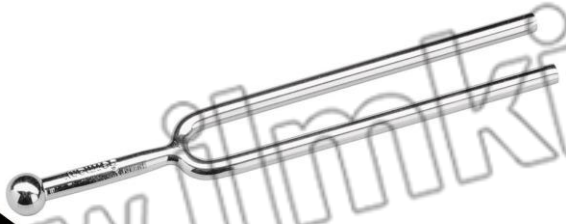


UNIT 11

SOUND

11.1 SOUND WAVES

LONG QUESTIONS

Q.1. Explain the production and sensation of sound waves with the help of an experiment. *(K.B+A.B+U.B)*

Ans: **PRODUCTION AND SENSATION OF SOUND WAVES**

Production of Sound:
Like other waves sound is also produced by vibrating bodies.

Sensation of Sound:
Due to vibration of bodies the air around them also vibrates and the air vibrations produce sensation of sound in our ear.

Examples:

- In a guitar, sound is produced due to the vibrations of its strings (As shown in Figure)
- Our voice results from the vibrations of our vocal chords.
- Human heart beats and vibrations of other organs like lungs also produce sound waves. Doctors use stethoscope to hear this sound.

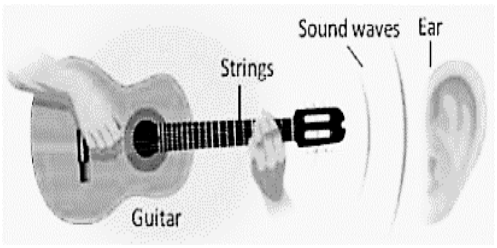


Figure: Vibrations of Guitar Strings Produce Sound Waves

Experiment:
In school laboratories, we use a device called tuning fork to produce a particular sound. If we strike the tuning fork against rubber hammer, the tuning fork will begin to vibrate (As shown in Figure). We can hear the sound produced by tuning fork by bringing it near our ear.

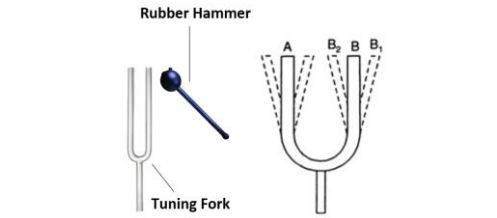


Figure: Strike a Rubber Hammer on a Tuning Fork

We can also feel the vibrations by slightly touching one of the prongs of vibrating tuning fork with a plastic ball suspended from a thread (as shown in figure). Touch the ball gently with the prong of vibrating tuning fork. The tuning fork will push the ball because of its vibrations.

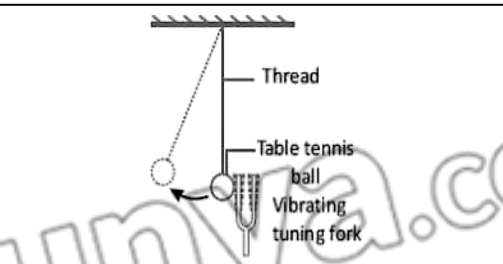


Figure: The Production of Waves from a Vibrating Tuning Fork

If we dip the vibrating tuning fork into a glass of water, we can see a water splash due to the vibrating prongs of tuning fork.

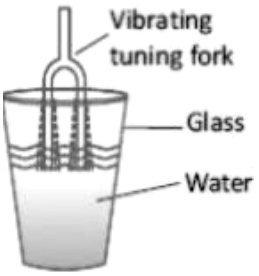


Figure: Vibrating Tuning Fork

Conclusion:

From above experiments, we can conclude that sound is produced by vibrating bodies.

Q.2. With the help of an experiment prove that sound requires material medium for its propagation. ***(U.B+A.B)*** **(Ex. Q# 11.3)** **(DGK-G1)-2015**

Ans: **SOUND REQUIRES MEDIUM FOR PROPAGATION**

Unlike light waves which are electromagnetic in nature and can also pass through vacuum, sound waves require some material medium for their propagation which are longitudinal in nature. This can be proved with the help of an experiment by using bell jar apparatus. (As shown in Figure).

Bell Jar Apparatus:

The bell jar is placed on the platform of a vacuum pump. An electric bell is suspended in the bell jar with the help of two wires connected to a power supply.

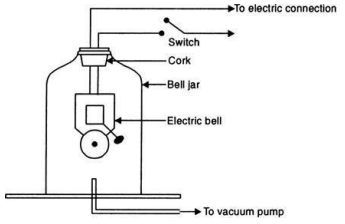


Figure: Bell Jar Apparatus

Experiment:

By switching ON the power supply, electric bell will begin to ring. We can hear the sound of the bell. Now start pumping out air from the jar by means of a vacuum pump. The sound of the bell starts becoming more and more feeble and eventually dies out, although bell is still ringing. When we put the air back into the jar we can hear the sound of the bell again.

Conclusion:

From the above experiment, we can conclude that sound waves can only travel/propagate in the presence of air (medium).

Q.3. Describe the Longitudinal nature of sound waves. ***(K.B+U.B)*** **(Ex. Q# 11.4)**

Ans: **LONGITUDINAL NATURE OF SOUND WAVES**

Propagation of sound waves produced by a vibrating tuning fork can be understood with the help of an experiment as shown in figure.

Experiment:

Before the vibration of tuning fork, density of air molecules on the right side is uniform as shown in above figure-(a). When the right prong of tuning fork moves from mean position 0 to B as shown in above Figure-(b), it exerts some pressure on the adjacent layer of air molecules and produces a **compression**.

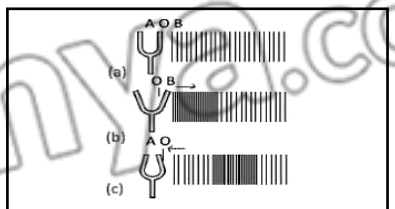


Figure: Vibrations of Tuning Fork after Striking with a Rubber Hammer

This compressed air layer in turn compresses the layer next to it and so on. A moment later, the prong begins to move from B towards A as shown in above Figure-(c). Now the pressure in the adjacent layer decreases and a **rarefaction** is produced. This rarefaction is transferred to the air layer next to it and so on. As the tuning fork moves back and forth rapidly, a series of compressions and rarefactions are created in the air. In this way, sound wave propagates through the air.

Wavelength:

"Distance between two consecutive compressions or rarefactions is called as the wavelength of sound wave**"**.

Conclusion:

From the above experiment, we can conclude that the direction of propagation of sound wave is along the direction of oscillating molecules, which shows the longitudinal nature of sound waves.

11.1 SHORT QUESTIONS

Q.1 Sound is a form of wave. List at least three reasons to support the idea that sound is a wave. ***(K.B+U.B)*** **(Ex. Q# 11.5)**

Ans: **SOUND-WAVE**

Definition:

"Sound is the form of energy that travels in the form of pressure waves from one place to another and require medium for its propagation**"**.

We know that waves manifest the phenomenon of reflection, refraction and diffraction. Since the sound can also be reflected, refracted and diffracted like other waves. This proves that they are waves.

Q.2 How sound waves are produced?

OR What do you know about the production and propagation of sound waves? What is the necessary condition for the production and propagation of sound? ***(K.B)*** **(Ex. Q# 11.1)**

(Physics of Sound Text Book Pg. # 20)

Ans: **PRODUCTION & PROPAGATION OF SOUND WAVES**

Production of Sound:

Like other waves sound is also produced by vibrating bodies.

Propagation of Sound:

Sound is a form of energy that travels/propagates in the form of waves from one place to another place in the presence of a medium.

Condition:

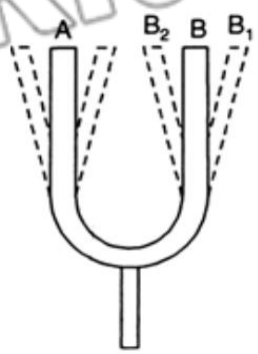
Sound require material medium for its production and propagation.

Q.3 What is tuning fork? ***(Knowledge Base)***

Ans: **TUNING FORK**

Definition:

"It is a U-shaped body having two metal prongs with a stem at the bottom and is used for producing sound of particular frequency."



Q.4 What do you know about stethoscope? OR How stethoscope works? ***(A.B)***
(For Your Information Text Book Pg. # 20)

Ans:

STETHOSCOPE

Working:

Stethoscopes operate on the transmission of sound from the chest-piece, via air-filled hollow tubes, to the listener's ears. The chest-piece usually consists of plastic disc called diaphragm. If the diaphragm is placed on the patient's body sound vibrate the diaphragm, creating acoustic pressure waves which after multiple reflection travel up the tubing to the doctor's ears.

Q.5 If we dip a vibrating tuning fork into a glass of water, we will see a splash. What does make the water splash? ***(A.B)***

Ans: *Given on Page# 40*

Q.6 Define the wavelength of sound wave. OR How will you define wavelength in the case of longitudinal waves (sound waves)? ***(K.B)***

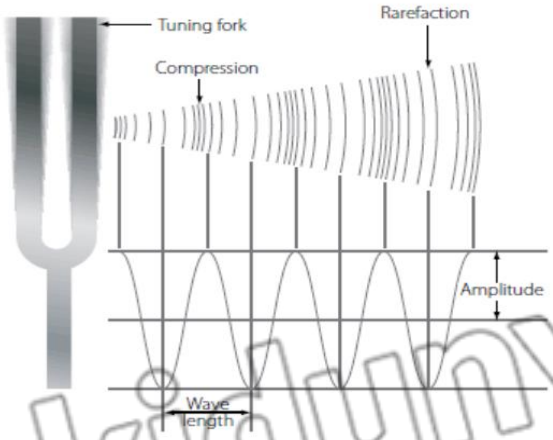
Ans: *Given on Page# 41*

Q.7 With the help of wave form illustrate the longitudinal nature of sound waves formed by the vibrating tuning fork. Also define the compressions and rarefactions.
(K.B+U.B) ***(Physics Insight Text Book Pg. 22)***

Ans:

WAVE FORM

In the figure given below waveform illustrate the longitudinal nature of wave formed by vibrating tuning fork in the air.



COMPRESSIONS

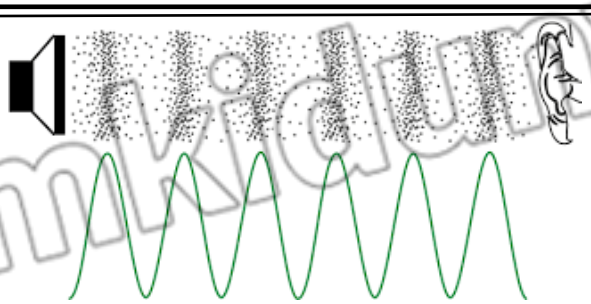
Definition:

"Compressions are places where air pressure is slightly higher than the surrounding air pressure due to high density of air particles."

RAREFACTIONS

Definition:

"Rarefactions are the regions that correspond to low air pressure due to low density of air particles."



Q.8 Identify which part of these musical instruments vibrates to produce sound. ***(U.B+A.B)***

• Electric bell • Loud speaker • Piano • Violin • Flute

(Quick Quiz Text Book Pg. # 22)

Ans:

VIBRATING PART OF ELECTRIC BELL

When the switch is pressed. Due to the movement of armature, the hammer vibrates and strikes the gong so the bell rings. As a result, the hammer vibrates and the bell continuous to ring as long as the push button/switch is pressed.

VIBRATING PART OF LOUD SPEAKER

The most basic sound in the loud speaker can be produced by vibration of speaker's diaphragm in and out at a single frequency. The speaker cone moves very fast in and out which causes vibrations in the air. Those vibrations are picked up by our ears.

VIBRATING PART OF PIANO

A piano has strings which are struck by the small "hammers" when you press the keys. The strings vibrate and create the sound, which is amplified by the sound board.

VIBRATING PART OF VIOLIN

When we touch the strings of violin, they vibrate, effecting all the molecules in the area around these strings. These vibrations produce the sound.

VIBRATING PART OF FLUTE

Flute is a hollow pipe. When the air is blown over its mouth, the air inside the pipe set into vibrations. As a result, a pleasant sound is produced.

