Area} \times \text{time}}$ ---- (1)

As we have, the total energy of a particle executing periodic motion $= \frac{1}{2} m\omega^2 A^2$ --- (2)



Now, consider a tube of cross-section area 's' and length 'l'.

Then volume of the tube = sl

Let 'n' be the number of particles per unit volume. Then total numbers of particles inside the tube = nsl

$\therefore$ total energy of particles $= \frac{1}{2} m\omega^2 A^2 nsl$ --- (3)

Then subsituting (3) in (1)

$$\Rightarrow I = \frac{\frac{1}{2} m\omega^2 A^2 n\cancel{s}l}{\cancel{s}t}$$

$$\Rightarrow I = \frac{1}{2} mn\frac{l}{t} A^2\omega^2$$

$$\Rightarrow I = \frac{1}{2}\rho u A^2\omega^2$$

$$\Rightarrow I = \frac{1}{2}\rho u A^2 (2\pi f)^2$$

$$\Rightarrow I = \frac{1}{2}\rho u A^2 4\pi^2 f^2$$

$$\Rightarrow I = 2\pi^2 f^2 A^2 \rho u \text{ ---- (4)}$$

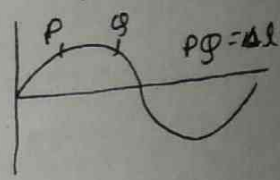
where, $mn = \rho$, density of the medium.

$l/t = u$, wave velocity.

$I \propto A^2$

the intensity of wave is directly proportional to the square of amplitude.

velocity of transverse wave along a stretched string -



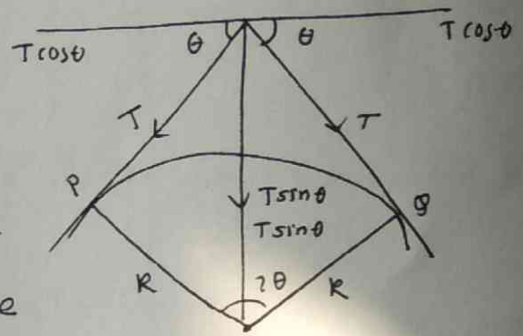
The wave velocity along a stretched string can be expressed interms of tension along the string and mass per unit length of the string.

when a jerk is given to the string fixed at one end and a transverse wave can be produced. consider an element length Δl of arc PQ of the string. Let 'T' be the tension along the string and μ be the mass per unit length of string. Then,

$$\mu = \frac{\text{mass}}{\text{length}}$$

$$\Rightarrow \mu = \frac{m}{\Delta l}$$

$$\Rightarrow m = \mu \Delta l \quad ----(1)$$



The element length Δl forms the arc PQ of radius R. The tension along the string can be resolved into two perpendicular components $T\cos\theta$ and $T\sin\theta$.
The horizontal component $T\cos\theta$ cancel eachother and the radial component $T\sin\theta$ provides the net tension which is along the center of arc PQ hence provides centripetal force.

$\therefore$ The resultant tension along radial component

$$= T\sin\theta + T\sin\theta$$

$$F = 2T\sin\theta \quad ---(2)$$

As the force provides centripetal force,

Also, $F = \frac{mu^2}{R}$ --(3)

From equation (1) and (3)

$$F = \frac{\mu \Delta l\, u^2}{R} \quad --(4)$$

From (2) and (4)

$$\frac{\mu \Delta l\, u^2}{R} = 2T\sin\theta$$

For small displacement, $\sin\theta \approx \theta$

$$\therefore \frac{\mu \Delta l\, u^2}{R} = 2\theta T \quad --(5)$$

From fig, angle made at center $= \frac{\text{Arc}}{\text{radius}}$

$$\Rightarrow 2\theta = \frac{PQ}{R}$$

$$\Rightarrow 2\theta = \frac{\Delta l}{R} \quad -(6)$$

From (5) and (6) $\quad \frac{\mu \Delta l\, u^2}{R} = \frac{\Delta l\, T}{R}$

$\Rightarrow \mu u^2 = T$

$\Rightarrow u^2 = T/\mu$

$\Rightarrow u = \sqrt{T/\mu}$ ---(x)

This gives the velocity of transverse wave along the stretched string.

