L.E.COLLEGE, MORBI

General Department

Sub :Engineering Physics **Sub code:_____**

Unit-4 : Acoustics and Ultasonics

Topics and Sub-topics

Acoustics:

- Characteristics of musical sound
- Loudness
- Characteristics of sound and absorption(without Sabine formula)
- Absorption coefficient
- Acoustics of buildings – Factors affecting building and their remedies

Ultrasonic

- Production: Magnetostriction and piezoelectric methods
- Applications : SONAR, NDT through ultrasonic, Medical Applications

Learning Outcomes

- define sound as longitudinal waves propagating in medium and classify types of sound and its properties.
- analyze Music and Noise with measurement techniques and further classifications.
- know about Ultrasound and its generation bymechanical and electrical methods.
- enumerate various methods fordetection of ultrasonic sound.
- enumerate simple application of ultrasound: detection, ranging, mechanical devices, medical fields, and ultrasonic testing methods (NDT) and its outcomes.

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What is wave?

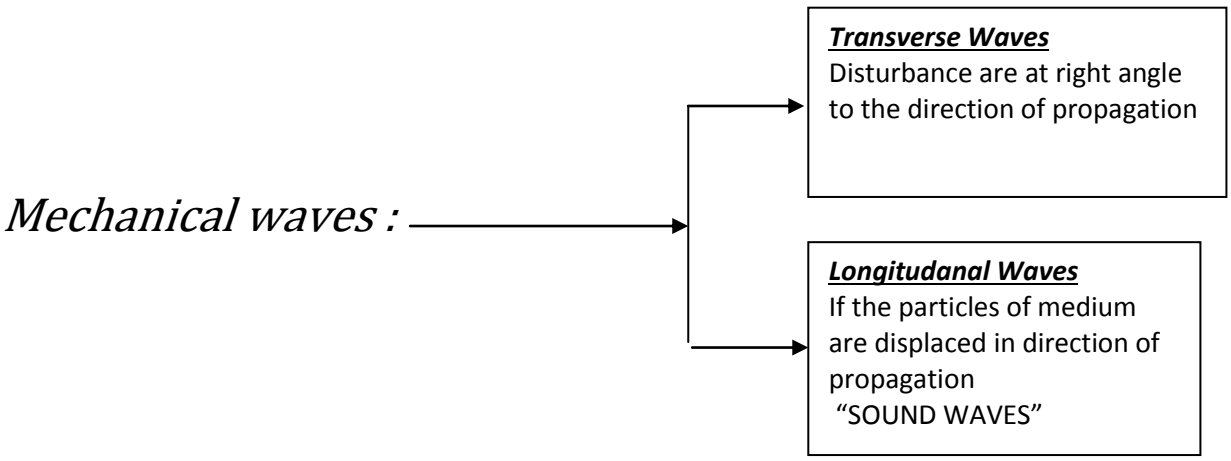
A periodic disturbance produced in a medium or a space is known as wave.

They are classified in following categories

(1)Mechanical Waves

(2)Electromagnetic Waves

(3)Matter Waves



Basics of Sound waves

Sound Waves ⟶ Mechanical Waves ⟶

"Sound is a mechanical wave that is an oscillation of pressure transmitted through some medium (like air or water), composed of frequencies within the range of hearing

Acoustics is the interdisciplinary science that deals with the study of all mechanical waves in gases, liquids, and solids including vibration, sound, ultrasound and infrasound

ACOUSTICS

- ***CLLASICFICATION OF SOUND BASED ON FREQUENCY***

Sound waves can be classified based on frequency in three groups.