Q.8 Explain how sound is produced by a school bell? ***(U.B)***

(Self-Assessment Text Book Pg. # 22)

Ans:

PRODUCTION OF SOUND BY A SCHOOL BELL

When the school bell is struck by the hammer, due to vibration of the medium particles of the air around it also vibrates and the air vibrations produce sensation of sound in our ear.

Q.9 Why are sound waves called, the mechanical waves? ***(K.B)***

(Self-Assessment Text Book Pg. # 22) / (RWP-G2)-2016 / (SWL-G2)-2017

Ans:

SOUND WAVES ARE MECHANICAL WAVES

Sound waves require a medium for their propagation and they cannot travel in vacuum. When sound waves pass through a medium (air), the particles of medium vibrate back and forth along the direction of propagation of sound wave so that, sound waves are longitudinal in nature. That is why sound waves are called mechanical waves.

Q.10 Suppose you and your friend are on Moon. Will you be able to hear any sound produced by your friend? ***(K.B)*** **(Self-Assessment Text Book Pg. # 22)**

Ans:

NO SOUND ON MOON

As there is no air on Moon, and the vacuum has no molecules to carry vibration. So that we will not be able to hear any sound produced by our friend on Moon.

Q.11 On what factors do the frequency of tuning fork depend? ***(K.B)*** **(FSD-G2)-2014**

Ans: **FACTORS AFFECTING THE FREQUENCY**

Following are the factors affecting the frequency of tuning fork:

- Mass of prongs of tuning fork.
- Amplitude of prongs.
- Stiffness of material of tuning fork.

Q.12 Why medium is required for propagation of sound. ***(K.B)***

Ans: **MEDIUM FOR PROPAGATION**

Sound waves are compressional waves in nature. That is type of mechanical waves and we know that mechanical waves require medium for their propagation. So we can say material medium is necessary for the propagation of sound from one point to another. This material medium can be a gas, a liquid or a solid.

11.1 MULTIPLE CHOICE QUESTIONS

1. The study of sound is called: ***(K.B)***

(A) Acoustic (B) Optics
(C) Electrostatics (D) All of these

2. Sound is produced by: ***(K.B)***

(A) Propagation (B) Vibration
(C) Both of these (D) None of these

3. Sound can travel only in presence of: ***(K.B)***

(A) Medium (B) Vacuum
(C) Air (D) Both a and c

4. Sound waves are: ***(K.B)*** **(GRW-G1)-2013**

(A) Electromagnetic (B) Transverse
(C) Longitudinal (D) None of these

5. Sound is a form of energy: ***(K.B)***

OR Which form of energy sound is?

(MTN-G1),(FSD-G2)-2014 / (FSD-G2),(SGD-G1),(GRW-G1/G2)-2015 / (BWP-G1)-2016 / (DGK-G2),(SGD-G2),(SWL-G1),(GRW-G1),(LHR-G2),(MTN-G1)-2017

(A) Chemical (B) Thermal
(C) Electrical (D) Mechanical

6. The distance between two consecutive compressions and rarefactions is called: ***(K.B)*** **(SGD-G2)-2015**

(A) Time period (B) Frequency
(C) Wavelength (D) Focal length

7. Which is an example of longitudinal waves? ***(U.B)***

OR The example of longitudinal waves is:

(GRW-G1)-2014 / (FSD-G1),(SGD-G2),(LHR-G1)-2015 / (RWP-G2),(MTN-G1),(DGK-G1)-2016 / (DGK-G1),(RWP-G1),(MTN-G2),(DGK-G2),(SGD-G1),(BWP-G2),(SWL-G2),(GRW-G1)-2017

(A) Sound waves (B) Light waves
(C) Radio waves (D) Water waves

8. Which of these waves consist of compressions and rarefactions? ***(U.B)*** **(GRW-G1)-2016**

(A) Radio waves (B) Sound waves
(C) Television waves (D) X-Rays

11.2 CHARECTERISTICS OF SOUND

LONG QUESTIONS

Q.1 Enlist the characteristics of sound waves. Define the loudness of sound. Also describe the factors upon which it depends? *(K.B + U.B + A.B)*

(MTN-G1), (SGD-G2), (SGK-G1), (BWP-G2), (DGK-G2)-2014, (SGO-G2), (LHR-G2), (MTN-G2), (AJK-G2)-2015, (AJK-G1), (RWP-G2)-2016, (DGK-G1), (FSD-G1), (SGD-G1)-2017

Ans: **CHARACTERISTICS OF SOUND**

Sounds of different objects can be distinguished on the basis of different characteristics which are described below:

- **Loudness**
- **Pitch**
- **Quality**
- **Intensity**

LOUDNESS OF SOUND

Definition:

"Loudness is the characteristic of sound by which **loud and faint** sounds can be distinguished**"**.

Example:

When we talk to our friends, our voice is low, but when we address a public gathering our voice is loud.

Dependence:

Loudness of a sound depends upon a number of factors. Some of them are discussed below:

Amplitude of the vibrating body:

The loudness of the sound varies directly with the amplitude of the vibrating body.

Loudness $\propto$ amplitude of vibrating body.

Examples:

- The sound produced by a sitar will be loud if we pluck its wires more violently.
- When we beat a drum forcefully, the amplitude of its membrane increases and we hear a loud sound.

Area of the vibrating body:

The loudness of sound also depends upon the area of the vibrating body.

Loudness $\propto$ Area of vibrating body.

Examples:

- Sound produced by a large drum is louder than that by small one because of its large vibrating area.
- If we strike a tuning fork on a rubber pad, a feeble sound will be heard. But if the vibrating tuning fork is placed vertically on the surface of a bench, we will hear a louder sound.

Distance from the vibrating body:

Loudness of sound also depends upon the distance of the vibrating body from the listener. It is caused by the decrease in amplitude due to increase in distance.

Physical condition of the ears:

Loudness also depends upon the physical condition of the ears of the listener.

Example:

- A sound appears louder to a person with sensitive ears than to a person with defective ears.

Conclusion:

From this we can conclude that the loudness increases with the amplitude and area of the vibrating body and vice versa.

Q.2 What do you know about the pitch and quality of sound? Explain. ***(K.B + U.B + A.B)***
(FSD-G1), (GRW-G2), (DGK-G1)-2014, (FSD-G1), (DGK-G1), (SWL-G1), (SGD-G1), (BWP-G1), (MTN-G1/G2), (DGK-G2), (RWP-G2), (LHR-G1)-2016, (MTN-G1), (LHR-G1), (RWP-G2), (LHR-G2), (BWP-G1), (FSD-G2), (RWP-G2)-2017

Ans:

PITCH

Definition:

"Pitch is the characteristic of sound by which we can distinguish between a **shrill** and a **grave** sound**"**.

Dependence:

It depends upon the frequency. A higher pitch means a higher frequency and vice versa.

Pitch ∝ frequency

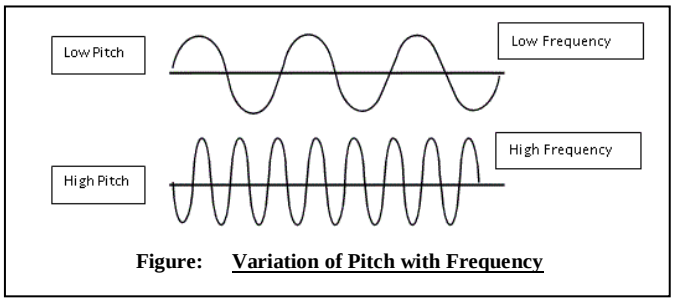


Figure: Variation of Pitch with Frequency

Frequency:

The number of vibration or cycle of vibrating body in 1 second is called its frequency. ($f = \frac{1}{T}$)

Frequency depends upon the source.

Example:

The frequency of the voice of ladies and children is higher than that of men. Therefore, the voice of ladies and children is shrill and of high pitch. The relationship between frequency and pitch is illustrated as shown in figure.

QUALITY

Definition:

"The characteristic of sound by which we can **distinguish** between two sounds of same **loudness** and **pitch** is called quality**"**.

Example:

While standing outside a room, we can distinguish between the notes of a piano and a flute being played inside the room. This is due to the difference in the quality of these notes.

Dependence:

It depends upon the waveform of the sound waves. The loudness and pitch of these two sounds are the same but their waveforms are different. So their quality is different and can be distinguished from each other

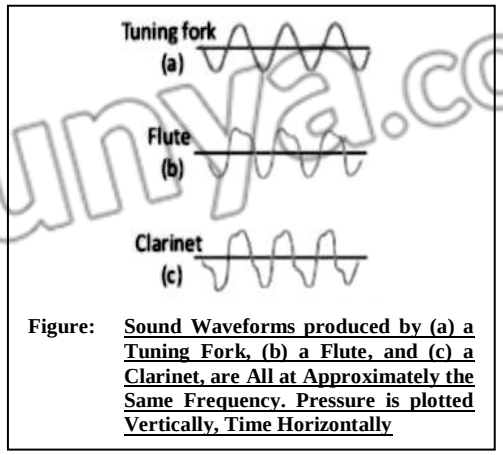


Figure: Sound Waveforms produced by (a) a Tuning Fork, (b) a Flute, and (c) a Clarinet, are All at Approximately the Same Frequency. Pressure is plotted Vertically, Time Horizontally

Wave form:

The waveform of the sound produced by a tuning fork, flute and clarinet, shown in the figure. The loudness and the pitch of these three sounds are the same but their waveforms are different. So their quality is different and they can be distinguished from each other.

Q.3 What do you know about the intensity and sound intensity level? Also derive the relationship between loudness and intensity of sound. ***(K.B + A.B + U.B)***

(DGK-G1), (RWP-G1), (BWP-G1), (GRW-G2), (BWP-G2), (LHR-G1)-2014, (RWP-G2), (BWP-G1), (AJK-G2), (LHR-G1), (DGK-G2), (SWL-G1)-2015, (SGD-G2), (DGK-G1), (RWP-G2)-2016, (FSD-G2), (DGK-G1), (LHR-G1), (GRW-G2)-2017

Ans:

INTENSITY OF SOUND

Definition:

"Sound **energy** passing per second through a unit **area** held **perpendicular** to the direction of propagation of **sound waves** is called intensity of sound**"**.

Dependence:

The intensity of sound depends on the amplitude of sound wave.

Quantity:

Intensity is a physical quantity and can be measured accurately.

Mathematical Form:

$$\textbf{Intensity} = \frac{\textbf{Energy}}{\textbf{Time} \times \textbf{Area}}$$

$$\textbf{Intensity} = \frac{\textbf{Power}}{\textbf{Area}}$$

Unit:

The unit of intensity of sound is watt per square meter (Wm^{-2}).

SOUND INTENSITY LEVEL

Definition:

"The difference $(\mathbf{L - L_o})$, between the loudness **L** of an unknown sound and the loudness $\mathbf{L_o}$ is called the intensity level of the unknown sound.

Mathematical Equation:

$$\text{Intensity level} = K \log \frac{I}{I_o}$$

Where **K** is the constant of proportionality, **I** is the intensity of unknown sound and $\mathbf{I_o}$ is the intensity of faintest audible sound.

Reference Intensity:

The human ear responds to the intensities ranging from $10^{-12} Wm^{-2}$ to more than $1Wm^{-2}$ (which is loud enough to be painful). Because the range is so wide, intensities are scaled by factors of ten. The barely audible and the faintest intensity of sound i.e., $10^{-12} Wm^{-2}$ is taken as reference intensity, called zero bel (a unit named after Alexander Graham Bell).

The loudness of a sound depends not only on the intensity of sound but also on the physical conditions of the ear. The human ear is more sensitive to some frequencies than the others.

Derivation:

By Weber Fechner Law

The loudness ***(L)*** of a sound is directly proportional to the logarithm of intensity i.e.

$$L \propto \log I$$

$$L = K \log I ...(i)$$

Where K is a constant of proportionality. Let L_o be the loudness of the faintest audible sound of intensity I_o and L be the loudness of an unknown sound of intensity I, then by Eq. (i), we can write

$$L_o = K \log I_o ...(ii)$$

Subtracting Eq. (ii) from Eq. (i), we get

$$L - L_o = K(\log I - \log I_o) = K \log \frac{I}{I_o}$$

Therefore, $$\text{Intensity level} = K \log \frac{I}{I_o} ...(iii)$$

Dependence of K:

The value of K depends not only on the units of I and I_o but also on the unit of intensity level. If intensity I of any unknown sound is 10 times greater than the intensity I_o of the faintest audible sound i.e., $I = 10I_o$ and the intensity level of such a sound is taken as unit, called bel, the value of K becomes 1.