* Energy transmission in stretched string -

The kinetic energy of an element in stretched string can be written as

$$K.E = \frac{1}{2} m v^2$$

$$\Rightarrow K.E = \frac{1}{2} \mu \Delta l \, A^2 \omega^2 \cos^2(\omega t - kx) \qquad \left[\because \mu = \frac{\text{mass}}{\text{length}},\ y = A\sin(\omega t - kx)\right]$$

The rate of transmission of K.E

$$= \frac{1}{2} \mu \frac{\Delta l}{t} A^2 \omega^2 \cos^2(\omega t - kx) \quad ---- (1)$$

Now, the potential energy of the element length Δl is

$$P.E = \frac{1}{2} k y^2$$

$$= \frac{1}{2} m \omega^2 A^2 \sin^2(\omega t - kx)$$

$$= \frac{1}{2} \mu \Delta l \, \omega^2 A^2 \sin^2(\omega t - kx)$$

The rate of transmission of P.E

$$= \frac{1}{2} \mu \frac{\Delta l}{t} A^2 \omega^2 \sin^2(\omega t - kx) \quad --- (2)$$

$\therefore$ total rate of transmission of energy (power) =

$$\frac{1}{2} \mu \frac{\Delta l}{t} A^2 \omega^2 \cos^2(\omega t - kx) + \frac{1}{2} \mu \frac{\Delta l}{t} A^2 \omega^2 \sin^2(\omega t - kx)$$

$$= \frac{1}{2} \mu \frac{\Delta l}{t} A^2 \omega^2 \left[\sin^2(\omega t - kx) + \cos^2(\omega t - kx) \right]$$

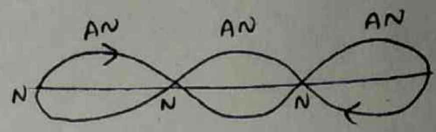
$$= \frac{1}{2} \mu u A^2 \omega^2$$

$$= \frac{1}{2} \mu u A^2 (2\pi f)^2 \qquad \left[\because \frac{\Delta l}{t} = u, \text{ wave velocity}\right]$$

$$= \frac{1}{2} \mu u A^2 4\pi^2 f^2$$

$$P = 2\pi^2 f^2 \mu u A^2$$

nonary (standing) wave -
nen two progressive waves equal in amplitude
nd wavelength travelling in opposite direction
iperimpose, a resultant wave is formed which
es not travel forward in medium and the



sultant wave formed is called stationary wave. In stationary wave there
e certain points like 'N' where particles vibration is minimum i,e particles
not vibrate (completely at rest). These positions are called nodes. where as
ere are certain points like 'AN' where particle vibrations are maximum
lled anti-nodes.

Let $y_1 = A\sin(\omega t - kx)$

and $y_2 = A\sin(\omega t + kx)$ be the two progressive waves travelling in opposite
rection. when those two waves overlap, the total displacement i,e resultant
splacement is

$$y = y_1 + y_2$$

$$\Rightarrow y = A\sin(\omega t - kx) + A\sin(\omega t + kx)$$

$$\Rightarrow y = A\left[2\sin\left(\frac{\omega t - kx + \omega t + kx}{2}\right) \cdot \cos\left(\frac{\omega t - kx - \omega t - kx}{2}\right)\right]$$

$$\Rightarrow y = 2A\sin\omega t\cos(-kx)$$

$$\Rightarrow y = 2A\cos kx\sin\omega t$$

$$\Rightarrow y = B\sin\omega t \text{ ---- } (*)$$

here $B = 2A\cos kx$ is the amplitude of resultant wave i,e eqn $(*)$ represents
re equation of stationary wave, of amplitude B.

he amplitude is maximum when,

$$\cos kx = \pm 1$$

$$\Rightarrow \cos kx = \cos n\pi \quad [n = 0, 1, 2, 3, \ldots$$

$$\Rightarrow kx = n\pi$$

$$\Rightarrow x = \frac{n\pi}{k}$$

$$\Rightarrow x = \frac{n\pi\lambda}{2\pi}$$

$$\Rightarrow x = \frac{n\lambda}{2}$$

$$\Rightarrow x = 0, \frac{\lambda}{2}, \lambda, \frac{3\lambda}{2}, \ldots$$

ese are the position of anti-nodes.