1. Infrasonic sound waves (f<20 Hz)
2. Audible sound waves (20 Hz< f < 20 KHz)
3. Ultrasonic sound waves (f > 20 KHz)

- Sound waves with frequencies lying in the range of 20 Hz to 20 KHz known as *Audible sound waves*,
- Sound waves with frequency less than 20 Hz is known as *infrasonic sound waves*
- *Sound waves with frequency more than 20 KHz is known as* Ultrasonic Sound Waves

❖ ***CLLASICFICATION OF AUDIBLE SOUND WAVES***

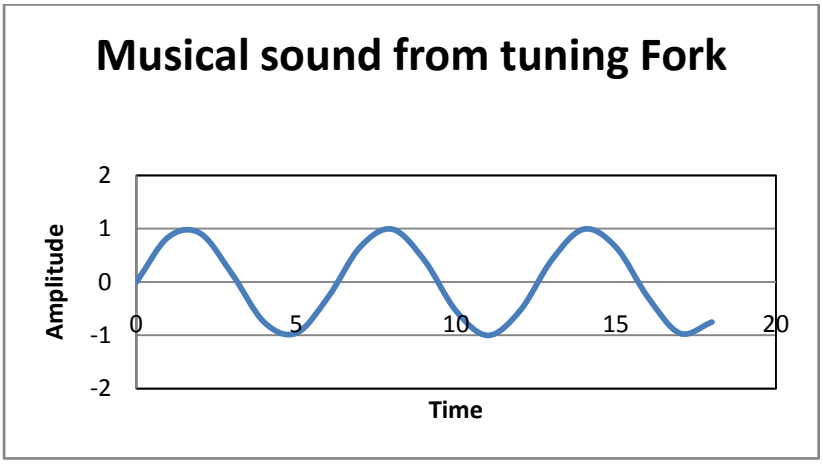
Audible Sound wave is classified into two categories

(1) Musical Sound waves
(2) Noise

Musical Sound Waves

A sound waves which produces a pleasing sensation 'on the ear' is called a ***Musical Sound waves****, this effect rises because of some special properties like periodicity, regularity, and* continuity (Amplitude, Wavelength)

E.g. guitar, violin, sitar etc. can produce pleasing effect.

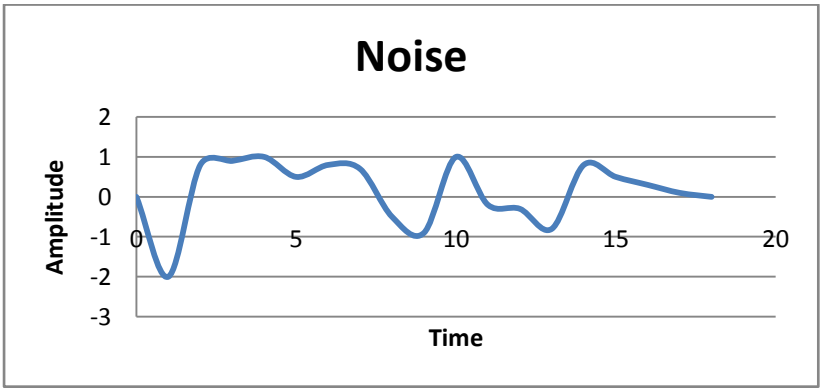


Noise

A sound which produces unpleasing sensation, or lack of characteristics of Musical Sound is known as musical sound.

A Noise has a complex nature, which has an irregular period and amplitude is called a Noise.

Sound which is not soothing to human ears.E.g. Traffic , vehicles , etc.



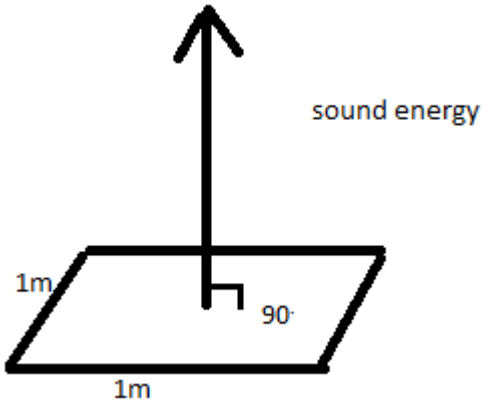
Characteristics of Musical Sound Waves

Musical Sound has three important characteristic which are as under

(1) Loudness ---Intensity,
(2) Pitch---Frequency,
(3) Timber---Quality.

