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Unit-5 Wave motion and its application

✡ Definitions:-

1) Periodic Time (T):-

→ During the wave motion, the time required for one complete oscillation is called periodic time (T).

Unit = Second

Dimensional formula = $M^0L^0T^1$

2) Frequency :-

→ The number of complete vibrations performed by the particle in one second.

Unit = Hert

Dimensional formula = $M^0L^0T^{-1}$

3) Wave length :-

→ During the wave motion, wave length is the distance between two successive crest and troughs.

Unit = metre

Dimensional formula = $M^0L^1T^0$

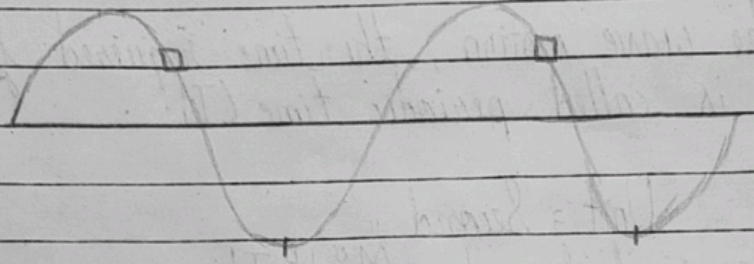
4) Amplitude:-

→ The maximum displacement made by a particle in any direction from its mean position during wave motion is called amplitude

Unit = cm, mm Dimensional formula = $M^0L^1T^0$

5) phase:-

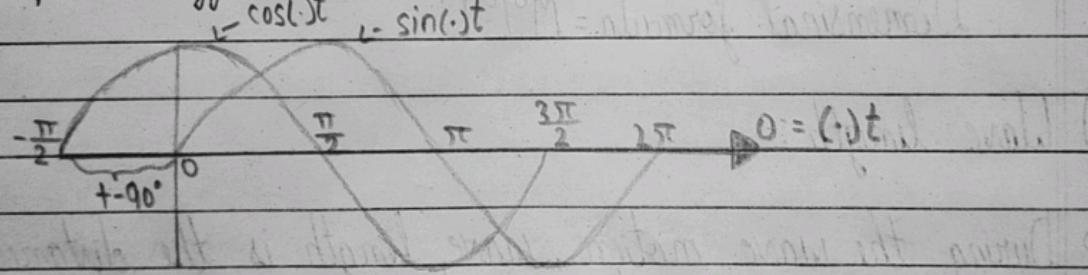
→ phase is a physical quantity that gives information about the direction and location of the motion of a particle vibrating at any time during wave motion.



Oscillations of particle with equal phase.

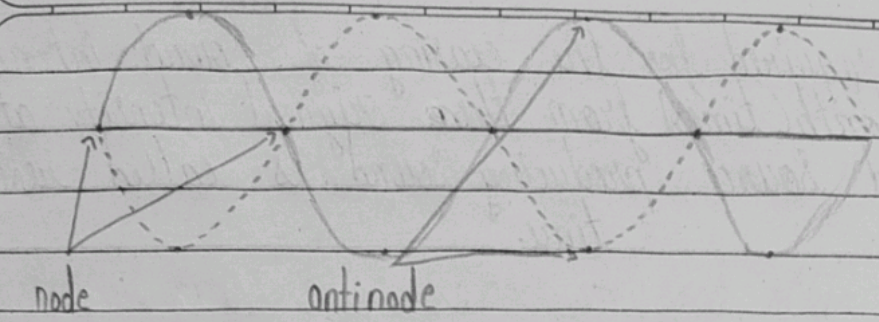
6) Phase diffurince:-

→ If the maximum displacement of two waves are found together at the same point, relative to the same frequency and time, then the phase difference between the two side to be zero.



7) Stationary waves:-

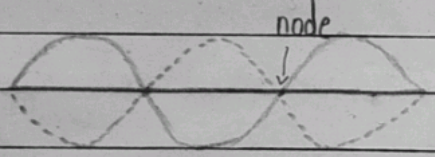
→ When two waves of the same amplitude and the same wavelength, moving in opposite directions superpose on each other the resultant wave is called Stationary waves.



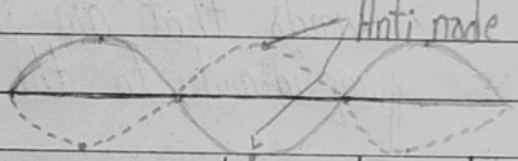
Stationary waves.