e amplitude is minimum when,

$$\cos kx = 0$$

$$\Rightarrow \cos kx = \cos(2n+1)\frac{\pi}{2} \quad , [n = 0, 1, 2, 3, \ldots$$

$$\Rightarrow kx = (2n+1)\frac{\pi}{2}$$

$$\Rightarrow x = \frac{(2n+1)\pi}{2k}$$

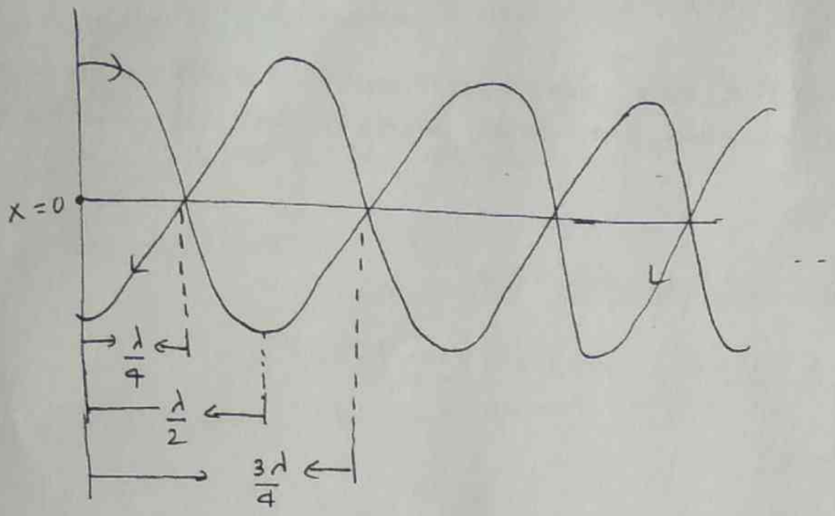
$\Rightarrow x = (2n+1)\frac{\pi}{2.2\pi}\lambda$

$\Rightarrow x = (2n+1)\frac{\lambda}{4}$

$\Rightarrow x = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}, \ldots$

hese are the position of nodes.

hus we see that anti-nodes and nodes are formed alternatively.



* Resonance of stationary wave -

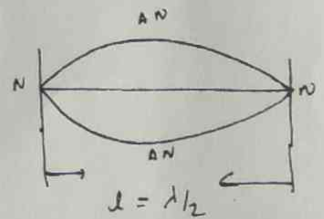
In general standing waves are formed in a bounded medium. For instance, when a string is tied at both ends, standing wave is formed. but the standing wave is set up only for a certain discrete set of frequencies. we can say that the system resonates at these frequencies and called resonance of stationary wave

The minimum frequency at which resonance occur is called fundamental frequency or first harmonic.

First harmonic occurs at

$$l = \frac{\lambda}{2}$$

$$\Rightarrow \lambda = 2l \quad \text{---(1)}$$



we have, $u = f\lambda$

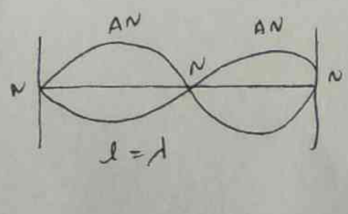
If f_0 be the fundamental frequency then,

$$u = f_0\lambda \quad \text{--(2)}$$

From (1) and (2)

$$u = f_0 2l$$

$$\Rightarrow f_0 = \frac{u}{2l} \quad \text{---(3)}$$



For 2nd harmonic, occurs at

$$l = \lambda \quad \text{---(4)}$$

f_1 be the frequency of 2nd harmonic then,

$$u = f_1\lambda \quad ---(5)$$

from (4) and (5), $u = f_1 l$

$$\Rightarrow f_1 = \frac{u}{l}$$

$$\Rightarrow f_1 = \frac{2u}{2l}$$

$$\Rightarrow f_1 = 2f_0 \quad ---(6)$$ [This is called 1st overtone]

similarly, for third harmonics

$$f_2 = 3f_0 \quad --(7)$$ [2nd overtone]