(1)Loudness---Intensity

- *Loudness is characteristics of sound due to which particular sounds appear to be a feeble or Louder, which is applicable to all sounds whether classified as musical or noisy.*
- *Loudness of sound is related to the sensitivity of our ear, the sound of same loudness may appear feeble to one listener and louder to another listener.*
- *Loudness and Intensity is not a same quantity, there are very different from each other.*
- *"Quantity of sound energy crossing per unit area, in a unit time ,and area is normal to the direction of propagation.*
- *Unit of Intensity is W/m^2.*



- *There is no relation of Intensity with our hearing because our ear cannot hear Ultrasonic or Infrasonic sounds whatever their Intensity may be.*
- *Our ear cannot hear the sound of Intensity less than 10^{-12} W/m^2,which is known as Threshold of Intensity.*
- *In normal conversation, the Intensity of Sound is 10^{-6} W/m^2 .*

(2) PITCH – FREQUENCY

- *Human Ear's perception of frequency of a sound is pitch*
- *So, " Pitch is a individual experience of a particular frequency"*
- *Pitch help us in distinguishing sound of high and low frequency although the Intensity is same and its produced by a same musical Instruments.*
- *Pitch may vary depending upon the sensitivity of the human hearing.*

Low Pitch – Low freq. of vibration (Voice of Males)

High Pitch—High freq. of vibration (Voice of Females)

- *Frequency is physical quantity and can be measured accurately while pitch is physiological quantity, which depends upon listener hearing capacity.*
- *Unit of pitch is mels*
- *E.g. Two ears of same person may not perceive sound of given frequency as having same pitch.*
- *Pitch of buzzing of mosquito is higher than that of roaring of lion. (same way loudness is inverse)*

(3) TIMBER—QUALITY

- *It is a quality of sound, which enables us to distinguish between two sounds with a same loudness and pitch.*
- *It help us to distinguish the same note played on different musical instruments or sung by different singers,even though the pitch and loudness is same.*
- *It expresses our ability to recognize the sound of a violin as different from that of a guitar,even same sound is played*
- *No serious attempt has been made to establish a unit for Timber*

QUESTION:

DIFFERENCE BETWEEN LOUDNESS AND INTENSITY

LOUDNESS	*INTENSITY*
1. It is a degree of sesation produced on the ear.	*1. It is the quantity of sound energy flowing across unit area in unit time.*
2. It varies from listener to listener.	*2. It is independent of listener*
3. It is a physiological quantity	*3. It is a physical quantity*
4. Its unit is sone.	*4. Its unit is wm-2*

- *EXPLAIN WEBER-FECHNER LAW.*
  - *"Loudness is directly proportional to the logarithm of Intensity", its known as Weber-Fechner Law.*
  - *"The degree of sensation of sound is proportional to the logarithm of the stimulus producing the sound. "*

$$\therefore \quad L \propto Log(I)$$

$$\therefore L = K \cdot Log_{10}(I) \text{----------(1)}$$

Where "K" is proportionality const. and

Depends upon sensitivity of ear, quality of sound.

- *Derivation of this equation.*

$$\therefore \frac{dL}{dI} = \frac{K}{I}$$

Where dL/dI is sensitiveness of Ear, therefore sensitiveness decrease with increase of Intensity.

- *Because of Logarithmic nature," Loudness is not doubled when intensity is doubled" .*
- *Let I_1 be the initial intensity which produces loudness L_1*

$$\therefore L_1 = K \cdot Log_{10}(I_1)$$

now if the Intensity is doubled, $I_2 = (2 I_1)$,so loudness L_2 will be,

$$\therefore L_2 = K \cdot Log_{10}(I_2)$$

$$\therefore L_2 = K \cdot Log_{10}(2 I_1)$$

$$\therefore L_2 = K \cdot Log_{10}(2) + K \cdot Log_{10}(I_1)$$

$$\therefore L_2 = K \cdot Log_{10}(2) + L_1$$

$$\therefore L_2 - L_1 = K \cdot Log_{10}(2). \text{----------(2)}$$

$K \cdot Log(2)$ *is constant, eq. (2) Says that Loudness will increases with same amount whenever Intensity is doubled.*

EXPLAIN RELATIVE INTENSITY (I_L) (FOR 2 OR 3 MARKS)

Relative Intensity of sound is the logarithmic ratio of Intensity (I) to the standard Intensity (I_0).

$$\therefore I_L = K \cdot Log\left(I / I_0\right)$$

Let I and I_0 intensities of two sound waves and L_1 and L_0 be their corresponding measures of Loudness,

as per WEBER-FECHNER LAW.

$$L_1 = K \cdot Log(I)$$

$$L_2 = K \cdot Log(I_0)$$

Relative Intensity is difference of Loudness. SO,

$$\therefore I_L = L_1 - L_0 = K \cdot Log(I) - K \cdot Log(I_0)$$

$$\therefore I_L = K \cdot Log\left(I / I_0\right)$$

If K = 1,Then " I_L" expressed in unit " bel ".