Therefore, using K =1, Eq. (iii) becomes

$$\text{Intensity level} = \log \frac{I}{I_o} (\text{bel}) ....(\text{iv})$$

Decibel (Unit of Intensity Level):

Bel is a very large unit of intensity level of a sound. Generally, a smaller unit called decibel is used. Decibel is abbreviated as (dB). It must be remembered that 1 bel is equal to 10 dB. If the intensity level is measured in decibels, Eq. (iv) becomes

$$\text{Intensity level} = 10 \log \frac{I}{I_o} (\text{dB}) ...(\text{v})$$

Decibel Scale:

By using equation (v), we can construct a scale for measuring the intensity level of sound. Such scale is known as "decibel scale". The intensity level of different sounds in decibel is given in table below.

The decibel scale is a logarithmic measure of the amplitude of sound waves. In a logarithmic scale, equal intervals correspond to multiplying by 10. Instead of adding equal amounts.

(Table for MCQs)

Intensity Level of Different Sounds in decibel		
Sources of Sound	**Intensity (Wm^{-2})**	**Intensity Level (dB)**
Nearby jet airplane	10^3	150
Jackhammer/ fast train	10^1	130
Siren	10^0	120
Lawn mover	10^{-2}	100
Vacuum cleaner	10^{-5}	70
Mosquito buzzing`	10^{-8}	40
Whisper	10^{-9}	30
Rustling of leaves	10^{-11}	10
Faintest audible sound i.e, Threshold	10^{-12}	0

11.2 SHORT QUESTIONS

Q.1 Define loudness of sound and what are the factors which affect it? (Ex. Q# 11.8)
(SGD-G2),(SGK-G1),(BWP-G2),(MTN-G1),(DGK-G2)-2014 / (SGD-G2),(LHR-G2),(MTN-G2),AJK-G2)-2015 / (AJK-G1),(RWP-G2)-2016 / (DGK-G1),(FSD-G1),(SGD-G1)-2017

Ans: (K.B) Given on Page # 46.

Q.2 Define pitch of the sound. On which factors does it depend?
(GRW-G2)-2014 / (FSD-G1),(DGK-G1/G2),(SWL-G1)-2015 / (MTN-G1/G2),(DGK-G2),(RWP-G2)-2016 / (MTN-G1),(LHR-G1),(RWP-G2)-2017

Ans: (K.B) Given on Page # 47.

Q.3 Define the quality of sound. Upon which factors it depends?
(FSD-G1)-2014 / (FSD-G2),(RWP-G1)-2015 / (RWP-G1),(LHR-G1),(DGK-G1)-2016 / (BWP-G1),(FSD-G2),(RWP-G2)-2017

Ans: (K.B + U.B) Given on Page # 47

Q.4 What is the difference between the frequency and pitch? *(K.B)*

Ans: *(Ex. Q.# 11)*

The differences between the frequency and pitch are as follows:

Frequency	Pitch
Definition	
• The number of vibrations or cycle of vibrating body in one second is called frequency.	• Pitch is the characteristics of sound by which we can distinguish between a shrill and a grave sound.
Dependence	
• Frequency depends upon the source.	• Pitch depends upon the frequency.

Q.5 Define intensity of sound? Also write the intensity of faintest and loudest sound. ***(K.B)***
(GRW-G2),(BWP-G2)-2014 / (LHR-G1),(DGK-G2),(SWL-G1)-2015 / (SGD-G2),(DGK-G1) 2016 / (FSD-G2),(DGK-G1),(LHR-G1),(GRW-G2)-2017

Ans: *Given on Page # 48.*

Q.6 Write down the relation between loudness and intensity of a sound. (Define Weber Fechner Law) ***(K.B+U.B+A.B)*** **(Ex. Q# 11.7)**

Ans: *Given on Page # 48*

Q.7 Define intensity level or sound intensity level. ***(K.B+U.B+A.B)*** **(Ex. Q# 11.9)** **(RWP-G2)-2016**

Ans. *Given on Page # 48*

Q.8 Define SI unit of sound level (bel). ***(K.B+A.B+U.B)*** **(Ex. Q# 11.9)** **(BWP-G1)-2016**

Ans. **bel**

Definition:

"If the intensity of any unknown sound is **10** times greater than the intensity $\mathbf{I_0}$ of the faintest audible sound i.e. $\mathbf{I = 10I_0}$ then the intensity level of such sound is taken as unit, called Bel. The value of **K** becomes **1"**.

Mathematical Equation:

$$\text{Sound Level} = K \log \frac{I}{I_0} \text{ (bel)} \ldots \text{(i)}$$

By substituting K = 1, equation (i) becomes

Hence, the time period and frequency of simple pendulum will be 1.99s and 0.50 Hz

Q.9 Find sound level of sound of train (in bel and dB scale). If Intensity of sound of train (I) is $10^{-2}\,Wm^{-2}$ and intensity of faintest sound (I_o) is $10^{-12}\,Wm^{-2}$. *(A.B + U.B)*

Ans: **SOUND LEVEL OF SOUND OF TRAIN**

Solution:

Given Data:

Intensity of sound of train $= I = 10^{-12}\,Wm^{-2}$

Intensity of faintest audible sound $= I_o = 10^{-12}\,Wm^{-2}$

To Find:

(i) Sound intensity level (in Bel) $= L - L_o = ?$

(ii) Sound intensity level (in decibel) $= L - L_o = ?$

Formula:

(i) $\text{Sound level} = \log \dfrac{I}{I_o}$

(ii) $\text{Sound level} = \log \dfrac{I}{I_o}\,dB$

Calculation:

By using formula, we have

(i) $$\text{Sound level} = \log \frac{10^{-2}}{10^{-12}}(\text{bel})$$
$$= \log 10^{10} = 10(\log 10)$$
$$= 10 \times 1 = 10\ (\text{bel})$$

By using formula, we have

(ii) $$\text{Sound level} = 10 \log \frac{10^{2}}{10^{-12}}(\text{dB})$$
$$= 10 \log 10^{10} = 10 \times 10(\log 10)$$
$$= 10 \times 10 \times 1 = 100\,\text{dB}$$

Q.10 How opera singers are able to break thin glass goblet? *(K.B + A.B)*

(For your info. Text book Pg. # 23)

(RWP-G1)-2016,

Ans: **RESONANCE**

Thin-walled glass goblets can vibrate when hit by sound waves. This is due to the phenomenon of sound known as resonance. Some singers can produce a loud note of particular frequency such that it vibrates the glass so much that it shatters.

Q.11 What do you know about silent whistle? *(K.B+A.B)* (Interesting Information)

(Text book Pg. # 23) **(GRW-G2)-2017**

Ans: Some people use silent whistle to call dogs whose frequency lies between 20,000 Hz to 25,000 Hz. It is silent for human but not for dogs because the audible frequency range for dogs is much higher.

Q.12 Draw the waveforms of sound produced by the following instruments: *(K.B)*

- **Tuning fork**
- **Flute**
- **Clarinet** ***(For your info. Text book Pg. # 23)***

Ans: *Given on Page # 47*

Q.13 Why voice of women is more shrill than that of men? (BWP-G2)2017, (Quick quiz Pg. # 24)

Ans: **SHRIL VOICE OF WOMEN**

Pitch is the characteristics of sound which distinguishes between shrill and grave sound. As the pitch of sound depends on frequency. The pitch of sound of women is higher than that of men. That is why voice of women is more shrill than that of men.

Q.14 Which property of sound wave determines its: (a) loudness (b) pitch? ***(K.B)***

(Quick quiz Pg. # 24)

Ans: **DEPENDANCE OF LOUDNESS & PITCH**

The properties which determines the loudness and pitch are also the factors upon which loudness and pitch depends, these are:

Loudness:

Loudness of sound depends on:

- Amplitude of vibrating body
- Area of vibrating body
- Distance from the vibrating body

Pitch:

Pitch of sound depends upon the frequency. A higher pitch means a higher frequency and vice versa.

Q.15 What would happen to the loudness of sound with increase in its frequency? ***(K.B)***

(For your Information Text Book Pg. # 24), (Quick quiz Pg. # 24)

Ans: **RELATION BETWEEN LOUDNESS & FREQUENCY**

A sound wave with a frequency of 3500 Hz and an intensity of 80 dB sounds about twice as loud to us a as a sound of 125 Hz and 80 dB. It is because our ears are more sensitive to the 3500 Hz sound than to the 125 Hz. Therefore, intensity by itself does not mean loudness. Loudness is how our ears detects and our brain perceives the intensity of sound waves.

In terms of physics, loudness does not change with frequency, however your ear's response is not flat - it is less sensitive at low and high frequencies and most sensitive around 1kHz. So for lower and higher frequencies perceived loudness is less. That is why hifi equipment allows for boosting of bass and treble, to compensate for this.

Q.16 Frequency of tuning fork depends on which factors? ***(K.B)*** (Do you Know Text book Pg. # 24)

Ans: **FREQUENCY OF TUNING Fork**

Frequency of tuning fork depends on the mass of its prongs. The greater the mass, the lower the frequency of vibration which means the lower the pitch and vice versa.

Q.17 Prove that k = 1 when $I = 10\ I_0$ and $L - L_0 = 1$ ***(Conceptual Base + A.B)***

Ans: $\mathbf{L - L_0 = k \log \frac{I}{I_0}}$ …(i)

We know that

$I = 10\ I_0$ and $L - L_0 = 1$ Put in eq. (i)

$$\mathbf{1 = k \log \frac{10 I_0}{I_0} \Rightarrow 1 = k \log 10} \ldots(ii)$$

We know that

$\mathbf{\log 10 = 1}$ Put in eq. (ii)

$k = 1$

Q.18 Give comparison of logarithmic scale to the linear scale. ***(K.B)***

(For your info. Text book Pg. # 25)

Ans: The decibel scale is a logarithmic measure of the amplitude of sound waves. In a logarithmic scale, equal intervals correspond to multiplying by 10 instead of adding equal amounts.

Table for MCQs

Logarithmic Scale Decibels (dB)	Linear Scale Amplitude (m)
0	1
20	10
40	100
60	1,000
80	10,000
100	1000,000
120	1,000,000

11.2 MULTIPLE CHOICE QUESTIONS

1. Characteristic by which We can distinguish between two sounds of same loudness and pitch is called: ***(K.B)*** **(GRW 2013)**

(A) Loudness (B) Pitch
(C) Quality (D) Intensity of sound

2. Pitch of sound depends on: ***(K.B)*** **(BWP-G1)-2017**

(A) Amplitude (B) Frequency
(C) Time period (D) Displacement

3. Loudness of sound depends on: ***(K.B)***

(A) Amplitude of vibrating body (B) Area of vibrating body
(C) Distance of vibrating body (D) All of these

4. Which is the characteristic of sound distinguish between a shrill and a grave sound? ***(K.B)***

(A) Pitch (B) Loudness
(C) Intensity (D) Quality

5. Frequency of silent whistle lies between: ***(K.B)***

(A) 20,000Hz - 25,000Hz (B) 20,000Hz - 35,000Hz
(C) 20Hz - 20,000Hz (D) 15,000Hz - 40,000Hz

6. The intensity of sound depends on: ***(K.B)***

(A) Time period (B) Frequency
(C) Amplitude (D) None of these

7. Intensity is a quantity: ***(U.B)***

(A) Vector (B) Scalar
(C) Physical quantity (D) None of these

8. Intensity of faintest sound is: ***(K.B)***

(A) 10^{12} Wm^{-2} (B) $10^{-12}Wm^{-2}$
(C) $10^{-8}Wm^{-2}$ (D) $10^{-9}Wm^{-2}$

