

6-concept of sound

CONTENT: Definition, types of waves, effecting factors of sound , musical sound and noise, noise pollution , Doppler effect and applications, Echo-condition-reducing methods- applications, ultra Sonics – applications.

INTRODUCTION:

Sounds are Mechanical waves. All sound waves produced by vibrating bodies due to mechanical work. Velocity of sound in air at 0°C is 320m/sec . Velocity of sound in air at room temperature(28°C) is 340m/sec .

Properties of sound:

- 1)sound waves are mechanical waves.
- 2)sound waves are medium(solid, liquid, gas) dependent and temperature dependent.
- 3)sounds can travel in solids, liquids and gases.
- 4)sounds can not travel in vacuum.
- 5) properties of sound depends on elastic property(modulus) of the medium.
- 6) velocity of sound is maximum in solids(granite 6000m/s) and it is minimum in gases(air 340m/s).

----→ What is transverse and longitudinal Waves?

Waves are a means of transferring energy, without actually transporting matter. Waves can be either transverse (or) longitudinal .

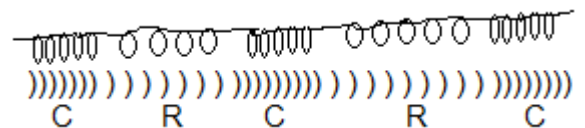
Transverse wave motion: In this, disturbance created (particle motion) in a medium is perpendicular to wave motion(energy). In this we get crests and troughs.

Ex: waves on a string, waves on surface of water, EM waves, light waves

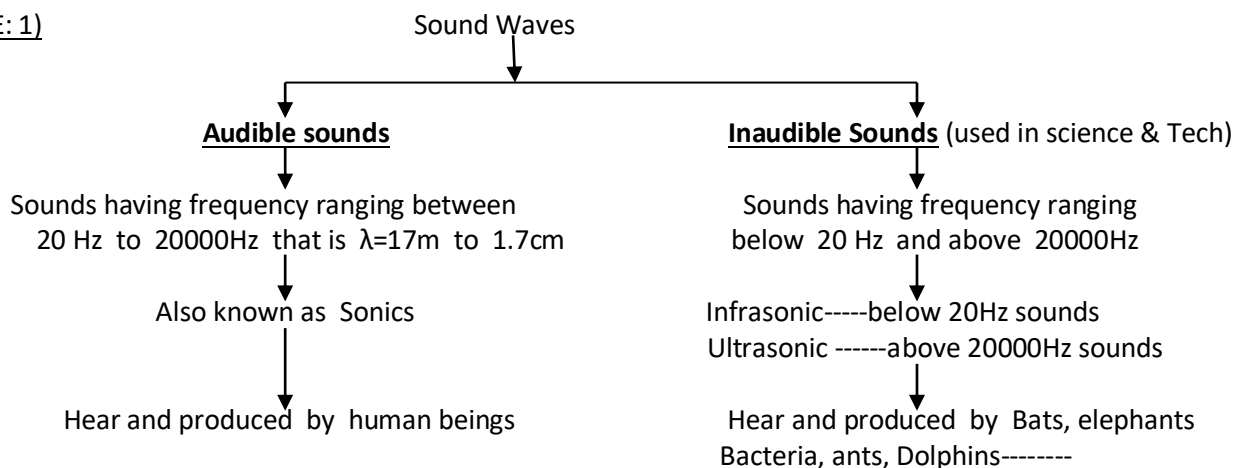


Longitudinal wave motion: In this, disturbance created in a medium is parallel(same direction) to wave motion. In this we have compressions and rarefactions.

Ex: stretched spring, Sound in air, Sound in traffic.



NOTE: 1)

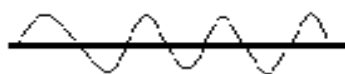


2) Audible sound can be divided into two categories. These are musical sound, noise

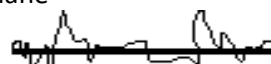
(a) Musical sound: -----> Any sound that gives pleasing effect on ears is called a musical sound. These are the series of equal and periodic oscillations in a medium. Ex: sounds produced by sitar, flute....