In general, $f_n = (n+1) f_0$

* Difference betn progressive and standing wave-

* progressive -

1. The disturbance travels forward in the medium and is handed over from one particle to next after some time
2. The amplitude of oscillation is same at all positions in the medium.
3. No particles is permanently at rest.
4. Energy is transmitted from particle to particle across every section of the medium.
5. As the disturbance moves ~~from~~ every part of the medium suffers a change in density.
6. At every point there is variation in pressure.
7. Regular phase difference exists between successive particles.
8. The value of maximum velocity for all particles of the medium is same.

* standing-

1. The disturbance is at rest and does not move at all. so there is no transfer of disturbance to the neighbouring particles.
2. The amplitude of oscillation varies from zero at node to maximum at anti-node.
3. The particles at nodes are permanently at rest.
4. Energy is not transmitted from particles to particle i.e no transfer of energy across every section of the medium.
5. At anti-nodes, there is no change in density but at node there is maximum.
6. pressure variation is maximum at nodes and zero at anti-nodes.
7. All the particles ~~bein~~ in between two successive nodes are in phase.
8. The value of maximum velocity for different particles is different and velocity of the particles at the node is always zero.

Acoustics

prepared by cps

.he word acoustics is derived from Greek word, meaning to 'hear.' Hence acoustics is defined as the science of sound. It conveys a double meaning and refers to the mental sensation perceived by ears and the cause responsible for that perception, namely, the physical phenomena external to the air, the wave motion which excites the auditory nerve.

Acoustic is a branch of physics dealing with production, propagation ~~and~~ perception and analysis of sound. It deals with design of and construction of different units of buildings to get proper acoustic conditions and also with the correction of the corresponding defects existing rooms.

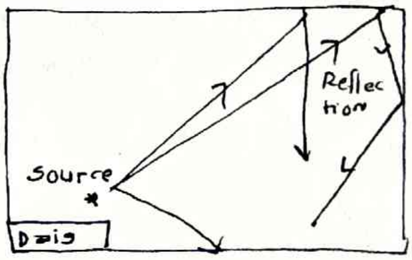
The science of acoustic of buildings has now achieved a unique place in design of modern buildings.

* Factors affecting good acoustic results -

(1) Reverberation time
(2) Loudness
(3) Focusing
(4) Echoes
(5) Echelon effect
(6) Resonance
(7) Noises.

* Reverberation -

when sound produced in a room or hall, It is noted that sound continues to be heared for sometime. sound produced in a hall or room undergoes multiple reflections from the walls, floor and ceiling before It becomes inaudible. The listner does not ~~hear~~ a single sharp sound but roll of sound.



Reverberation is the persistence and prolongation of sound in a room or hall due to the successive reflections from surfaces even when the source of sound has stop to emit sound. And time taken for sound to fall below the minimum audible range measured from the instant when the source of sound stopped sounding is called reverberation time.

The reverberation time in a hall should not be too large and also should not be too short. If the reverberation time is too short, the sound may not be sufficiently loud in all portion of the hall and the hall sounds dead.

If the reverberation time is too long, echoes will be present which results in speech being unitelligible. Therefore, value of reverberation time is maintained at an optimum value.

The satisfactory reverberation time are

* speech → 0.5 sec
* music → 1.0 to 0.2 sec
* Theatres → 1.1 to 0.15 sec

The reverberation time is controlled by
1. providing windows and ventillators.
2. covering the ceiling, part of the walls and even back of the chairs with absorbent materials like felt, fiber board, glass, wool etc.
3. using heavy curtains with folds.
4. covering the floor with carpets.
5. having a good sized audience.
6. Decorating the walls by pictures and maps.

* Absorption coefficient-

The ratio of sound intensity absorbed by a surface to the total energy incident on the surface is known as absorbing power or absorbing coefficient of the surface. It is denoted by 'a'.

$$\therefore \text{Absorption coefficient (a)} = \frac{\text{sound energy absorbed}}{\text{total sound energy incident}}$$

An open window is an ideal of perfect sound absorber. It is so because whole of the sound energy falling on an open window passes out and none is reflected.