9. Intensity of loudest audible sound is: ***(K.B)***

(A) $10^{-12}Wm^{-2}$ (B) $1Wm^{-2}$
(C) $20Wm^{-2}$ (D) None of these

10. Intensity of whispering: *(K.B)*

(A) $10^{-5}Wm^{-2}$ (B) $10^{-8}Wm^{-2}$

(C) $10^{-9}Wm^{-2}$ (D) $10^{-12}Wm^{-2}$

11. The loudness of sound is directly proportional to logarithm of intensity, this Law is called: *(K.B+U.B)*

(A) Weber Fechner Law (B) Law of Gravitation

(C) Intensity Level (D) Echo

12. Voice of women and children as compare to men is: *(K.B)*

(A) Grave (B) Shrill

(C) Faint (D) Loud

13. I bell is equal to: *(K.B + U.B)* **(FSD-G2)-2017**

(A) 20dB (B) 10dB

(C) 100dB (D) 50dB

14. The amplitude of 100 dB sound is: *(K.B)*

(A) 1000 (B) 10,000

(C) 100,000 (D) 1001000

15. The unit of intensity of sound is: *(U.B)*

(A) Wm^{-1} (B) Wm^{-2}

(C) Wm^{-3} (D) Wm

16. Intensity of rustling of leaves is: *(K.B)*

(MTN-G2)-2014, (MTN-G2), (BWP-G2)-2016, (MTN-G2), (LHR-G1)-2017

(A) $10^{-9}\ Wm^{-2}$ (B) $10^{-10}\ Wm^{-2}$

(C) $10^{-11}Wm^{-2}$ (D) $10^{-12}\ Wm^{-2}$

17. Intensity level of train siren is: *(K.B)* **(LHR-G1)-2014, (BWP-G2), (SGD-G1), (DGK-G1)-2017**

(A) 150 dB (B) 130 dB

(C) 100 dB (D) 120 dB

Example: 11.1

Calculate the intensity levels of the (a) faintest audible sound (b) rustling of leaves. *(U.B + A.B)*

(AJK-G2)-2015 / (DGK-G2)-2016

Ans: Solution:

$$\text{Intensity level} = 10\log\frac{I}{I_o}(\text{dB})$$

(a) Intensity level of faintest audible sound can be calculated by substuting $I = I_o = 10^{-12}\ Wm^{-2}$

Therefore,

$$\text{Intensity level of faintest audible sound} = 10\log\frac{10^{-12}}{10^{-12}}\text{dB}$$

$$= 0\,\text{dB}$$

(b) As the intensity of the rustle of leaves is $I = 10^{-11}\,W\,m^{-2}$,

Therefore,

$$\text{Intensity level due to rustling of leaves} = 10\log 10^{-11}/10^{-12}\,\text{dB}$$

$$= 10\,\text{dB}$$

11.3 REFLECTION (ECHO) OF SOUND

LONG QUESTION

Q.1 Define and explain reflection (echo) of sound with the help of an experiment.

(MTN-G1)-15 / (LHR-G1)-17

Ans: **REFLECTION (ECHO) OF SOUND**

Definition:

"When sound is incident on the surface of a medium it bounces back into the first medium. This phenomenon is called reflection (echo) of sound**"**.

Example:

When we clap or shout near a reflecting surface such as a tall building or a mountain, we hear the same sound again a little later. This sound which we hear is called an echo and is a result of reflection of sound from the surface.

Explanation:

The sensation of sound persists in our brain for about 0.1s. To hear a clear echo, the time interval between our sound and the reflected sound must be at least 0.1s. If we consider speed of sound to be 340 ms^{-1} at a normal temperature in air, we will hear the echo after 0.1s.

Dependence upon Distance:

The total distance covered by the sound from the point of generation to the reflecting surface and back should be at least **340 ms^{-1}×0.1s = 34.0 m.** Thus, for hearing distinct echoes, the minimum distance of the obstacle from the source of sound must be half of this distance, that is, **17 m**. Echoes may be heard more than once due to successive or multiple reflections.

Experiment:

Take two identical plastic pipes of suitable length, as shown in figure (We can make the pipes using chart paper).

- Arrange the pipes on a table near a wall.
- Place a clock near the open end of one of the pipes and try to hear the sound of the clock through the other pipe.
- Adjust the position of the pipes so that you can hear the sound of the clock clearly.
- Now, measure the angle of incidence and angle of reflection. The echo of sound can only be heard if both the angle are equal.
- Lift the pipe on the right vertically to a small height and we will observe that the sound will start becoming fainter and finally no sound will be heard at some certain distance.

11.3 SHORT QUESTIONS

Q.1 Define reflection (ECHO) of sound? *(K.B)*

(MTN-G2)-2014 / (LHR-G1),(GRW-G1),(DGK-G2)-2015, (AJK-G1), (GRW-G1), (LHR-G1)-2016, (RWP-G2), (BWP-G1), (MTN-G2), (GRW-G2)-2017

Ans: When sound is incident on the surface of a medium it bounces back into the first medium. This phenomenon is called echo or reflection of sound.

Q.2 For how much time sound persists in our mind? Calculate the minimum distance for Echo. ***(K.B + U.B + A.B)***
(AJK-G1/G2),(BWP-G1)-2014 / (AJK-G1),(GRW-G1),(LHR-G1)-2016 / (RWP-G2),(BWP-G1),(MTN-G2),(GRW-G2)-2017

Ans.

SENSATION OF SOUND

The sensation of sound persists in our brain for about **0.1s.** to hear a clear echo, the time interval between our sound and the reflected sound must be at least **0.1s.**

MINIMUM DISTANCE FOR ECHO

Calculation:

If we consider speed of sound to be 340 ms^{-1} at a normal temperature in air, we will hear the echo after 0.1s. The total distance covered by the sound from the point of generation to the reflecting surface and back should be at least $340 ms^{-1} \times 0.1 s = 34.0 m$. Thus, for hearing distance echoes, the minimum distance of the obstacle from the source of sound must be half of this distance that is 17m. Echoes may be heard more than once due to successive or multiple reflections.

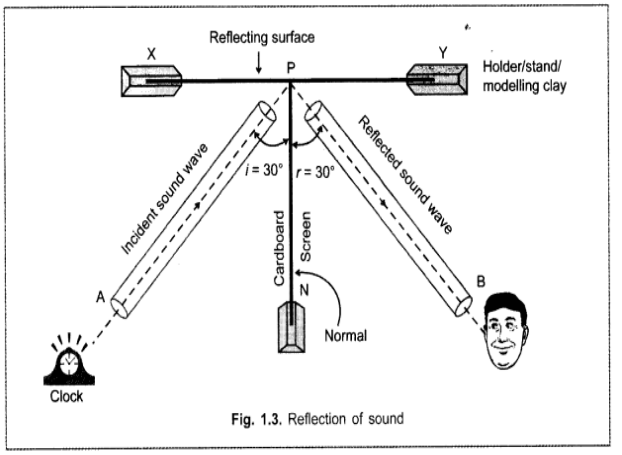


Fig. 1.3. Reflection of sound

Figure: Reflection (Echo) of Sound

Q.3 Is there any difference between echo and reflection of sound? Explain. ***(K.B)*** **(RWP-G2)-2014**

Ans:

DIFFERENTIATION

The differences between echo and reflection of sound are as follows:

Echo	Reflection of sound
• While to hear an echo the minimum distance must be **17 m** and minimum time interval must be **0.1 s.**	• Reflection can occur from any distance.

Q.4 What do you know about blue whale's rumble? ***(K.B + A.B)(Interesting Info. Text book Pg. # 26)***

Ans:

BLUE WHALE'S RUMBLE

A blue whale's **180 dB** rumble is the loudest animal sound ever recorded. Whale sound also appear to be a part of a highly evolved communication system. Some whales are thought to communicate over hundreds and may be thousands of kilometers. This is possible, in part, because sound waves travel five times faster in water than in air. In addition, the temperature characteristics of ocean water –decrease in temperature with depth-create a unique sound phenomenon.

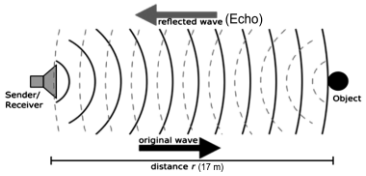


Figure: Minimum Distance for Echo

Q.5 Why do the elephants use low frequency sound waves to communicate? ***(K.B+A.B)***

(Do you know Text book Pg. # 26)

Ans: **ELEPHANTS'S SOUND FREQUENCY**

Elephants use low frequency sound waves to communicate with one another. Their large ears enable them to detect these low frequency sound waves, which have relatively long wavelengths. Elephants can effectively communicate in this way, even when they are separated by many kilometers.

Q.6 Relate the speed of sound in water with the speed of sound in air. ***(K.B)***

Ans: **SPEED OF SOUND**

Sound waves travels five times faster in water than in air, because the force of attraction between molecules of liquid is greater than gas that is why energy transferred more rapidly in liquid as compared to gas.

Q.7 How speed of sound depend upon elasticity and density of medium? ***(A.B+Conceptual)***

Ans: If the elasticity of medium increases the speed of sound also increase because speed is directly proportion to elasticity of the medium but speed of sound decreases when the density of the medium increases. That is why speed of sound is minimum in water, when the temperature of water is $+4C^{o}$ because density of water is maximum at this temperature.

11.3 MULTIPLE CHOICE QUESTIONS

1. Echo of sound is: ***(K.B)***

(A) Refraction (B) Reflection

(C) Diffraction (D) Interference

2. The sensation of sound persists in our brain about: ***(K.B)*** **(RWP-G2)-2017**

(A) 1s (B) 0.1s

(C) 0.01s (D) 2s

3. For hearing distinct echoes, the minimum distance of obstacle from source of source of sound must be: ***(K.B + U.B)***

(A) 34m (B) 17m

(C) 38m (D) 16m

4. We can see sound waves with the help of: ***(K.B)***

(A) Electroscope (B) Stroboscope

(C) Gastroscope (D) Oscilloscope

EXAMPLE 11.2

Calculate the frequency of a sound wave of speed 340 ms^{-1} and wavelength 0.5m. (*U.B + A.B)* (LHR-G1)-2015, (AJK-G1)-2016

Solution:

Given that; speed of waves $v = 340\ ms^{-1}$

Wavelength $\lambda = 0.5m$

Using the formula $v = f\lambda$

Putting the values

$$f = 340 ms^{-1} / 0.5m = 680 Hz$$

11.4 SPEED OF SOUND

LONG QUESTIONS

Q.1 Explain the speed of sound by relating the speed of sound in different media. Write down the speed of sound in air. How can we calculate the speed of sound? *(K.B + U.B + A.B) (Ex. Q# 11.2)*

SPEED OF SOUND

Sound waves can be transmitted only by any medium containing particles that can vibrate. They cannot pass through vacuum.

Relation Between Speed and Medium:

In general, the relation between the speed of the sound in solid, liquid and gas is:

Speed of sound in liquid = 5 × speed of sound in a gas (air)

Speed of sound in solid = 15 × speed of sound in a gas (air)

Speed of sound in various media is given as follows:

Speed of Sound in Various Media

Medium	Speed (ms^{-1})
Gases:	
Air (0 °C)	331
Air (25 °C)	346
Air (100 °C)	386
Hydrogen (0 °C)	1290
Oxygen (0° C)	317
Helium (0 °C)	972
Liquids at 25 °C:	
Distilled water	1498
Sea water	1531
Solids 25 °C:	
Wood	2000
Aluminum	6420
Brass	4700
Nickel	6040
Iron	5950
Steel	5960
Flint Glass	3980

(Table for MCOs)

Speed of Sound is Affected by:

The nature of the medium will affect the speed of the sound waves. The speed of sound in air is also affected by the changes in some physical conditions such as:

- temperature
- pressure
- humidity

The speed of sound in air is **343 ms^{-1}** at one atmosphere of pressure and room temperature (21°C).

Variation in speed:

The speed varies with temperature and humidity. The speed of sound in solids and liquids is faster than in air.

Mathematical Equation:

Following relation can be used to find the speed of sound:

$$v = f\lambda$$

Where v is the **speed**, *f* is the **frequency** and A is the **wavelength** of sound wave.

Q.2 How can you measure the speed of sound by Echo method?

MEASURING SPEED OF SOUND BY ECHO METHOD

Experiment:

We can measure the speed of sound with the help of an experiment by using the apparatus given below:

Apparatus:

Measuring tape, stopwatch, flat wall that can produce a good echo.