(b) Noise: -----> Any sound which is unpleasant, irregular and discontinuous sound is known as noise.
Ex: hammer hitting a nail, horn ringing, sounds from moving aeroplane

Musical Sound



Noise



-----> What are the Differences between musical sounds and noise?

Musical sound	Noise
1) it is pleasant to the ears	1) It is unpleasant to the ears
2) Vibrations of particles in the medium are regular	2) Vibrations of particles in the medium are irregular.
3) These are the periodic pulses	3) These are produced with irregular intervals.
4) There is a uniform pitch and loudness.	4) there is a non uniform pitch and loudness.
5) ex: sounds produced by sitar, flute, electronic keyboard	5) ex: -bike horn, hammer hitting a nail, diwali crackers, automobiles.

-----> What are the effecting factors of Sound?

The distance travelled by sound in Air in unit time is called velocity of sound .

Velocity of sound in Air is $V = \sqrt{\frac{\gamma P}{d}}$, $\gamma = \frac{C_p}{C_v}$ = constant (specific heat ratio).

1) Effect of density: The velocity of sound is inversely proportional to square root of the density.

$V \propto \frac{1}{\sqrt{d}}$ ---- in hot air --- density decreases , velocity increases.

----- in cool air ---- density increases , velocity decreases.

2) Effect of humidity: Dry air is the mixture of O_2 , CO_2 , N_2 ----molecules. Humid air (moisture) is the mixture of dry air and water vapour. The density of humid air less than of dry air. Hence velocity of sound in air increases as humidity increases.

3) Effect of temperature:

From gas equation, $PV = nRT$, here volume $V = \frac{m}{d}$, moles $n = \frac{m}{M}$

$$\frac{P}{d} = \frac{RT}{M} \text{ ---- velocity of sound } V = \sqrt{\frac{\gamma P}{d}} = \sqrt{\frac{\gamma RT}{M}} \text{ ---- } V \propto \sqrt{T}$$

Hence velocity of sound is directly proportional to square root of temperature.

NOTE:

1) At $0^\circ C$ ----- $V_0 \propto \sqrt{T_0}$

$$\begin{aligned} \text{At } t^\circ C \text{ ----- } V_t \propto \sqrt{T} \quad & \text{-----} \quad \frac{V_t}{V_0} = \sqrt{\frac{T}{T_0}} \quad \text{-----} \quad \frac{V_t}{V_0} = \sqrt{\frac{273+t}{273}} \quad \text{-----} \quad V_t = V_0 \sqrt{\left(1 + \frac{t}{273}\right)} \\ & V_t = V_0 \left[1 + \frac{t}{546} \right] \quad \text{-----} \quad V_t = V_0 + \frac{V_0}{546} t \end{aligned}$$

$$\text{But } V_0 = 330 \text{ m/s} \text{ ----- } V_t = V_0 + 0.61 t$$

Hence, velocity of sound increases by 0.61 m/s for every $1^\circ C$ temperature.

2) At 20°C, density of air is $d = 1.293 \text{ kg/m}^3 = 0.001293 \text{ gm/cc}$

For 1 mole of air mass $m = 28.97 \text{ gm}$ --- $\{ m = V d = 22.4 \text{ litre} \times 0.001293 \text{ gm/cc} \}$

----->Define noise pollution? Explain causes, effects and minimizing methods of noise pollution?

Noise pollution: A pollution created by unwanted sound (pleasant and unpleasant) into the atmosphere is called the noise pollution. Units----->decibel (dB)



Causes of noise pollution:- there is many common noise pollutions.

1)community noise:- Cinema theatres, offices, banks, workshop are the sources of community noise pollution. This has a range of 30 to 50 dB.

2)Traffic noise:- Noise produced by huge number of vehicles at a junction. Here the noise pollution between 75 to 100 dB.

3)Aircraft noise:- Due to aircraft sound, too much noise will be produced. It has a noise about 140 dB.

4)Construction noise:- Construction of roads, bridges, buildings are the sources of noise pollution. It has a range between 75 to 95 dB.