* sabine's formula or law
(standard reverberation time)

This law states that the standard reverberation time is the time taken by the intensity of sound to fall one millionth (10^{-6}) of its original intensity after the original sound is cut-off.

Let $a_1, a_2, a_3 \ldots a_n$ be the absorbtion coefficients of various surfaces inside the room or hall and $s_1, s_2, s_3 \ldots s_n$ be there respective areas of surfaces. Then the average value of the absorption coefficient $\bar{a}$ is given by

$$\bar{a} = \frac{a_1 s_1 + a_2 s_2 + \cdots + a_n s_n}{s_1 + s_2 + \cdots + s_n}$$

$$\Rightarrow \bar{a} = \frac{\Sigma a s}{s}$$

$$\Rightarrow \Sigma a s = \bar{a} s \quad \text{----(1)} \qquad [\because s = \text{total surface area}]$$

By statistical method, Jager showed that the average distance travelled by sound between two successive reflection is $\frac{4V}{s}$.
where V = volume of room or hall.
If v be the velocity of sound in air, then time between two successive

$$\text{reflection} = \frac{\text{distance travelled}}{\text{velocity}}$$

$$= \frac{4V/s}{v} = \frac{4V}{sv} \text{ sec.}$$

In $\frac{4V}{S\upsilon}$ second the number of reflection = 1

In 1 second the number of reflection = $\frac{1}{4V/S\upsilon} = \frac{S\upsilon}{4V}$

The number of reflections in 't' sec $= \frac{S\upsilon t}{4V}$

hat means the average no. of reflections in time t, $= \frac{S\upsilon t}{4V}$

At one reflection fraction of sound absorbed $= \bar{a}$

Fraction of sound reflected $= (1-\bar{a})$

After two reflections, fraction of sound reflected $= (1-\bar{a})(1-\bar{a})$

In $\frac{S\upsilon t}{4V}$ reflections fraction of sound reflected

$$= (1-\bar{a})^{S\upsilon t/4V} \quad \text{--(2)}$$

f I_0 be the initial intensity of sound and I_t be the intensity of sound after time 't' then,

Fraction of sound reflected $= \frac{I_t}{I_0}$ --(3)

rom (2) and (3)

$$\frac{I_t}{I_0} = (1-\bar{a})^{S\upsilon t/4V} \quad \text{--(4)}$$

But according to the definition of reverberation time,

$$\frac{I_t}{I_0} = 10^{-6} \quad \text{--(5)} \quad \text{and } t = T$$

rom (4) and (5)

$$(1-\bar{a})^{S\upsilon T/4V} = 10^{-6}$$

aking log on both sides

$$\frac{S\upsilon T}{4V} \{\log(1-\bar{a}) = (-6)\log_e 10^1$$

$$\Rightarrow \frac{S\upsilon T}{4V}\left[-\bar{a} - \frac{\bar{a}^2}{2} - \frac{\bar{a}^3}{2} \dots\right] = (-6)\log_{10} 10^1 \times 2.3026$$

$$\Rightarrow \frac{S\upsilon T}{4V}(-\bar{a}) = (-6) \times 2.3026 \times 1 \quad \text{[neglecting higher order terms]}$$

And $\log_{10} 10^1 = 1$

$$\Rightarrow T = \frac{(-6) \times 2.3026 \times 4V}{S\upsilon(-\bar{a})}$$

$$T = \frac{6 \times 2.3026 \times 4V}{\upsilon(\bar{a}S)} \quad \text{--(7)}$$

om eqn (1) and (7)

$$\Rightarrow T = \frac{6 \times 2.3026 \times 4V}{330\ \Sigma aS} \quad [\bar{a}S = \Sigma aS \text{ and } \upsilon = 330\,m/s]$$

$$\Rightarrow T = \frac{0.167V}{\Sigma aS} \quad \text{--(x)}$$

he reverberation time depends upon the volume of room and total absorption or absorbing power of the hall.