Procedure:

- Use the tape to measure a distance of 50 meters from the wall.
- Now clap your hands in front of the wall at a distance of 50 meters and check if you can clearly hear an echo from the wall. Make sure the echo is not coming from any other wall in the area. The time taken by the sound to travel 100 meters is the time difference between the clap and the echo.
- Now restart the clapping and start the stopwatch at the first clap. Count the number of claps, and stop the clapping and the stopwatch when you hear the echo of the 10th clap (say).
- Now find the average time for 10 claps. After calculating the time interval t between claps and using the formula S = vt, we can calculate the speed of the sound.

11.4 SHORT QUESTIONS

Q.1 When and how the speed of sound in air was first accurately measured?

(K.B + U.B+A.B) **(Do you know Text book Pg. # 28)**

Ans: **MEASURING SPEED OF SOUND**

The speed of sound in air was first accurately measure in 1738 by members of the French Academy. Two cannons were set up on two hills approximately 29 km apart. By measuring the time interval between the flash of a cannon and the "Boom", the speed of sound was calculated. Two cannons were fired alternatively to minimize errors due to the wind and to delayed reactions in the observes. From their observations, they deducted that sound travels ate about 336 ms^{-1} at 0^oC.

Figure: Measuring Speed of Sound by Echo Method

Q.2 Why the speed of sound is greater in solid and liquid as compared to gases. ***(Conceptual Base + A.B)***

Ans: The speed of sound is greater in solid and in liquid because the inter molecular forces in solid and liquid is greater than gases that is why the Atom and the molecule of solids and liquid are tightly arranged and they transfer sound energy more rapidly as compared to molecule of gases.

Q.3 Why sound travel faster on rainy day than on dry day? ***(Conceptual Base + A.B)***

Ans: On rainy day sound travel faster because humidity of air increases on rainy day. The density of water vapours is low as compared to the air molecules and when density decreases speed increases that is why sound move faster when the air has more water vapours.

11.4 MULTIPLE CHOICE QUESTIONS

1. The speed of sound in solid than in gases is about: *(K.B)*
(A) 5 times (B) 15 times
(C) 20 times (D) 10 times

2. The speed of sound in air at 1 atm pressure and at room temperature (21°C) is: *(K.B + U.B)*
(A) 320ms^{-1} (B) 360m/s
(C) 343ms^{-1} (D) None of these

3. The speed of sound varies with: *(K.B)*
(A) Temperature (B) Humidity
(C) Pressure (D) All of these

4. In general, the speed of sound is greater in: *(K.B)*
(A) Solids (B) Liquids
(C) Gases (D) None of these

5. The speed of sound in air was first accurately measured in: *(K.B)*
(A) 1838 (B) 1738
(C) 1638 (D) 1938

6. Formula of finding the speed of sound is: *(U.B + A.B)* **(GRW-G1)-2016**
(A) $v = f\lambda$ (B) $f = \frac{v}{\lambda}$
(C) $v = \frac{f}{\lambda}$ (D) $f = \frac{v}{\lambda}$

7. The speed of sound in air: *(K.B)* **(GRW-G2), (LHR-G2), (RWP-G2)-2014**
(A) 1246 kmh^{-1} (B) 1264 kmh^{-1}
(C) 1262 kmh^{-1} (D) 2162 kmh^{-1}

8. If speed of sound is 320 ms^{-1} , the distance covered in a time of 1.5 s will be: *(U.B + A.B)* **(RWP-G2)-2014**
(A) 408 m (B) 480 cm
(C) 480 m (D) 221 m

9. The speed of sound at 0° C is: *(K.B)*
(LHR-G2)-2015, (LHR-G1), (AJK-G1), (LHR-G1)-2016, (BWP-G1)-2017
(A) 386 ms^{-1} (B) 376 ms^{-1}
(C) 231 ms^{-1} (D) 331 ms^{-1}

10. Calculate the frequency of sound wave of speed 340 ms^{-1} and wavelength 0.5 m? *(U.B + A.B)* **(FSD-G2)-2017**
(A) 340 Hz (B) 0.5 Hz
(C) 170 Hz (D) 680 Hz

11. A doctor counts 72 heart beats in 1 minute, the frequency of heat beat is: *(U.B + A.B)*
(A) 1.2 Hz (B) 1.5 Hz
(C) 1 Hz (D) 2.1 Hz

EXAMPLE 11.3

Flash of lighting is seen 1.5 seconds earlier than the thunder. How far away is the cloud in which the flash has occurred? (speed of sound = 332 ms^{-1}) *(U.B + A.B)*
(AJK-G1)-2015 / (DGK-G1), (RWP-G1), (FSD-G1)-2016

Ans: **Solution:**
Given that, time t = 1.5 s, speed of sound v=332 ms^{-1}
Therefore, distance of the cloud S =vt = 1.5s × 332 ms^{-1}= 498 m.

11.5 NOISE POLLUTION

LONG QUESTIONS

Q.1 Define noise. Also describe the noise pollution in detail. ***(K.B + U.B + A.B)***
(Ex. Q# 11.16)

Ans:

NOISE

Definition:

"Sound which has jarring and **unpleasant effect** on our ears is called noise. Noise corresponds to **irregular** and **sudden** vibrations produced by some sounds".

Example:

- Sound of machinery
- The slamming of a door
- Sounds of traffic in big cities

NOISE POLLUTION

Definition:

"Noise become noise pollution when it exceeds from its safe level".

Sources of Noise Pollution:

Transportation equipment and heavy machinery are the main sources of noise pollution.

Example:

- Noise of machinery in industrial areas
- Loud vehicle horns
- Hooters and alarms

Major Issue:

Noise pollution has become a major issue of concern in big cities. Noise is an undesirable sound that is harmful for health of human and other species.

Effects of Noise:

Noise has negative effects on human health as it can cause conditions such as:

- hearing loss
- sleep disturbances
- aggression
- hypertension
- high stress levels
- accidents by interfering with communication and warning signals.

Safe Level of Noise:

A safe level of noise depends on two factors:

- the level (volume) of the noise
- the period of exposure to the noise.

The level of noise recommended in most countries is usually 85-90 dB over an eight-hour workday.

Methods to Reduce Noise:

Noise pollution can be reduced to acceptable level by replacing the noisy machinery with environment friendly machinery and equipment, putting sound-reducing barriers, or using hearing protection devices.

11.5 SHORT QUESTIONS

Q.1 Differentiate between musical sound and noise? ***(K.B)***
(LHR-G1), (RWP-G1)-2016 / (LHR-G2)-2015 / (SGD-G2), (FSD-G1), (RWP-G1), (DGK-G2)-2017

Ans: **DIFFERENTIATION**

The differences between musical sound and noise are as follows:

Musical Sound	Noise
Definition	
• Sound which have pleasant effect on our ears are called musical sound.	• Noise is a sound that has jarring or unpleasant sound or effect on our ears and is harmful to human or other species.
Regular / Irregular Manner	
• Frequency and amplitude of musical sounds change in a regular manner.	• Frequency and amplitude of noise change in an irregular manner.
Examples	
• Violin • Flute • Piano	• Sound of machinery • The slamming of a door

Q.2 What is meant by noise pollution? Describe its sources. ***(K.B)***

(SWL-G1)-2014 / (SGD-G2), (GRW-G2)-2016 / (SWL-G1)-2017

Ans: **NOISE POLLUTION**

Definition:

"Noise become noise pollution when it exceeds from its safe level".

Sources of Noise Pollution:

Transportation equipment and heavy machinery are the main sources of noise pollution.

Example:

- Noise of machinery in industrial areas
- Loud vehicle horns
- Hooters and alarms

Q.3 How can noise pollution be reduced? ***(K.B)*** **(SWL-G1)-2017**

Ans: **NOISE REDUCTION**

Trees and different appliances are used to **reduce** the noise.

Q.4 What are effects of noise? ***(A.B)***

Ans: *Given on Page # 61*

Q.5 What do you know about safe level of sound? ***(K.B)***

Ans: *Given on page # 61*

Q.6 What are major sources of noise in our society? ***(K.B)***

Ans: *Given on page # 61*

11.5 MULTIPLE CHOICE QUESTIONS

1. Noise correspond to: ***(K.B)***

(A) Vibration (B) Sudden vibrations
(C) Regular vibrations (D) Both (A) and (B)

2. Noise has negative effects on human health it cause except: ***(K.B)***

(A) Aggression (B) Hypertension
(C) High stress level (D) Fever/flue

3. The level of noise recommended in most countries over an eight hour workday is usually: ***(K.B)*** **(BWP-G2)-2014**

(A) 82-90 dB (B) 83-90 dB
(C) 84-90 dB (D) 85-90 dB

11.6 IMPORTANCE OF ACOUSTICS

LONG QUESTIONS

Q.1 What do you know about acoustic protection and reverberation? Also describe the methods to enhance acoustic protection? ***(K.B+A.B)***

Ans:

ACOUSTICS PROTECTION

Definition:

"The technique or method used to absorb undesirable sounds by soft and porous surfaces is called acoustic protection".

Importance:

Reflection of sound is more prominent if the surface is rigid and smooth, and less if the surface is soft and irregular. Soft, porous materials, such as draperies and rugs absorb large amount of sound energy and thus quiet echoes and softening noises.

Thus by using such material in noisy places we can reduce the level of noise pollution. However, if the surface of classrooms or public halls are too absorbent. The sound level may be low for the audience.

REVERBERATIONS

Definition:

"When sound reflects from the walls, ceiling and floor of a room, the reflecting surfaces are too reflective and the sound becomes garbled. This is due to multiple reflections called reverberations**"**.

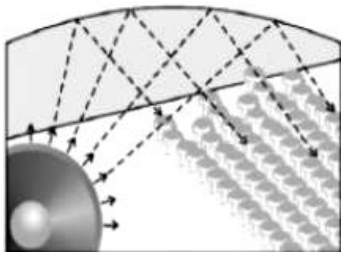


Figure: Curved Ceiling of a Conference Hall

Balance in designing of lecture halls:

In the design of lecture halls, auditorium, or theater halls, a balance must be achieved between reverberation and absorption. Sometimes reflective surfaces like sound boards are placed behind the stage and / or curved ceilings are used to reflect sound to distribute or reach all corners of hall.

METHODS

Reflective Surfaces:

It is often advantageous to place reflective surfaces behind the stage to direct sound to the audience.

Curved ceilings:

Generally, the ceilings of lecture halls, conference halls and theatre halls are curved so that sound after reflection may reach all the corners of the hall (as shown in figure).

Curved sound boards:

Sometimes curved sound boards are placed behind the stage so that sound after reflection distributed evenly across the hall (as shown in figure).

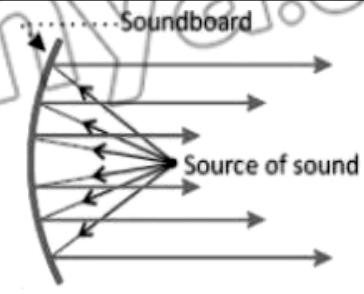


Figure: Soundboard Used in Big Hall

11.6 SHORT QUESTIONS

Q.1 Define acoustics protection and reverberations. ***(K.B)***

(SGD-G1)-2014 / (BWP-G2), (DGK-G1)-2016 / (RWP-G1), (MTN-G2)-2017

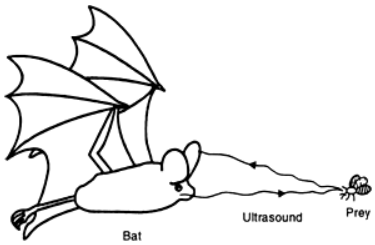
Ans. *Given on Page # 63*

Q.2 Why the phrase "blind as bat" is a false statement? ***(K.B)*** **(For your info. Text book Pg. # 30)**

Ans:

BLIND AS A BAT

The phrase "Blind as bat" is a false statement. Bats have some vision using light, but when placed in pitch-black rooms crisscrossed with fine wires, they can easily fly around and unerringly locate tiny flying insects for food. We usually assume that vision requires light but both bats and dolphins have the ability to "see" using sound waves.