8) Nodes:-

→ A point with a minimum amplitude in a Stationary wave is called nodes.



9) Anti nodes:-



→ The point with maximum amplitude in a positive and negative direction in a Stationary wave is called an anti-node.

10) Reverberation:-

→ The phenomenon of the original sound is heard even after the sound has stopped beings produced is called reverberation.

11) Reverberation time:-

→ The time period in which the reverberation is heard even after the source has stopped producing sound in a hall is called reverberation time

OR

→ The time required for the ceasing of sound intensity to one millionth (times) from the original intensity at the time the sound source producing sound, is called resurberation time.

12) Echo:-

→ The echo of sound waves is a natural phenomenon caused by the reflection of sound. The effect of audible sound on the human ear lasts for 1/10 second.

13) Noise:-

→ Sounds that are inconsistent and boring as well as unpleasant to the ear are called noises.

Eg The noise of people in public places like a railway station or bus station. The sound of vehicles on the road, the sound of train whistles.

14) Musical sound:-

→ Musical sound is a sound that arises from the recurring vibration of a fixed frequency and comes from the same intensity at rigular intervals.

Eg The sound coming from musical instrument like violin, sitar, guitar, shehnai etc.

15) Co-efficent of sound absorption:-

→ The ratio of the sound energy absorbed per second by any surface and the total sound energy per the second incident on

the same surface is called the sound absorption co-efficient.

16) Princple of super position of waves:

→ When two waves superpose on each other, the intensity of the resulting wave at any point in the medium is equal to the vector sum of the intensities of the two independent wave at the same point.

17) Ultra sonic waves:

→ The sound waves having frequency more than 20,000 Hz are known as ultra sonic waves.

☆ Give difference between transverse and longitudinal waves:

	Transverse wave	longitudinal wave
1)	The particles of the medium vibrate in the direction parallel to the direction of progation of the wave.	The particles of the medium vibrate in the direction perpendicular to the direction of propagation of the wave.
2)	The wave travels in the form of compressions and rarefactions	The wave travels in the form of crests and troughs.
3)	The wave is possible in liquids and glass	The wave is possible in solid media only.
4)	The waves can not be polarised	The wave can be polarised
5)	e.g. light wave, water wave etc	e.g. Sound wave.

☆ Give difference between Mechanical and Non-mechanical wave:-

	Mechanical wave	Non-mechanical wave
1)	To require elastic medium for the propogation of the waves	To require elastic medium for the propogation of the waves.
2)	Particles of the medium take part for propogation of waves.	Electric and magnetic vector are responsible for the propogation of waves.
3)	Water waves, rope waves, sound waves in air and water	light wave, electromagentic wave X-rays

☆ Give difference between echo and reverberation:-

	Echo.	Reverberation
1)	When a sound wave is incident on a obstacle a part of it is reflected and a part is absorbed.	The presence of sound is an enclosure even after the source is shut off is called reverberation
2)	Sound is constantly produced by source of sound.	Source of sound is shot off.

☆ Relation between velocity, wave length and frequency:-

→ The distance through the wave length advances in one second is called wave velocity.

→ Wave velocity = $\frac{\text{Distance travelled}}{\text{time}}$

$$\therefore V = \frac{\lambda}{T}$$

$$= \left(\frac{1}{T}\right)\lambda$$

$$\therefore V = f \cdot \lambda$$

$$\therefore f = \left(\frac{1}{T}\right)$$

Where, V = wave velocity
f = frequency
λ = wave length

☆ State formula and explain each term of it:-

1) Wave equation

→ During the wave propagation the wave equation, given in the following form

$$Y = A \sin(\omega t + \Psi)$$

→ Y = Displacement of a particle participating in the wave motion at time t.

→ A = Amplitude

→ ω = Angular velocity.

→ $\omega = 2\pi f = \frac{2\pi}{T}$

→ t = Time showing displacement

→ Ψ = inital Phase

2) Sabine's formula :-

→ $t = \frac{0.165\,V}{\Sigma \alpha S}$ or $RT_6 = \frac{0.165\,V}{\Sigma \alpha n^5 n}$

→ Where, RT or T = Reverberation time.
V = Volumn of auditorium.
α = co-effiunt of absorption of sound.
S = Surface area of different surfaces.

☆ Write properties of sound waves

1) Sound waves are longitudinal waves

2) Like light waves, sound waves can also be absorbed reflected, etc by the surface

3) The echo of a sound is due to its reflection from the surface.