* ultrasound -

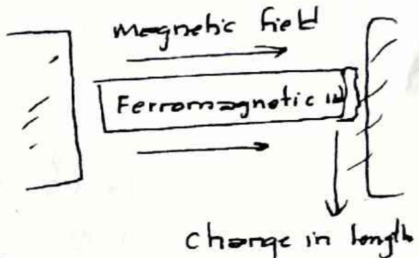
Sound waves with frequencies between 20Hz to 20kHz heard by human ear is called audible range. The sound wave having frequency above the audible range i,e above 20KHz are called ultrasonic waves.

The wavelengths of ultrasonic waves are very small as compared to audible sound.

* ultrasonic production -

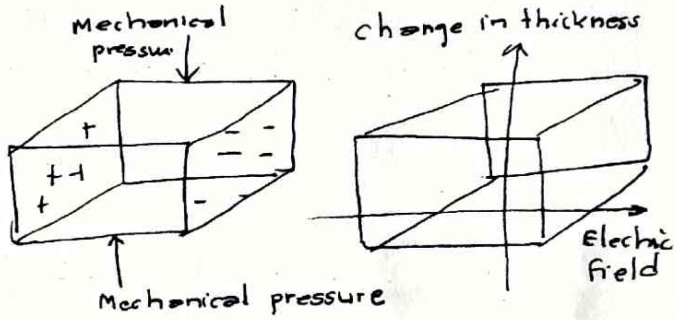
(1) Magnetostriction method -

when a ferromagnetic rod like iron or nickel is placed in a magnetic field parallel to its length, (strong magnetic field) the rod experiences a small change in its length. This is called magnetostriction effect. The change in length increase or decrease depends upon the strength of magnetic field, the nature of the materials and independent of magnetic field applied. This effect is very small and can be detected by a sensitive device.



If a ferromagnetic rod is placed in an alternating magnetic fields, the rod expands and contracts in length alternatevly. when the frequency of the alternating field is adjusted to the natural frequency of vibration of the rod, resonance will occur. The rod vibrates longitudinally with large amplitude and the rod generates ultrasonic waves from its ends.

(2) piezo-electric method:



If mechanical pressure is applied to one pair of opposite faces of certain crystal like quartz, equal and opposite electrical charges will appear across its other faces. This is called piezo-electric effect.

The converse of piezo-electric effect is also true. If an electric field is applied to one pair of faces, the corresponding changes in the dimensions of other pair of faces of the crystal are produced.

This is known as inverse piezoelectric effect or electrostriction. If an alternating voltage is applied to the opposite faces of quartz crystal pressure is developed along the other opposite faces of crystal. The quartz crystal contineously contracts and expands for the applied alternating field. Then the crystal is set into mechanical vibrations and hence produced ultrasonic waves.

It is more efficient than magnetostriction oscillator. Almost all the mordern ultrasonic generators are of this type. Moreover, ultrasonic frequencies are high as 5×10^8 or 500 MHz can be obtained with the arrangement.

The output of the oscillator is very high and it is not effected by temperature and humidity. but the demerits is that the cost of piezoelect quartz is very high and cutting and shaping of quartz crystal are very complex.

* properties of ultrasonic waves:

1. They have high energy content.
2. Just like ordinary sound wave, ultrasonic waves get reflected, refracted and absorbed.
3. They can be transmitted over long distances with no appreciable loss of energy.
4. If an arrangement is made to form stationary waves of ultrasonic in liquid, it serves as a diffraction grating. It is called acoustic grating
5. They produce intense heating effect when passed through a substance.

* Applications-

(1) ultrasonic waves are used to detect the presence of flaws or defects in the form of crack, blowholes, poprosity etc in the internal structure of a material.

2) ultrasonics are used for making holes in very hard materials like glass, diamond etc.

3. The properties of some metals changes on heating and therefore, can not be welded by electric or gas welding. In such cases, the sheets are welded together at room temperature by using ultrasonics.
4. ultrasonic waves are used for cutting and machining.
5. It is used as a direction signalling.
6. It is used to measure the depth of the sea.
7. small organism and bacteria are either killed or maimed when ultrasonic waves fall on them.
8. strong ultrasonic waves are used for cleaning and washing cloths
9. ultrasonic waves are used to get relief from neurological pain.