Effects of noise pollution:

1)Noise pollution may cause headache, high blood pressure.

2)Noise may induce dangerous resonance that leads to damage the ear drum.

3)In some situations noise pollution collapse the nervous system.

4)It interrupts the communication of people.

5)It affects the kidneys, liver and may also produce mental disorder.

Minimizing (or) prevention of noise pollution:

1)Road traffic should be restricted from unnecessary blowing of horns.

2)Using ear plugs decreases effects of noise.

3)Proper changes in design of industrial machinery must be made.

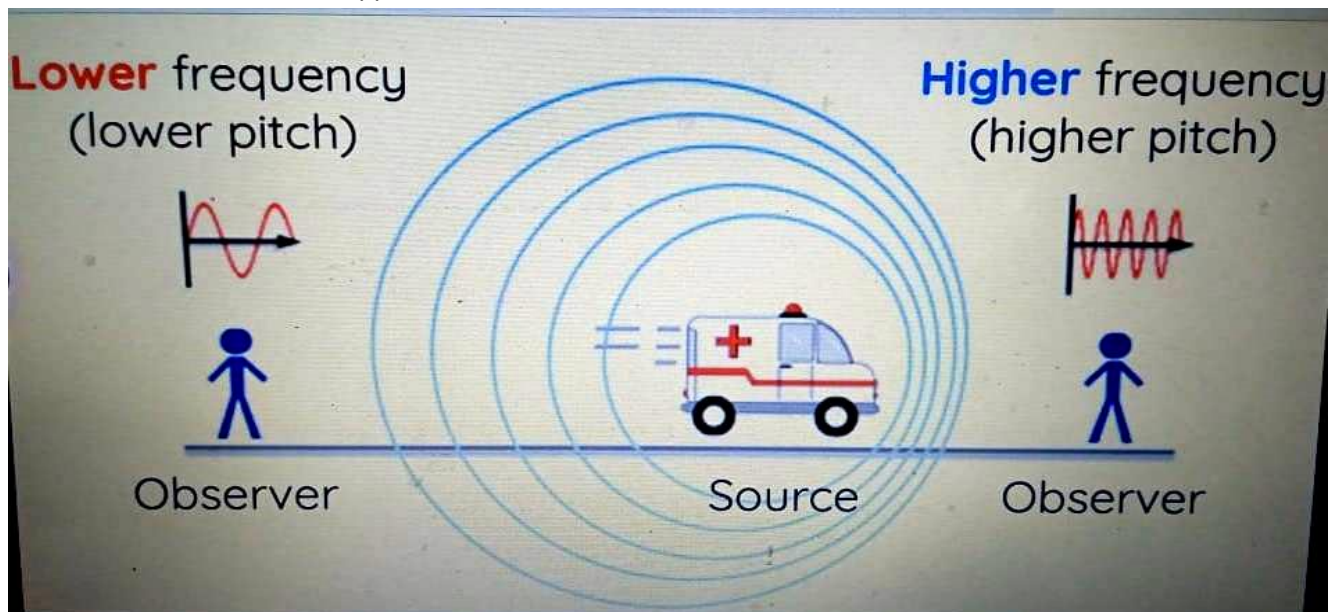
4)aerodromes must be located away from city.

5)Proper plantation must be done to absorb noise.

6)Noise free zones must be maintained near hospitals, schools, public places and parks.

----->What is Doppler effect? Write it's applications?

"The apparent change in the frequency OR pitch of sound when the source of sound and the observer are in relative motion is called Doppler effect."