4) A midium is required for sound wave propogation.

5) Sound cannot propogate in a vacuum.

6) When a sound wave travels from one midium to another its frequency remains constant, but the velocity changes.

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☆ Write properties of light waves:-

1) light rays propagating in electric and magnetic fields combine.

2) A light ray is electromagnetic waves.

3) Light is a form of energy.

4) There is a sensation in your eyes when light comes any object.

5) Light ray travels in a straight line.

6) The speed of light in a vacuum is 3×10^8 m/s.

7) The speed of light varies in different medium.

8) Absorption, Reflection, Refraction, Dispersion, interference, diffraction and polarization can occur for a light beam.

☆ Explain reverberation and State the factors affecting on reverberation time.

OR

Explain the methods to control reverberation time and its application

Ans The reverberation can be controlled by

(1)- Providing window and ventilators.
- using curtains with holes.
- covering floor with carpets.
- Decorating the wall by pictures and map.

2) Adiquit loudness may be increased by using large surrounding board behind the speaker and facing the audience.

3) The ceiling should be low.

4) Echos may be avoided by covering long distances wall and high ceiling with absorbent material.

5) The minimum distance between sounding-body and reflecting surface is 17 m.

6) In a good hall no noise should be reached from outside.

☆ Define ultra sonic waves and State its properties. Write applications of ultra sonic waves in engineer and medical field.

Ans The sound waves having frequency more than 20,000 Hz are known as ultra sonic waves.

→ Properties of ultra sonic waves :-
- They are nothing but acustical waves with frequency higher than 20K Hz.
- They are highly energetic.
- They are longitudinal waves.
- Wave length of ultra sonic waves is small
- We cannot hear these waves.
- Some animals, mosquitoes, insects and birds can hear these waves.
- When they travel in medium, they produce heating effect.

→ Application of ultra sonic waves:

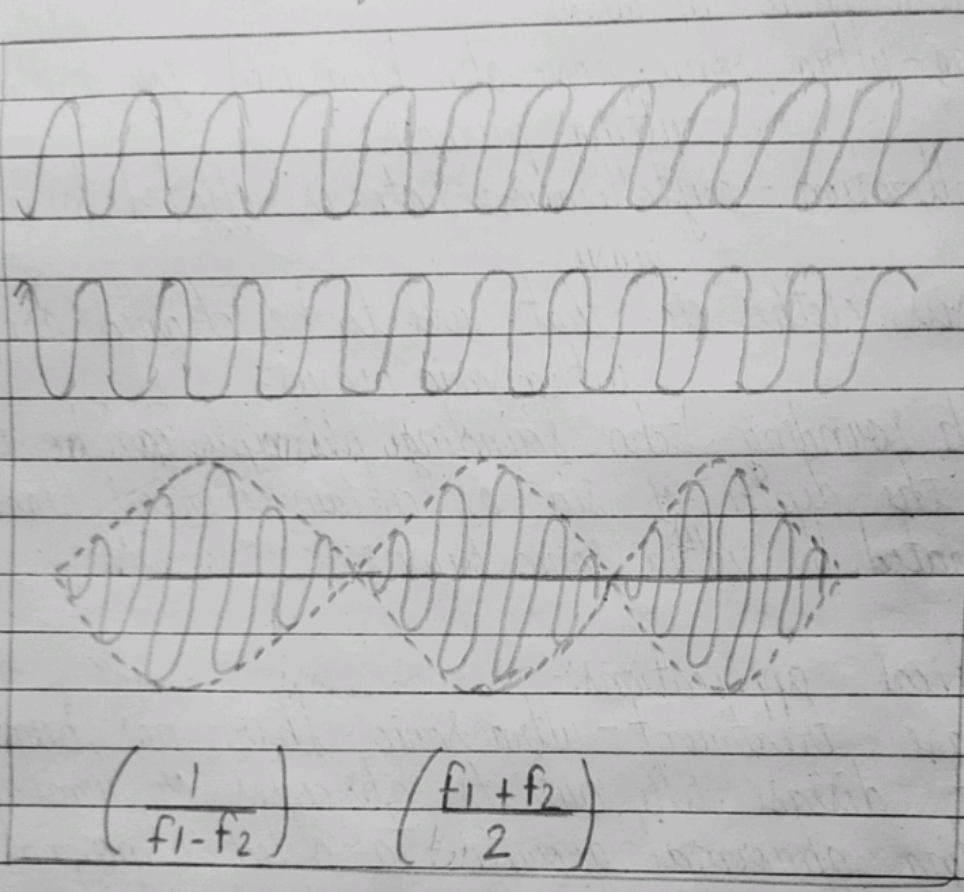
→ Engineering application:
- Soldering metals have been soldered or brand by subjecting them to ultra-sonic vibrations.
- Drilling - ultra sonic have also been used for drilling or metal cutting purpose.
- Crystallization - crystallisation rate is effected by ultra sonic waves.
- Utensils, clothes etc. that have to be cleaned are subjects to ultra sonic waves.
- Depth sounding. Echo sounding principle can be used to find out the depth of sea or certain chemical reaction are accelerated by ultra sonic waves.