Que.::

Explain the method to determine the absorption coefficient of material.

(02 march 2010) ***Or***

Explain the method to determine the absorption coefficient of material.

(02 march 2010)Or

What is the absorption coefficient? Explain how to determine the absorptioncoeffiecient. ***(03 january 2010)***

Ans.:05:

ABSORPTION COEFFICENT.

- *Absorption coefficient is a ratio of sound energy absorbed by a material to the total sound energy incident on it.*

$$\therefore \text{ Absorption Coefficient } (\alpha) = \frac{\text{Sound energy absorbed by the surface}}{\text{Total Sound Energy incident on it.}}$$

If there different materials in a hall,then the total sound absorption by the different materials is given by

$$A = a_1+a_2+a_3+a_4+\ldots\ldots\ldots\ldots\ldots$$

$$A = \alpha_1 s_1+\alpha_2 S_2+\alpha_3 S_3+\alpha_4 S_4+\ldots\ldots\ldots\ldots\ldots$$

$$A = \sum_1^n \alpha_n s_n$$

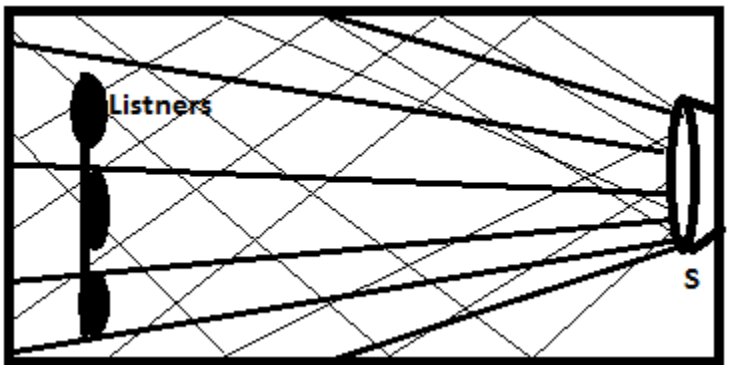
Where $\alpha_1, \alpha_2, \alpha_3, \alpha_4,$ are absorption coefficients of materials with areas S_1, S_2, S_3.

- *Sabine chose an area of $1m^2$ open window to be the standard unit of absorption. Because all the sound energy falling on it, pass through, so it can be said that sound energy is completely absorbed by it.*
- *So a unit area of open window is selected as the standard which is an "Ideal absorber of sound"*
- *Thus the unit of absorption is the **Open Window Unit**.(O.W.U.) also known as a "sabine"*

Reverberation and Reverberation Time

- *Sound produce by a source is remains for some time even after the source has stoped to produce the sound, This effect of sound waves are known as a Reverberation*
- *Person inside the room or a hall continues to receive the successive reflections of progressively decreasing Intensities.*

- *Time taken by the sound waves to fall below the minimum audibility level even after the source of sound stopped to produce it ,this time period is known as Reverberation of Time.*



Sound undergoes by a multiple reflection by walls, floor and ceiling and directly towards the listeners which produce reverberation effect.

QUE: 09 : SABINE FORMULA (02 MARKS)

SABINE'S FORMULA

- *Sabine defined the reverberation time as, the time taken by the sound intensity to fall to one millionth of its original intensity after the source stopped emitting sound.*
- *The reverberation time is given by*

$$T \propto \frac{Volume\ \ of\ the\ hall,\ \ V}{Absorption\ \ ,\ \ A}$$

$$T = \frac{K \cdot V}{A} \qquad where\ \ K\ is\ Pro.lity\ const.$$

$$T = \frac{0.167V}{\Sigma aS} \qquad where\ A = \sum_1^n \alpha_n s_n$$

Where, *V is the volume of the hall.*
A is the Total sound absorption
a is the absorption coefficient of various materials.
S is the surface area.