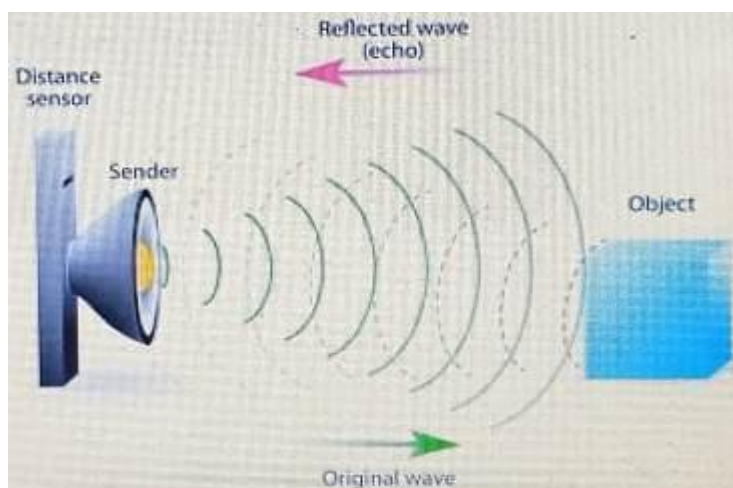


Applications of Doppler effect:

- 1) This process is used to find speed and direction of motion of submarines in sea. This is known as Sound Navigation and Ranging (SONAR).
- 2) This effect is used to find speed and direction of motion of aeroplanes. This is known as Radio Detection and Ranging (RADAR).
- 3) This effect is useful to measure the radial speed of satellites.
- 4) Saturn's rings were discovered using Doppler effect.
- 5) Doppler effect by electromagnetic waves is used in astronomy to measure the velocities of stars relative to the earth.

----->Define ECHO/ Find minimum distance to travel (get) echo?

ECHO: "A reflected sound from an obstacle is called the echo."



The echo is clearly audible only when there is a sufficient time gap between the source and the reflector such as a wall, a mountain etc.

If the 'C' is velocity of sound, 'd' is the distance between source and reflector then

$$\text{Time for ECHO is } t = \frac{\text{total distance}}{\text{sound velocity}} = \frac{d+d}{C}$$

$$t = \frac{2d}{C}, \text{ here } C = 330 \text{ m/sec at } 0^\circ\text{C}$$

and minimum time for the echo is 0.1 sec. Then $0.1 = \frac{2d}{330} \rightarrow d = \frac{0.1 \times 330}{2} = \frac{33}{2} = 16.5 \text{ metre.}$

So to hear the ECHO, there must be a minimum distance of 16.5 m,, between source and the reflector at 0°C.

Applications of ECHO (or) Reflection of sound:-

- 1)ECHO system is used in defense to find the depth of the sea, distance of enemy aircraft.
- 2)ECHO technique is used in ultra sound scanning system.
- 3)ECHO technique is used to identify the stones in kidneys.
- 4)Megaphone and stethoscope work on the principle of reflection of sound.
- 5)Echoes are used to identify tumours inside the human body.

Minimizing (reducing) methods of ECHO:

Echos can be minimized by

- 1)Providing a large volume room with windows & doors.
- 2)Providing a room with large number of carpets and curtains.
- 3)Having Rough walls.
- 4)Having Low Ceiling.

---→ What is Reverberation tim?

The phenomenon of sound in a closed place due to multiple reflections of sound even after the source stops sounding is called the reverberation."

In reverberation- sound is continuous for some time, and in ECHO-sound is heard with distinct breaks.

Reverberation time:

"It is the duration of time for which the reverberation exists in a room ". It depends on the size of the room and nature of the reflecting materials in the room.

----->Write about Sabine's formula for reverberation time ?

According to Sabine's formula the reverberation time in a given enclosure, is inversely proportional to the total absorption in the room.

that is $T \propto \frac{1}{A}$, $A = \Sigma(a \times S) = a_1S_1 + a_2S_2 + a_3S_3 + \dots$

here a ---> absorption coefficients of the materials

S ----> surface areas of a given things in a room.

and Reverberation time is directly proportional to volume(V) of the room.

That is $T \propto V$, therefore $T \propto \frac{V}{A}$ -----> $T = k \frac{V}{A} = \frac{0.16 V}{A}$ ----->

$$T = \frac{0.16 V}{\Sigma(a \times S)}$$

Foam ' a ' = 0.9, Wood - 0.75, Cotton - 0.53, Carpet - 0.3, glass - 0.18, Rubber --0.1 to 0.2, window -1

----->What are the differences between reverberation and ECHO?