→ Medical applications:-
- Disease treatment - ultra sonic there has been used to treat disease like bursitis, abscesses or lumbagouts
- Locating abnormal growth - to detect abnormal growth in brain, ultra sonic waves are made incident on cribral ventricles.
- Surgicle use - surgical use of ultra sonic wave includes the splutive cutting of the tissues during on operation.
- Dental cutting - ultra sonic wave have been very useful for dental cutting almost painless.

☆ Explain beat formation:

→ Consider two waves having equal amplitudes, nearly equal wave length and slightly diffrint frequency, travelling in the same medium in the same direction, superpose on eachother to form the interfrence at the point of superposition and beats are formed. The amplitude of the resultant sound at that point rises and falls regularly.

- Due to interference of sound waves, the amplitude and intensity of the resulting sound wave increase and decrease at regular intervals at that point, which is called beat formation.



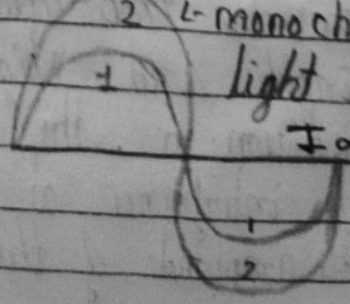
$\left(\frac{1}{f_1 - f_2}\right)$ $\left(\frac{f_1 + f_2}{2}\right)$

☆ Explain interference of light.

→ The phenomenon of interference is produced when two waves of monochromatic light is incident on a point.

- As a result amplitude is produced which is different from the orignal amplitude. The intensity of light is proportinal to the square of amplitude of the wave. As a result, the intensity of light is changed due to interference

Interference of light



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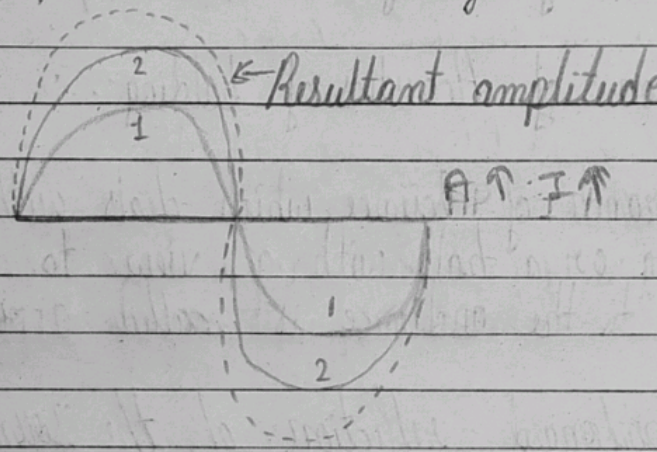
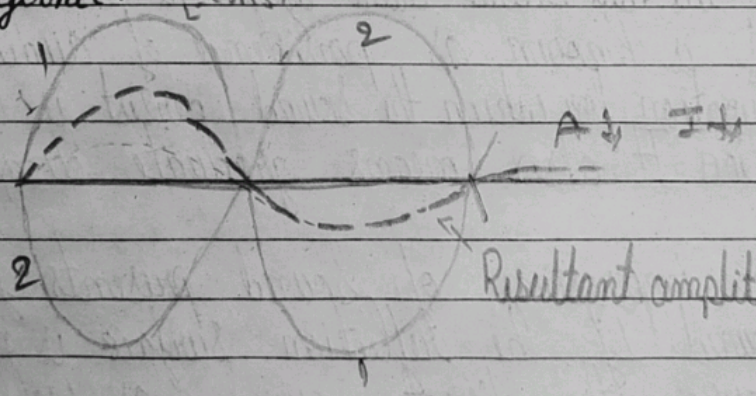
→ There are two types of interference:

(1) Constructive interference:

→ When a crest of one wave is incident on crest of another wave at a point and a through of one wave is incident on a trough of another wave at a point, the amplitude of the resultant wave increases. As a result intensity of light increases at a given incident point. This type of interference is called constructive interference.