Q.3 Why do pilots wear special headphones? ***(A.B)*** ***(For your info. Text book Pg. # 30)***

Ans:

SPECIAL HEADPHONES

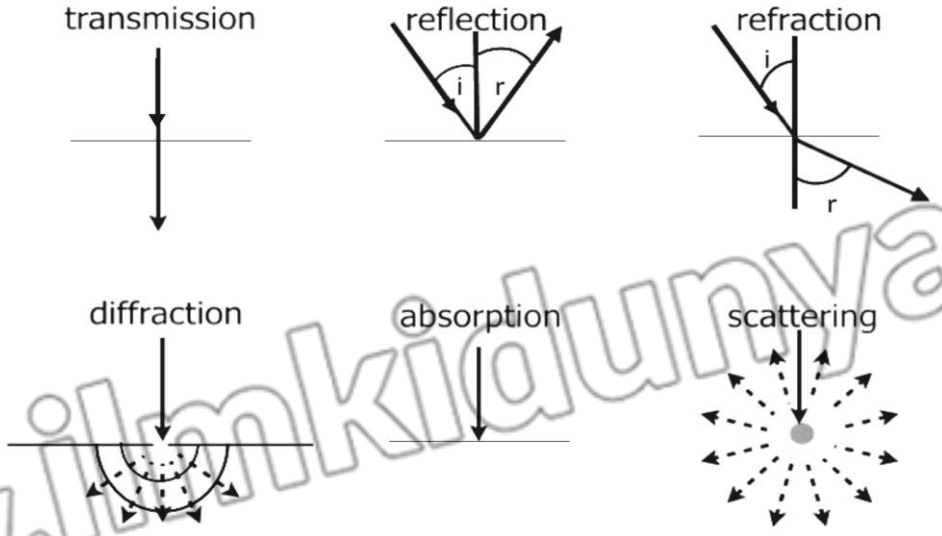
Pilots wear special headphones that reduce the roar of an airplane engine to a quite hum.

Q.4 Prove with the help of diagram that sound displays all the properties of waves. ***(K.B + U.B)***

Ans:

PROPERTIES OF SOUND WAVES

Sound displays all the properties of waves when it interacts with materials and boundaries.



Q.5 Write the advantage of acoustic protection. ***(K.B) (Ex. Q# 11.17)***

Ans:

ACOUSTIC PROTECTION

Following are the advantages of acoustic protection.

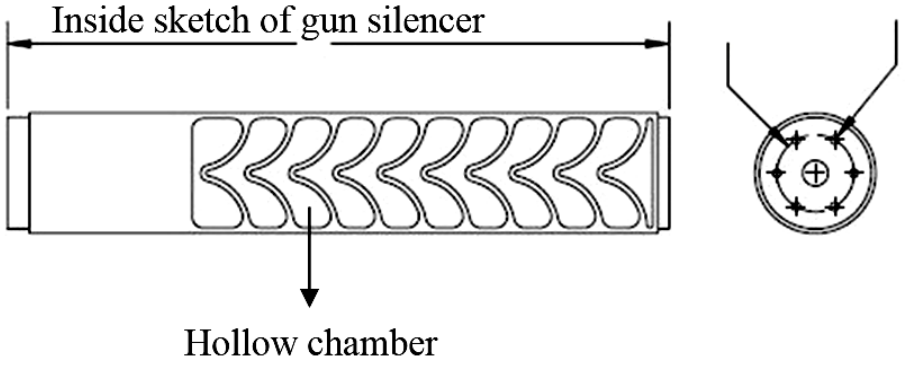
- Soft porous materials, such as draperies and rugs absorb large amount of sound energy and thus quiet echoes and softening noises. Thus by using such materials in noisy places we can reduce the level of noise pollution.

Q.6 Why balance between Reverberation and absorption is necessary in construction of classroom? ***(Conceptual Base + A.B)***

Ans: In classroom when reverberation is greater due to more reflecting surfaces the sound become garbled and when the absorption is greater due to absorbing surfaces the intensity of sound become very low. So that is why the balance is necessary.

Q.7 How does silencer reduce noise?

Ans: Both types of silencers (gun and automobile silencers) reduce noise by allowing the rapidly expanding gases from the firing of the cartridge to be decelerated and cooled through a series of hollow chambers. Silencers have a lot of hollow chambers. The trapped gas exits the suppressor over a longer period of time and at a greatly reduced speed, producing less noise signature.



11.6 MULTIPLE CHOICE QUESTIONS

1. The method used to absorb undesirable sound by soft and porous surface is called: ***(K.B)***

(A) Acoustics (B) Echos
(C) Intensity (D) Pitch

2. Multiple reflections called: ***(K.B)***

(A) Acoustics (B) Reverberations
(C) Vibration (D) All of these

3. Sound produce by flute, violin, harmonium and drum is called: ***(K.B)***

(A) Music (B) Noise
(C) Reverberation (D) Acoustic protection

4. All are the acoustic protection except: ***(K.B)***

(A) Lecture Halls (B) Auditorium
(C) Theater halls (D) Kitchen

11.7 AUDIBLE FREQUENCY RANGE

SHORT QUESTIONS

Q.1 What do you know about the audible frequency range? ***(K.B + A.B) (Ex. Q# 11.15)***
(GRW-G2), (AJK-G2), (FSD-G2)-2014 / (DGK-G1)-2015 / (GRW-G2)-2016 / (RWP-G1), (GRW-G2), (BWP-G2)-2017

Ans: **AUDIBLE FREQUENCY RANGE**

Definition:

"The range of the frequencies which a human ear can hear is called the audible frequency range".

Range:

A normal human ear can hear a sound only if its frequency lies between 20Hz and 20,000 Hz.

Explanation:

A human ear neither hears a sound of frequency less than 20 Hz nor a sound of frequency more than 20,000 Hz. Different people have different range of audibility. It also decreases with age. Young, children can hear sounds of 20,000 Hz but old people cannot hear sound even above 15,000 Hz.

Q.2 What is audible frequency range for human and why we cannot hear if sound ranges more than this range. ***(K.B + U.B)***

Ans: **AUDIBLE FREQUENCY RANGE FOR HUMAN**

A human ear can hear sound only if its frequency lies between 20 to 20000 Hz. A human ear can neither hear a sound of frequency less than 20 Hz nor a sound of frequency are more than 20,000 Hz. Sounds of frequency beyond the 20,000 Hz inaudible because the eardrum of human ear cannot vibrate so rapidly. The audible range is different for different persons and it also varies with the age. Young children can hear 20,000 Hz but old people cannot sound hear sounds above 15,000 Hz.

MULTIPLE CHOICE QUESTIONS

1. For normal person, audible frequency range lies between: ***(K.B)***
(SGD-G2)-2014 / (RWP-G1), (MTN-G1)-2016 / (LHR-G2), (GRW-G2), (SWL-G1), (SGD-G1), (FSD-G1)-2017
(A) 200Hz-2000Hz (B) 15Hz-15000Hz
(C) 20Hz-20KHz (D) 20Hz-15000Hz

2. Old people cannot hear sound even above: ***(K.B)***
(A) 20,000Hz (B) 15 KHz
(C) 15,000 Hz (D) Both (B) and (C)

3. Which bird flies easily between wires in the black room? ***(K.B)***
(A) Sparrow (B) Bat
(C) Cow (D) Parrot

4. The range of the frequency which human, ear can hear is called as: ***(K.B)***
(A) Audible frequency range (B) Ultrasonic waves
(C) Transonic waves (D) None of these

5. Bats can hear Frequencies up to 120,000Hz: ***(K.B)***
(A) 10,000Hz (B) 120,000Hz
(C) 12,00,000Hz (D) 120,00,000Hz

6. Mice can hear frequencies up to: ***(K.B)***
(A) 35,00Hz (B) 35,000Hz
(C) 45,00Hz (D) 100,000 Hz

11.8 ULTRASOUND

Q.1 What is ultrasound? Write its uses. ***(K.B + A.B)*** **(FSD-G1)-2015**

Ans:

ULTRASOUND

Definition:

"Sounds of frequency higher than 20, 000 Hz which ore Inaudible to normal human ear are called ultrasound or ultrasonic".

USES OF ULTRASOUND

Detection of Small Objects:

Ultrasonic waves carry more energy and higher frequency than audible sound waves. Therefore, according to the wave equation $v = f\lambda$, the wavelength of ultrasonic waves is very small and is very useful for detecting very small objects.

Ultrasonic are utilized in medical and technical fields as well.

USE IN MEDICAL FIELD:

Treatment of diseases in medical field:

In medical field, ultrasonic waves are used to diagnose and treat different ailments. For diagnosis of different diseases, ultrasonic waves are made to enter the human body through transmitters. These waves are reflected differently by different organs, tissues or tumors etc. The reflected waves are then amplified to form an image of the internal organs of the body on the screen (As shown in Fig.)

Figure: Doctors are taking ultrasound test of a patient with an ultrasound machine

Such an image helps in detecting the defects in these organs.

Removal of blood clots:

Powerful ultrasound is now being used to remove blood clots formed in the arteries.

Diagnosis purposes:

Ultrasound can also be used to get the pictures of thyroid gland for diagnosis purposes.

USE IN TECHNICAL FIELD:

SONAR:

Ultrasound is used to locate underwater depths or is used for locating objects lying deep on the ocean floor, etc. The technique is called SONAR, (sound navigation and ranging). The sound waves are sent from a transmitter, and a receiver collects the reflected sound (As shown in figure).

The time-lapse is calculated, knowing the speed of sound in water, the distance of the object from the ocean surface can be estimated.

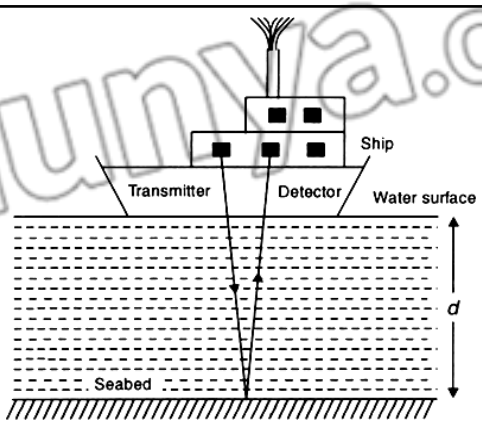


Figure: Ultrasonic are used to measure the depth of water by echo method

SONAR ranging is also used to see the shape and the size of the object.

Detection of Cracks:

Cracks appear in the interior of moving parts of high speed heavy machines such as turbines, engines of ships and airplanes due to excessive use. These cracks are not visible from outside but they can be very dangerous. Such cracks can be detected by ultrasonic. A powerful beam of ultrasound is made to pass through these defective parts. While passing, these waves are reflected by the surface of these cracks and flaws. The comparison of the ultrasonic waves reflected from cracks and from the surfaces of these parts can give a clue of the existence of the cracks.

Destroying germs and bacteria:

Germs and bacteria in liquids can also be destroyed by using high intensity ultrasonic waves.

11.8 SHORT QUESTIONS

Q.1 What are ultrasonic and why they are used in our life? ***(K.B+A.B)*** **(GRW 2013, LHR 2015)**

Ans:

ULTRASONICS / ULTRASOUND

Definition:

"Sounds of frequency higher than 20, 000 Hz which ore Inaudible to normal human ear ore called ultrasound or ultrasonic**"**.

Uses:

It has been seen that ultrasonic waves carry more energy than audible sound waves. Moreover, according to the relation $v = f\lambda$, the wavelength of ultrasonic waves is very small. Due to these characteristics they are usefully utilized in medical and technical fields.

Q.2 How we can find the depth of ocean? ***(K.B+A.B)*** **(SGD-G1), (LHR-G1), (BWP-G2)-2016**

OR What do you know about SONAR? **(SGD-G2), (MTN-G1), (DGK-G2)-2017**

Ans: *Given on Page # 67*

Q.3 Write down the maximum hearing frequency range of the following. *(K.B)*

- **Bats** • **Mice** • **Dogs** • **Cats** • **Humans**

Ans:

MAXIMUM HEARING REQUENCY

The maximum hearing frequency rage of the bats, mice, dogs, cats and humans are given as follows:

- Bats can hear frequencies upto 120000 Hz, other ani8mal cannot hear such high-pitched sounds.
- Mice can hear frequencies upto 100,000 Hz.
- Dogs can hear frequencies upto 35,000 Hz.
- Cats can hear frequencies upto 25,000 Hz.
- Humans can hear frequencies upto 20,000 Hz.