Que:06: ***Discuss the various factors affecting the acoustics of buildings and give their remedies. (March 2009 03 marks)***
Or
State any five factors affecting the acoustics of the building and give at least two remedies for each. (March 2009 marks 05)
Or
Give four factors which affect acoustics of building.
(June 2010 1 marks)

Or
Explain the various factors affecting the acoustics of building and give their remedies. (04 january 2010)
Or
Explain factor affecting acoustics of the building. (03 June 2009)

Ans: 06:

The various factors affecting the acoustics of building with their remedies are as under.

1. *Reverberation Time.*
2. *Loudness.*
3. *Echo.*
4. *Echelon effect.*
5. *Resonance.*
6. *Noise.*

(1) Reverberation Time

- Reverberation is the persistence of prolongation of sound in a hall even after the source stopped to produce it.

- The reverberation time is the time taken by the sound to fall below the minimum audibility level.

- In order to have a good acoustics effect, the reverberation time has to be maintained at optimum value, if the reverberation time is to small, Theloudness becomes inadequate. As a result, the sound may not reach the listener.

- Remedies

- (1) By providing window and openings.

- (2) By having full capacity of audience in the hall or room.

- (3) By using heavy curtains with folds.

- (4) By covering the floor with carpets.

- (5) By decorative the walls with beautiful pictures.

- (6) By covering the ceiling and walls with good sound absorbing material like, fiber board, roofing etc.

- The reverberation time is depends on the size of the hall and the quality of sound.

(2) Loudness

- The uniform distribution of loudness in a hall or a room is an important factor for satisfactory hearing. The loudness may get reduces due to the excess of sound absorbing materials used inside the hall or room.

Remedies

If the loudness of sound is not adequate, the loudness can be increased by adopting the following methods.

- (1) By using suitable absorbents at the place where the feel loudness to be high. As a result, the distribution of loudness becomes uniform.

- (2) By constructing low ceilings for the reflection of sound towards the listener.

- (3) By using the large sounding board behind the speaker and facing the audience.

- (4) By using public address system like loudspeakers.

(3) Echo

- An echo is heard due to reflection of sound from a distant sound reflecting object.

- If the time interval between the direct sound and reflected sound us less than 1/15th of a second, the reflected sound is helpful in increasing the loudness. But, those sounds arriving later than this cause confusion.

- Remedy

- An echo can be avoided by covering long distance walls and high ceiling with suitable sound absorbing material. This prevents the reflection of sound.

(4) Echelon effect

- It refers to the generation of a new separate sound due to multiple echo's. Any regular reflecting surface is said to produce the echelon effect. This echelon effect affects the quality of the original sound

Remedy

- The remedy to avoid echelon effect is to cover such surfaces with sound absorbing materials.

(5) Resonance

- Resonance occurs due to matching of frequency. In case, if the window panels and sections of wooden portions have not been tightly fitted they may start vibrating creating an extra sound in addition to the sound produced in the hall or room.

- Remedy

- The resonance may be avoided by fixing the window panels properly. Any other vibrating object which may produce resonance can be placed over a suitable sound absorbing material.

(6) Noise

- The hall or room should be properly insulated from external and internal noises.

- In general, there are three types of noises.

- A. airborne noise

- B. structure borne noise

- C. inside noise

- Remedies

- The hall can be made air conditioned. By using doors and windows with separate frames having proper sound insulating material between them.

REQUIRMENT OF GOOD ACOUSTICS CONDITIONS

a hall or an auditorium is said to be acoustically good if they satisfy the following conditions.

a. The quality of the sound is uniform throughout the entire hall.

b. There should not be any overlapping of sound.

c. The loudness of the sound is uniform throughout the hall.

d. The presence or absence of audience can not affect the quality of sound.

e. Resonance effect should be avoided.

f. The hall should have a proper reverberation time.

g. The external noise should not disturb quality of sound inside the hall or auditorium.

h. There should not be echelon effect.

Note: Acoustic Grating method is not added. And examples…..Thanks