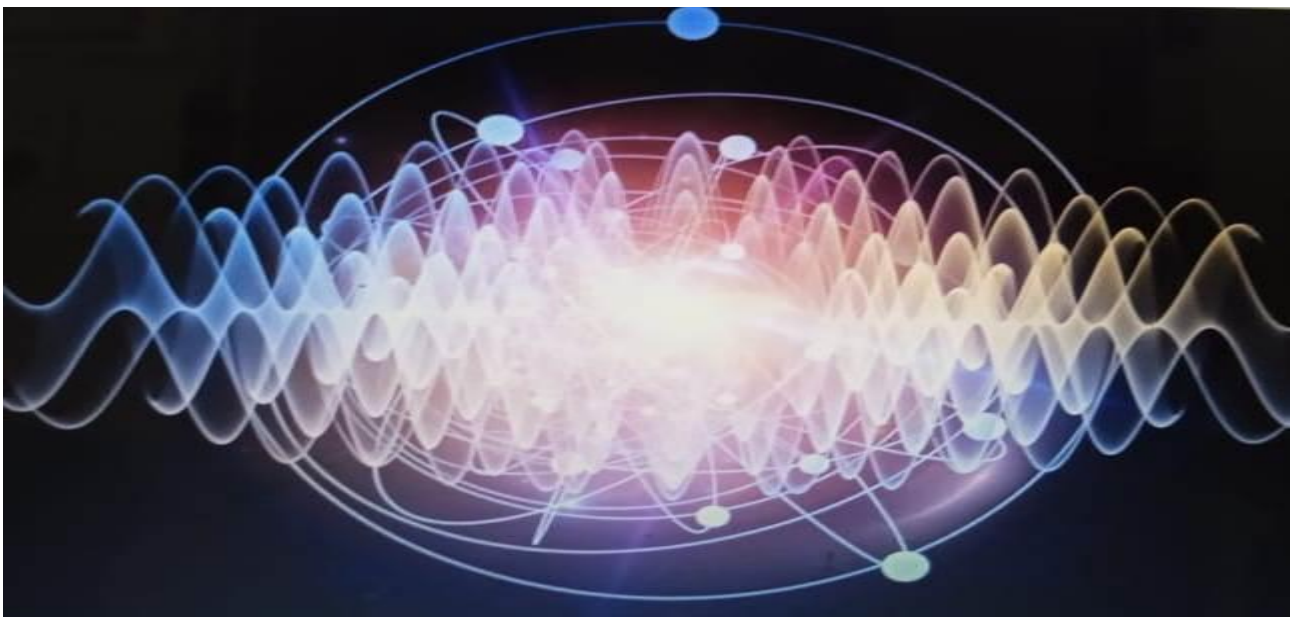
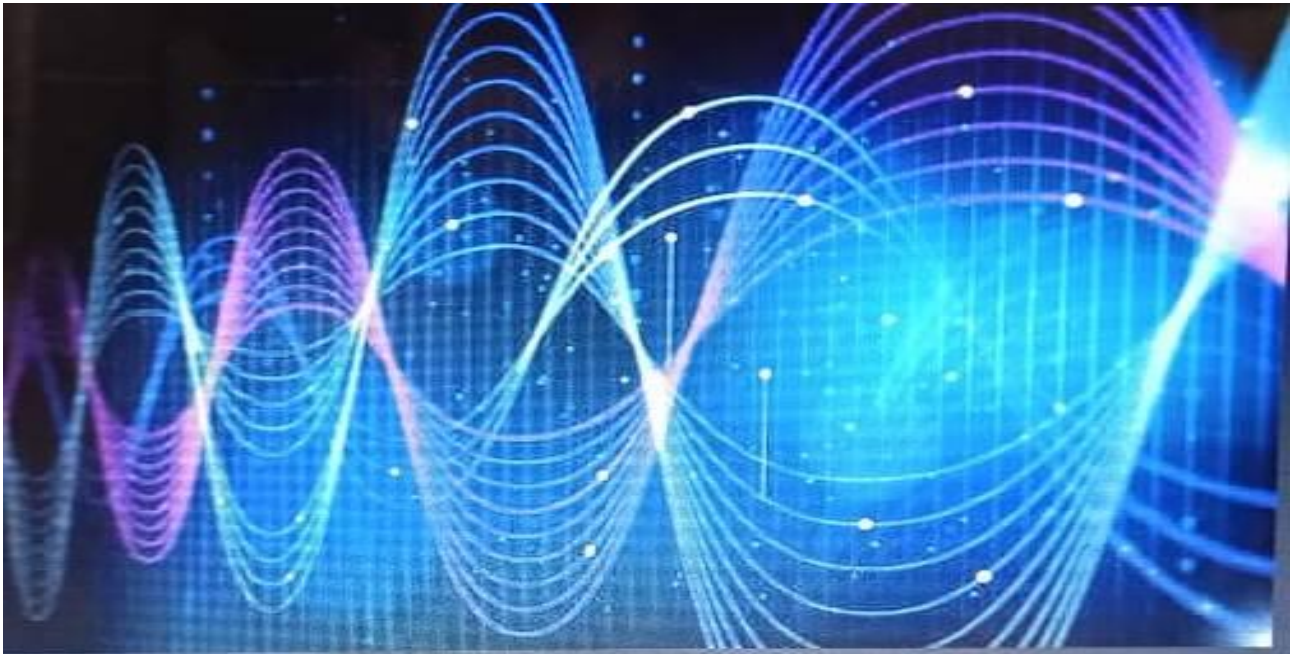
Reverberation	ECHO
1)It is due to multiple reflections of sound.	1)It is due to reflection of sound once from a distant object.
2)Clarity of original sound is lost.	2)Original sound is repeated distinctly.
3)It is desirable (useful) in music industry.	3)It is undesirable in music industry.
4)It has little practical Application.	4)It has many application . Ex: in RADAR system.