Q.4 State two uses of ultrasound in medical field. ***(K.B+A.B)*** **(Ex. Q# 11.18)**
(FSD-G1), (RWP-G1), (SWL-G2), (AJK-G1)-2014 / (FSD-G2), (BWP-G2), (RWP-G2), (AJK-G2), (SWL-G2)-2015, (BWP-G1), (MTN-G1,2), (FSD-G1), (BWP-G2)-2016 / (SGD-G1), (LHR-G1)-2017

Ans: *Given on Page # 67*

Q.5 The side effect of SONAR on blue whales? ***(K.B+A.B + Conceptual Base)***

Ans: Blue Whales are dying due to SONAR because they swim hundreds of miles rapidly changed their depth that is why the blood pressure in their veins become very high in causes bleeding from their eyes and ears. And even they beach themselves get away from the sound of SONAR. (In January 2005, 34 whales become stranded and died a long North Carolina's due to Sonar)

11.8 MULTIPLE CHOICE QUESTIONS

1. Ultrasonics are used to measure the depth of water by: ***(K.B)***

(A) Acoustics (B) Echo Method

(C) Sound Level (D) Diffraction

2. Which waves carry more energy and higher frequency than sound waves? *(K.B)*
(A) Ultrasonics (B) Infrasonic
(C) Audible sound (D) All of these

3. Ultrasonics are used to locate under-water depth the technique is called: *(K.B)*
(A) Acoustics (B) Reverb ration
(C) Sonar (D) Infrasonics

4. Sound waves with frequency less than 20Hz are called: *(K.B)*
(A) Ultrasonic (B) Infrasonics
(C) Notes (D) Acoustic

5. Ultrasound is the frequency of sound higher than: *(K.B)*
(A) 20Hz (B) 20KHz
(C) 15,000 Hz (D) 25,000 Hz

6. Infrasonic is the frequency of sound less than: *(K.B)*
(A) 20Hz (B) 20 KHz
(C) 15,000 Hz (D) 25,000 Hz

7. According to wave equation $v = f\lambda$ the wavelength of ultra-sonic waves are: *(U.B)*
(A) Very small (B) Very big
(C) Both "a" and "b" (D) None of these

8. Powerful ultrasound is now being used to remove blood clot from: *(A.B)*
(A) Capillaries (B) Arteries
(C) Convoluted tubule (D) None of these

9. By which waves small cracks can appear: *(A.B)*
(A) Ultrasonics (B) Infrasonic
(C) NOTSE (D) Sound frequency

10. By ultrasonic waves destroyed: *(A.B)*
(A) Germs (B) Bacteria
(C) Fungus (D) Both "a" and "b"

11. When the frequency of a sound wave is increased which of following decrease: *(U.B)*
(A) Wave length (B) Period
(C) Amplitude (D) Both (A) & (B)

MCQ'S ANSWER KEY (TOPIC WISE)

11.1 SOUND

1	2	3	4	5	6	7	8	9	10	11	12
A	B	B	B	D	A	B	D	D	B	C	B
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
D	A	D	A	C	D	C	A	D	C	D	B

11.2 CHARACTERISTICS OF SOUND

1	2	3	4	5	6	7	8	9	10	11	12
C	B	D	A	A	C	C	B	B	C	A	B
13	**14**	**15**	**16**	**17**							
B	C	B	C	D							

11.3 REFLECTION (ECHO) OF SOUND

1	2	3	4
B	B	B	D

11.4 SPEED OF SOUND

1	2	3	4	5	6	7	8	9	10	11
B	C	D	A	B	A	A	C	D	D	A

11.5 NOISE POLLUTION

1	2	3
D	D	D

11.6 IMPORTANCE ACOUSTICS

1	2	3	4
A	B	A	D

11.7 AUDIBLE FREQUENCY RANGE

1	2	3	4	5	6
C	C	B	A	B	D

11.8 ULTRASOUND

1	2	3	4	5	6	7	8	9	10	11
B	A	C	B	B	A	A	B	A	D	D

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

i. Which is an example of a longitudinal wave? ***(K.B)***
(GRW-G1)-2014 / (FSD-G1), (SGD-G2), (LHR-G1)-2015 / (RWP-G2), (MTN-G1), (DGK-G1)-2016 / (DGK-G1), (RWP-G1), (MTN-G2), (SGD-G1), (SGD-G1), (SWL-G1)-2017

(a) sound wave (b) light wave
(c) radio wave (d) water wave

ii. How does sound travel from its source to your ear? ***(K.B)***

(a) by changes in air pressure (b) by vibrations in wires or strings
(c) by electromagnetic wave (d) by infrared waves

iii. Which form of energy is sound? ***(K.B)*** **(Copy from Mcq. 5 Topic 11.1)**

(a) electrical (b) mechanical
(c) thermal (d) chemical

iv. Astronauts in space need to communicate with each other by radio links because: ***(K.B+A.B)*** **(SWL-G2), (RWP-G1,G2)-2017**

(a) Sound waves travel very slowly in space (b) Sound waves travel very fast in space
(c) Sound waves cannot travel in space (d) Sound waves have low frequency in space

v. The loudness of a sound is most closely related to its: ***(K.B)***

(a) Frequency (b) Period
(c) Wavelength (d) Amplitude

vi. For a normal person, audible frequency range for sound wave lies between: ***(K.B)***
(Copy from Mcq. 5 Topic 11.1)

(a) 10 Hz and 10 kHz (b) 20 Hz and 20 kHz
(c) 25 Hz and 25 kHz (d) 30 Hz and 30 kHz

vii. When the frequency of a sound wave is increased, which of the following will decrease? ***(K.B)***

i. Wavelength ii. Period iii. Amplitude

(a) i only (b) iii only
(c) i and ii only (d) i and iii only

ANSWER KEY

i	ii	iii	iv	v	vi	vii
a	a	b	c	d	b	c

REVIEW QUESTIONS

11.1. What is the necessary condition for the production of sound? ***(K.B)***

Ans: (See Topic 11.1, Short Question-4)

11.2. What is the effect of the medium on the speed of sound? In which medium sound travels faster: air, solid or liquid? Justify your answer. ***(K.B+U.B)***

Ans: (See Topic 11.4, Long Question-1)

11.3. How can you prove the mechanical nature of sound by a simple experiment? ***(K.B+U.B+A.B)***

Ans: (See Topic 11.1, Long Question-4)

11.4. What do you understand by the longitudinal wave? Describe the longitudinal nature of sound waves. ***(K.B+U.B)***

Ans: (See Topic 11.1, Long Question-4)

11.5. Sound is a form of wave. List at least three reasons to support the idea that sound is a wave. ***(K.B)***

Ans: (See Topic 11.1, Short Question-2)

11.6. We know that waves manifest phenomenon of reflection, refraction and diffraction. Does sound also manifest these characteristics? ***(K.B+U.B)***

Ans: Yes, they do manifest phenomenon of reflection, diffraction and refraction.

11.7. What is the difference between the loudness and intensity of sound? Derive the relationship between the two. ***(K.B)***

Ans: (See Topic 11.2, Short Question-5) + Definition

11.8. On what factors does the loudness of sound depend? ***(K.B)***

Ans: (See Topic 11.2, Short Question-1)

11.9. What do you mean by the term intensity level of the sound? Name and define the unit of intensity level of sound. ***(K.B+U.B+A.B)***

Ans: (See Topic 11.2, Short Question-6+7)

11.10. What is the units of loudness? Why do we use logarithmic scale to describe the range of the sound intensities we hear? *(K.B)*

Ans: **Unit of Loudness:**

Loudness is not a physical quantity, that's why it has no unit.

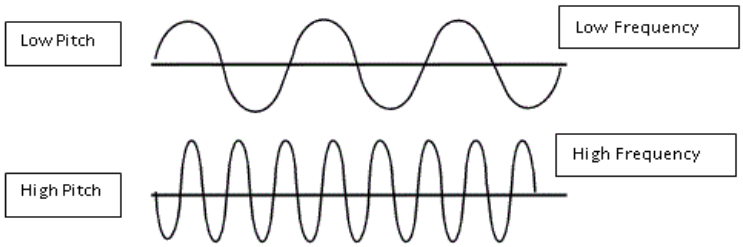
Logarithmic Scale:

We use logarithmic scale to describe the sound intensities we hear because this range is so wide.

11.11. What is the difference between frequency and pitch? Describe their relationship graphically. *(K.B)*

Ans: **DIFFERENCE**

The difference between frequency and pitch are as follows:

Frequency	Pitch
Definition	
• Number of waves passing through a point in one second is called its frequency.	• Pitch is the characteristics of sound by which we can distinguish between a shell and grave sound.
Unit	
• Its unit is Hertz (Hz).	• It has no unit.
Graph	
	

11.12. Describe the effect of change in amplitude on loudness and the effect of change in frequency on pitch of sound. *(K.B)*

Ans: **CHANGE IN AMPLITUDE:**

Loudness of sound depends upon the amplitude of vibrating body. So that, if there is an increase in the amplitude of a vibrating body there will be the increase in the loudness of sound and vice versa.

CHANGINE IN FREQUENCY:

Pitch of sound depends upon its frequency so that if there is increase in frequency there will be the increase its pitch and vise versa.

11.13. If the pitch of sound is increased, what are the changes in the following? *(U.B + A.B)*

a. The frequency **b. The wavelength**

c. The wave velocity **d. The amplitude of the wave**

Ans: According to wave equation, $v = f\lambda$, If there is an increase in the pitch of a wave then:

- frequency will increase
- wavelength will decrease

- wave velocity will increase
- amplitude of wave will remain unchanged

11.14. If we clap or speak in front of a building while standing at a particular distance, we rehear our sound after sometime. Can we explain how this happens? ***(K.B + A.B)***

Ans: It is due to reflection of sound. When sound is incident on the surface of a medium it bounces back into the first medium. This is known as reflection of sound or echo.

11.15. What is the audible frequency range for human ear? Does this range vary with the age of people? Explain. ***(K.B)***

Ans: (See Topic 11.7, Short Question-1)

11.16. Explain that noise is a nuisance. ***(K.B)***

Ans: (See Topic 11.5, Long Question-1)

11.17. Describe the importance of acoustic protection. ***(K.B)***

Ans: (See Topic 11.6, Short Question-1)

11.18. What are the uses of ultrasound in medicine? ***(A.B)***

Ans: (See Topic 11.8, Short Question-1) (In medical field)

CONCEPTUAL QUESTIONS (A.B)

11.1. Why two tin cans with a string stretched between them could be better way to communicate than merely shouting through the air?

Ans: **BETTER WAY TO COMMUNICATE**

String stretched between two tin cans could be better way to communicate than merely shouting through the air because sound waves propagate much better and faster in solids than air. Sound expands in air in all directions and communication between persons become difficult. In two tin cans and wire system, sound travel in a specific direction with greater speed than in air. So, it is a better way for communication.

11.2. We can recognize persons speaking with the same loudness from their voice. How is this possible?

Ans: **RECOGNITION OF VOICE**

We can recognize person speaking with same loudness from their voice because sound waves have different waveforms, so their quality is different and we can distinguished them from each other.

11.3. You can listen to your friend round a corner, but you cannot watch him/her. Why?

Ans: **LISTENING RATHER THAN WATCHING**

Voice can be listened around the corner because sound waves travel around obstacles, due to its very large wavelength it diffract around the corner of obstacle. We cannot watch a person around the corner because light wave cannot bend around normal sized objects due to its very small wavelength. So we can listen a friend around a corner but we cannot watch him.

11.4. Why the volume of a stereo in a room with wall-to-wall carpet is be tuned higher than in a room with a wooden floor?

Ans: **VOLUME OF STEREO IN A ROOM**

The volume of the stereo in a room with wall to wall carpet be tuned higher than in a room with wooden floor because it does not absorbs sound waves. So the loud sound is heard as compared to the room with wall to wall carpeted.

11.5. A student says that the two terms speed and frequency of the wave refer to the same thing. What is your response?

Ans: **SPEED VS FREQUENCY**

No, wave frequency is the amount of waves that you get in a single second, and the wave speed is the measure of how long it takes to travel in a given distance, so speed and frequency are two different quantities having time as common factor. Also frequency does not depend on the nature of medium but speed of sound is different in different medium.

11.6. Two people are listening to the same music at the same distance. They disagree on its loudness. Explain how this could happen.

Ans: **DIFFERENCE OF LOUDENSS AT SAME DISTNACE**

They disagree on loudness because loudness depends upon the sensitivity of the ear of the listener.