(2) Destructive Interference:



→ When a crest of one wave is indient on a trough of another wave at the point of incident, the amplitude of the resultant wave decrease. As a result intensity of light decrease This type of interference is destuctive interference.

✱ Conditions for interference:

→ Both sources of light must have the wave length, the same amplitude and limit continous waves at the same time

- The two sources of light should be coherent

- The two sources of light

✱ Acoustics of building:

→ Definition of Acoustics of building:-

→ The branch of Science which deals with the planning of a building or a hall with a view to provide best audible sound to the audience is called acoustics of buildings.

The perlonged reflection of the sound from the object present in the hall/room even after the source producing sound is switch off is known as persistence of audible sound. Hence, the duration for which the sound persist is known as the reverberation. It also means graduate decay of sound.

The impression of sound presents for about 1/10th of a sound. If the reflection surface is not far away from the source, the direct sound as well as reflected sound wave reach the listner almost simultaneously. The time laps between two is less than 1/10th of a second, in this case the second in this case the sound is heard only once. The reflected sound mixes with the original sound.

The reverberation time of a hall should neither be too large nor too small i.e if the reverberation time of the hall is large than there is overlapping of successive sound which create confuse confusion to the listner. Hence clarity of the sound is not found

Characteristics of Acoustically good auditorium:-

1) Sound ~~en~~ energy shold be uniformly distributed in all different part of the hall.

2) It is loud enough to be heard.

3) The quality of speech or music should not be changed.

4) In the auditorium should be able to listen to the sound of equal intensity and with full live clarity.

5) Appropriate echos are needed but unnecessary echos should be avoided.

6) Reverberation time should be of appropriate value. That is, neither too big nor too small.

7) Sound should not be concentrated in one place in any part of the room.

8) All surfaces of the auditorium, walls, ceiling as well as floor should be sound proof to prevent extra noise.

9) No extra sound from outside should come inside.

10) The echelon effect should not distrub the sound. Therefore stairs steps

must be covered with carpets. pillars are covered with sound absorbing materials.

11) Resonance with in the buildings should not cause vibration.

Factors affecting Reverberation time and Acoustics of buildings:

1) Site selection :- The surroundings of the auditorium need to be quiet. It is necessary to choose a place which is far away from noisy place like highways with busy traffic, railway station, bus-stands, airports, etc.

2) Size of auditorium:-

→ The size of the auditorium should be large enough for the sound intensity to spread evenly through out the auditorium.

3) Shape:-

→ The shape of the auditorium plays a very important role in determining its acoustical quality. Side walls and ceilings have the potential to be useful as reflective surfaces.

4) Seating arrangement:-

→ The wooden seat absorbs less sound, the cushioned seat absorbs more sound. So, there must be soft and cushioned seats.

5) Adequately opened windows should be kept in the auditorium Sound energy can escaping from an open window causes minimal reverberation.

6) If the window cannot be kept open due to noise from outside traffic.

7) The hall should have a slope instead of Steps.

8) Loudspeakers should be placed in front of the audience at proper and different places in the auditorium.

9) The reflecting surface and their geometry be considered.

* Explain relation between frequency and periodic time :

$$f = \frac{1}{T}$$

where f = frequency
T = periodic Time

* Define : Beat

→ The phenomenon of the loudness of sound becoming maximum periodically due to the superposition of two sound waves of equal amplitude and slightly different frequencies are called beats.

* State equation for velocity of sound in air and affecting factors on it

(.) Newton's Equation for the velocity of sound :-

$V = \sqrt{B/\rho}$ or $V = \sqrt{K/\rho}$

Where B or K = Bulk modulus of the medium.
ρ = density of the medium.

→ Effecting factor on it:

(a) Laplace's correction:

→ At STP, sound wave velocity, using this formula, is obtained 332 m/s.

(b) Effect of pressure on the velocity of sound in air:

→ At a constant temperature, there will be no change in the value of sound velocity.

(c) Effect of temperature on the velocity of sound in air:

→ Velocity of sound in air is directly proportional to the square root of its absolute temperature.

(d) Effect of humidity on the velocity of sound in air:

→ $\therefore V_2 > V_1$

(.) The velocity of sound increases in the humidity in the Increases.