---> What is Ultra Sonics and write it's applications?

The sounds of frequency greater than 20000Hz are called as Ultra Sonics. Animals like Bats, Dolphins, Dogs --- can hear and produce ultra Sonics. These are high energy sound waves and it can reflect, refract and absorbed.

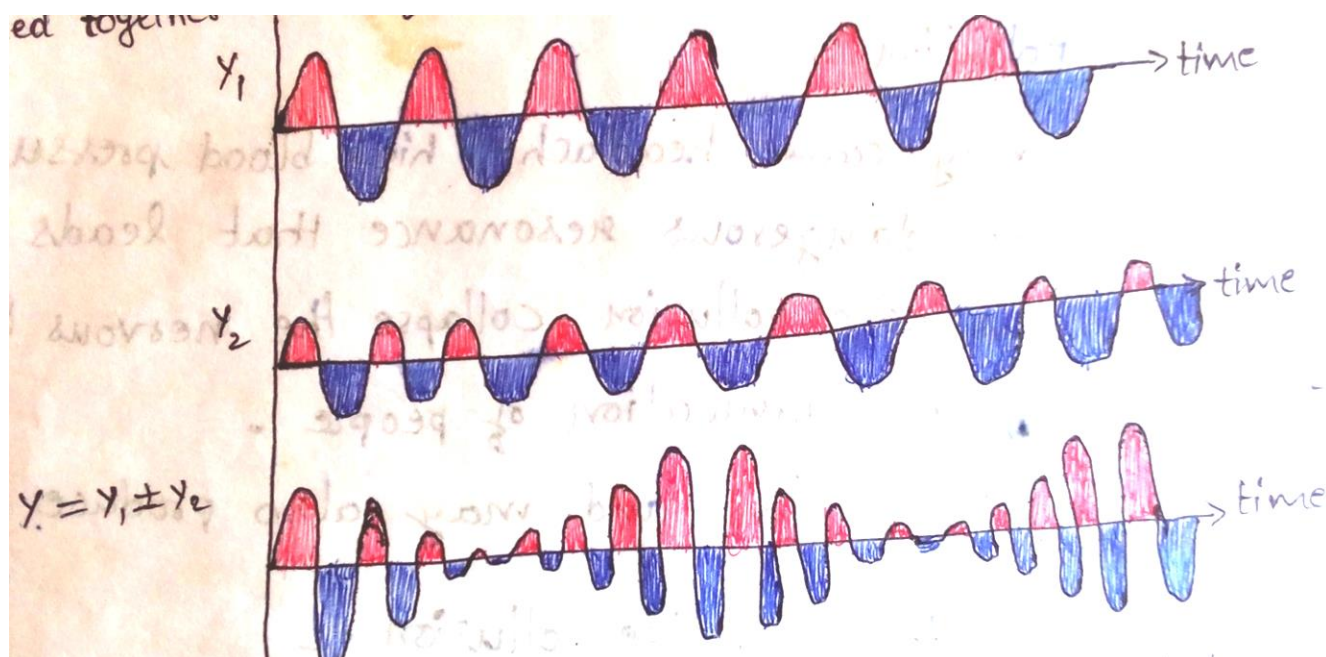
Applications:

- 1)These are used to detect the cracks in metals in constructions.
- 2)Used for soldering the aluminium wires, plates and capacitors.
- 3)Used for welding, cutting and drilling holes in metals.
- 4)Used to kill the bacteria in water purification methods.
- 5)Ultra Sonics are used to clean the strains(grease) in electronic components with cleaning solution.
- 6)These are used to identify and break the stones in kidney.
- 7)Ultrasound scan is the technique to image the internal parts of human body----- sonograms.
- 8)Used in Echocardiography, that is the image of heart using reflection property of ultra Sonics.
- 9)Reflection of ultra Sonics used in SONAR system.
- 10)Reflection of ultra Sonics used for Bats to find their food in dark place. It is known as Echolocation.



Beats :

The periodic increase and decrease of loudness when two waves of nearly equal frequencies superimpose(interfere) with each other is called the beats. If y_1 and y_2 are two slightly different forks when sounded together it will form beats as shown in below.



Properties of Beats:

- 1) One beat is defined as one successive maxima and minima.
- 2) Number of beats occur in one second is known as beat frequency.
- 3) If n_1 and n_2 are the frequencies of two sounds then the beat frequency is $\Delta n = n_1 - n_2$
- 4) Time interval between two successive maxima is equal to time interval between two successive minima.

$$\text{It is } t = \frac{1}{n_1 - n_2} = \frac{1}{\Delta n}$$

- 5) Maximum beats per second heard by human ear is 10.

- 6) So time interval for two successive maxima (or) minima is $\frac{1}{10\text{Hz}} = 0.1 \text{ sec}$

Applications of Beats:

- (1) A unknown frequency of a tuning fork (note) can be determined:

If n_1 is the known frequency, n_2 is the unknown frequency and Δn is the initial beat frequency.

Then unknown frequency can be determined as

$$n_2 = n_1 - \Delta n \quad \text{if second beat frequency increases when waxing.}$$

$$n_2 = n_1 + \Delta n \quad \text{if second beat frequency decreases when waxing.}$$

$n_2 = n_1 - \Delta n$ = if second beat frequency decreases when Rubbing(filed).

$n_2 = n_1 + \Delta n$ = if second beat frequency increases when waxing(filed).

Note:

(a)Loading(waxing): If some wax is attached to the prong of a tuning fork, it is called loading. The frequency of the tuning fork generally decreases on loading.

(b)Filling(rubbing): If the prong of a tuning fork is filed it become light and its frequency increases.

2)Musicians use the beats phenomenon to tune musical instruments:

Strings of musical instruments are tuned to the desired frequencies by sounding together and observing whether beats are produced (or) not.

3)Phenomenon of beats is used to detect dangerous gases in mines:

Two equal pipes are taken in a mine, one of it has air. If the mine has no any gas then two pipes does not produce beats. If the mine has a dangerous gas then two pipes vibrate and produce beats.

4)Beats in light are used n modern optical communication systems.