11.7. Is there any difference between echo and reflection of sound? Explain.

Ans: **ECHO AND REFLECTION OF SOUND**

The phenomenon of repetition of a sound caused by reflection of sound from a surface is called echo. For example, you shout from a valley, you hear an echo. While the reflection is the change in direction of a wave such as light or sound wave, away from a boundary.

Conditions for Echo:

To hear a clear echo, the minimum distance of obstacle and source of sound must be 17m, and the time interval between our sound and the reflected sound must be at least 0.1 s.

11.8. Will two separate 50dB sounds together constitute a100dB sound? Explain.

Ans: **CONSTITUTION OF A SOUND**

Since dB is the unit of sound level, and its value depend upon the log of intensities, therefore 50 dB sound from two bodies does not constitute 100 dB sound. Each 10 dB increase in sound makes the sound 10-times louder.

11.9. Why ultrasound is useful in medical field?

Ans:

ULTRASOUND IN MEDICAL FIELD

Ultrasound is useful in medical field because it carries more energy and higher frequency, $(v = f\lambda)$ with very small wavelengths than audible sound waves. Ultrasound due to its characteristics has vast applications in medical and in technical field.

NUMERICAL PROBLEMS (U.B+A.B)

11.1 A normal conversation sound intensity of about 3.0 x 10-6 Wm-2. What is the decibel level for this intensity? What is the intensity of the sound for 100 dB? *(A.B)*

(SGD-G2)-2015 / (GRW-G2)-2016

Solution:

(a) Given Data

Intensity of normal conversation = I = $3.0\times10^{-6}wm^{-2}$

Intensity of faintest sound = $I_o = 10^{-12}wm^{-2}$

To Find:

Intensity level = $L-L_o$ = ?

Formula:

$$L - L_o = 10 \log \frac{I}{I_o} dB$$

Calculation:

By using formula, we have

$$= 10 \log \frac{3\times10^{-6}\ \cancel{wm^{-2}}}{10^{-12}\ \cancel{wm^{-2}}} dB$$

Now intensity for 100 dB

$$L - L_o = 10\log\left(\frac{3\times10^{-6}}{10^{-12}}\right)$$

$$= 10\log\left(3\times10^{-6+12}\right)dB$$

$$= 10\log\left(3\times10^{6}\right)dB$$

$$= 10\times6.47dB$$

$$= 64.7 \text{ dB}$$

(b)

Given Data:

Intensity level L - L_o = 100 dB

Intensity of faintest sound = $I_o = 10^{-12}wm^{-2}$

To Find:

Intensity of given sound = I = ?

Formula:

$$L - L_o = 10 \log \frac{I}{I_o} dB$$

Calculation:

By using formula, we have

$$100\ \cancel{dB} = 10 \log \frac{I}{10^{-12}\ wm^{-2}}\ \cancel{dB}$$

$$\Rightarrow \quad \frac{100}{10} = \log \frac{I}{10^{-12}\ wm^{-2}}$$

$$10 = \log \frac{I}{10^{-12}}$$

$$10 = \log 10^{12} \times I$$

Taking antilog on both sides

$$\text{Antilog}10 = \text{Antilog}\left[\log\left(10^{12}\times I\right)\right]$$

$$1\times10^{10} = 10^{12} I$$

$$\frac{1\times10^{10}}{10^{12}} = I$$

$$I = 1\times10^{-2}$$

$$I = 0.01 Wm^{-2}$$

Result:

Hence, sound intensity level of normal conversation is 64.8 dB and intensity of sound for 100 dB is 0.01 Wm^{-2}

11.2 If at Anarkali bazaar Lahore, the sound level is 80 dB, what will be the intensity level of sound there?

Solution:

Given Data:

Sound level at bazar = $L - L_o = 80$ dB

Intensity of faintest audible sound

$= I_o = 10^{-12} wm^{-2}$

To Find:

Intensity of sound at Anarkali bazar = I = ?

Formula:

$$L - L_o = 10 \log \frac{I}{I_o} dB$$

Calculation:

By using formula, we have

$$80 \cancel{dB} = 10 \log \frac{I}{10^{-12}\ wm^{-2}} \cancel{dB}$$

$$\frac{80}{10} = \log \frac{I}{10^{-12}\ wm^{-2}}$$

$$8 = \log\left(10^{12} \times I\right)$$

Taking antilog on both sides

$$\text{Antilog } 8 = \text{Antilog } \left[\log\left(10^{12} \times I\right)\right]$$

$$10^8 = 10^{12} \times I$$

$$\frac{10^8}{10^{12}} = I$$

$$I = 10^{8-12}$$

$$I = 10^{-4} Wm^{-2}$$

Result:

Hence, the intensity of sound at Anarkali bazar is 10^{-4} Wm^{-2}

11.3 At a particular temperature, the speed of sound in air is $330 ms^{-1}$. If the wavelength of a note is 5cm, calculate the frequency of the sound wave. Is this frequency lies in the audible range of the human ear?

Solution:

Given Data:

Speed of sound = $v = 330\ ms^{-1}$

Wavelength = λ = 5cm

$$\lambda = \frac{5}{100} m = 0.05m$$

To Find:

Frequency = f = ?

Formula:

$v = f\lambda$

Calculation:

By wave equation,

$v = f\lambda$

$$f = \frac{v}{\lambda}$$

$$\Rightarrow = \frac{330 ms^{-1}}{0.05m}$$

$$= 6600 s^{-1} \qquad \left(\because s^{-1} = Hz\right)$$

$$f = 6.6 \times 10^3 Hz$$

$\because$ yes this frequency lies in the range of human ear

Result:

Hence, the frequency of sound wave is 6.6×10^3 Hz, which lies within the audible frequency range of human ear.

11.4 A doctor counts 72 heartbeats in 1 min. Calculate the frequency and period of the heartbeats.

Solution:

Given Data:

No of heartbeats = n = 72

Time = t = 1 min = 60sec

To Find:

Frequency = f = ?

Time period = T = ?

Solution:

We know that

$$f = \frac{n}{t}$$

$$= \frac{72}{60\,\text{sec}} \Rightarrow 1.2\,s^{-1} \qquad \left(\because s^{-1} = \text{Hz}\right)$$

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

$$= \frac{1}{1.2\,s^{-1}}$$

T = 0.833 sec.

Result:

Hence, the frequency and time period of heart beat is 1.2 Hz and 0.833 s respectively.

11.5 A marine survey ship sends a sound wave straight to the sea bed. It receives an echo 1.5s later. The speed of sound in a sea water is 1500 ms^{-1}. Find the depth of the sea at this position. (BWP-G2)-2016

Solution:

Given Data:

Time to hear echo = t = 1.5 s

Speed of sound = v = 1500ms^{-1}

To Find:

Depth of sea = h = ?

Formula:

S = v × t

Calculation:

By using formula, we have

S = vt

= (1500) (1.5)

= 2250m

For hearing echo, the minimum depth from sea bed to ship must be half of this depth (2250m)

Therefore,

$$h = \frac{S}{2}$$

$$= \frac{2250}{2} \qquad \Rightarrow \qquad h = 1125m$$

Result:

Hence, the depth of sea from a marine suwey ship is 1125 m.

11.6 A student clapped his hands near a cliff and heard the echo after 5s. What is the distance of the cliff from the student if the speed of the sound, v is taken as 346 ms^{-1}?

Given data:

Time to clear echo = t = 5s

Speed = v = 346 ms^{-1}

To Find:

Distance = d = ?

Formula:

$S = v \times t$

Calculation:

By using formula, we have

$S = vt$

$= 346 \times 5$

$S = 1730$ m

For hearing echo, the minimum distance from obstacle to the source of sound must be half of this distance (1730m).

Therefore,

$$d = \frac{S}{2}$$

$$d = \frac{1730}{2}$$

d = 865 m

Result:

Hence, the distance of different from the student to hear the echo is 865 m.

11.7 A ship sends out ultrasound that returns from the seabed and is detected after 3.42s. If the speed of ultrasound through seawater is 1531 ms^{-1}, what is the distance of the seabed from ship?

Solution:

Given data:

Time taken by sound = t = 3.42S

Speed of sound = v = 1531 ms^{-1}

To Find:

Distance of seabed from ship = d = ?

Calculation:

By using formula, we have

$S = vt$

$= 1531 \times 3.42$

$= 5236.02$ m

For hearing echo, the minimum depth of the seabed from the must be half of this distance (5236.02m)

$$d = \frac{s}{2}$$

$$d = \frac{5236.02}{2}$$

$$d = 2618m$$

Result:

Hence, the distance of seabed from ship is 2618 m.

11.8 The highest frequency sound humans can hear is about 20,000 Hz. What is the wavelength of sound in air at this frequency at temperature of 20ºC? What is the wavelength of the lowest sounds we can hear of about 20 Hz? Assume the speed of sound in air at 20º'C is 343 ms^{-1}.

Solution:

Given Data:

Highest frequency = f_1 = 20,000 Hz

Lowest frequency = f_2 = 20 Hz

Speed of sound = v = 343 ms^{-1}

To Find:

Wavelength of highest frequency = λ_1 = ?

Wavelength of lowest frequency = λ_2 = ?

Formula:

$v = f\lambda$

Calculation:

By using wave equation, we have

$v = f\lambda$

$$\Rightarrow \quad \lambda_1 = \frac{v}{f_1}$$

$$= \frac{343\,ms^{-1}}{20,000\,s^{-1}}$$

$\lambda_1 = 0.01715$ m $= 1.7 \times 10^{-2}$ m

As $V = f_2 \lambda_2$

$$\lambda_2 = \frac{v}{f_2}$$

$$\Rightarrow \quad = \frac{343 ms^{-1}}{20 s^{-1}}$$

$$= 17.15\,m$$

$$\lambda_2 = 17.2 m$$

Result:

Hence, the wavelength of highest and wavelength of lowest frequency is 1.7×10^{-2} m respectively.

11.9 A sound wave has frequency of 2 kHz and wavelength 35cm. How long will it take to travel 1.5 km? (LHR-G2)-2015 / (LHR-G1)-2016

Solution:

Given Data:

Frequency of wave = f = 2×10^3 Hz

Wavelength = λ = 35 cm = 0.35m

Distance travelled = s = 1.5 Km = 1500 m

To Find:

Time taken = t = ?

Formula:

$S = v \times t$

Calculation:

By wave equation

$V = f\lambda$

$= 2 \times 10^3$ Hz $\times$ 0.35 m

V = 700 ms^{-1}

As $S = v \times t$

1500 m = 700 ms^{-1} $\times$ t

$$t = \frac{1500\,m}{700\,ms^{-1}}$$

t = 2.1 sec

Result:

Hence, to travel 1.5 km sound wave will take 2.1 s.

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. (6×1=6)

1. Sound waves are examples of:

(A) Transverse waves (B) Electromagnetic waves
(C) Longitudinal waves (D) All of these

2. The SI unit of intensity of sound is:

(A) Wm^{-1} (B) Wm^{-2}
(C) Wms^{-1} (D) Wm^{2}

3. Pitch of sound depends upon:

(A) Frequency (B) Amplitude
(C) Intensity (D) Time period

4. The speed of sound in air is:

(A) 1264 kmh^{-1} (B) 1264 mh^{-1}
(C) 1264 kms^{-1} (D) 1264 ms^{-1}

5. Which form of energy is sound?

(A) Electrical (B) Mechanical
(C) Thermal (D) Chemical

6. After how much time the echo must be heard?

(A) 0.1 s (B) 0.10 s
(C) 0.20 s (D) 0.50 s

Q.2 Give short answers to following questions. (5×2=10)

i. What is meant by loudness of sound?
ii. What is the effect of change in frequency on the pitch of sound?
iii. What is the relation between loudness and intensity of sound?
iv. Calculate the intensity levels of the faintest audible sound.
v. What is the difference between musical sounds and noise?

Q.3 Answer the following questions in detail. (4+5=9)

a) What do you mean by sound intensity level? Derive its mathematical formula. Name and define unit of intensity level of sound.

b) A marine survey ship sends a sound wave straight to the sea bed. It receives an echo 1.5 s later. The speed of sound in sea water is 1500 ms^{-1}. Find the depth of the sea at this position.

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.