PETIT SEMINAIRE HIGHER SECONDARY SCHOOL – PUDUCHERRY

UNIT – 5 ACOUSTICS

STD: X SELF – EVALUATION

I. Choose the best answer:

1. When a sound wave travels through air, the air particles - **(a)** Vibrate along the direction of the wave motion.
2. Velocity of sound in a gaseous medium is 330 ms^{-1}. If the pressure is increased by 4 times without causing a change in the temperature, the velocity of sound in the gas - **(a)** 330 ms^{-1}. (Hint: Pressure has no effect with velocity of sound, if there is no change in temperature)
3. The frequency, which is audible to the human ear is - **(b)** 20 kHz
4. The velocity of sound in air at a particular temperature is 330 ms^{-1}. What will be its value when temperature is doubled and the pressure is halved? **(c)** 330 x √2 ms^{-1} (Hint: Pressure has no effect on velocity of sound, whereas $V \alpha \sqrt{T}$)
5. If a sound wave travels with a frequency of 1.25×10^4 Hz at 344 ms^{-1}, the wavelength will be - **(c)** 0.02752 m (Hint: $V = n\lambda$)
6. The sound waves are reflected from an obstacle into the same medium from which they were incident. Which of the following changes? - **(d)** none of these
7. Velocity of sound in the atmosphere of a planet is 500 ms^{-1}. The minimum distance between the sources of sound and the obstacle to hear the echo, should be - **(C)** 25 m

II. Fill in the blanks:

1. Rapid back and forth motion of a particle about its mean position is called Vibrational motion (or) Vibration
2. If the energy in a longitudinal wave travels from south to north, the particles of the medium would be vibrating in Both north and south
3. A whistle giving put a sound of frequency 450 Hz, approaches a stationary observer at a speed of 33 ms^{-1}. The frequency heard by the observer is 500 Hz
4. A source of sound is traveling with a velocity 40 km/h towards an observer and emits a sound of frequency 2000 Hz. If the velocity of sound is 1220 km/h, then the apparent frequency heard by the observer

is 2068 Hz (or) 2067.79 Hz

III. True or False (If false give the correct statement):

1. Sound can travel through solids, liquids, gases and even vacuum. - False

Correct statement: Sound can travel through solids, liquids, gases and cannot through vacuum.

2. Waves created by Earth quake are infrasonic - True
3. Velocity of sound is independent of temperature - False

Correct statement: Velocity of sound is dependent of temperature. V α √ T

4. The velocity of sound is high in gases than liquids. - False

Correct statement: The velocity of sound is less in gases than liquids (or) gases are less elastic than water.

IV. Match the following:

S.No	Column 1	Column 2
1	Infrasonic	10 Hz
2	Echo	Ultrasonography
3	Ultrasonic	22 kHz
4	High pressure region	compressions

V. Assertion & Reasoning:

1. Assertion: The change in air pressure affects the speed of sound.

   Reason: The speed of sound in a gas is proportional to the square of the pressure.

   (d) Assertion is false, but the reason is true.
2. Assertion: Sound travels faster in solids than in gases.

   Reason: Solid possess a greater density than that of gases.

   (b) If both the assertion and the reason are true but the reason is not the correct explanation of the assertion.

VI. Answer very briefly:

1. What is a longitudinal wave?

   Sound waves are longitudinal waves that can travel through any medium (solids, liquids and gases) with a speed that depends on the properties of the medium. These are the waves in which the particle of the medium vibrates along the direction of propagation of the wave.

2. What is the audible range of frequency?

   These are sound waves with a frequency ranging between 20 Hz and 20,000 Hz

3. What is the minimum distance needed for an echo?

   The minimum distance required to hear an echo is $1/20^{th}$ part of the magnitude of the velocity of sound in air. The minimum distance required to hear an echo is 17.2 m.

4. What will be the frequency sound having 0.20 m as its wavelength, when it travels with a speed of 331 $ms^{-1?}$

   $$n = \frac{v}{\lambda} = \frac{331}{0.20} = 1655 \text{ Hz.}$$

5. Name three animals, which can hear ultrasonic vibrations.

   Mosquito, Dogs, Dolphin and Bats

VII. Answer briefly:

1. Why does sound travels faster on rainy day than on a dry day?

   The speed of sound will increase with increase in the humidity in the air because the speed of the sound is inversely proportional to square root of the density of the air and the moisture content is more in the atmosphere. So sound travels faster on a rainy day.

2. Why does an empty vessel produce more sound than a filled one?

   - The intensity of sound is directly proportional to the square of amplitude of vibration.
   - When empty vessel is struck, the air molecules are set in vibration and when filled vessel is struck the liquid molecules are set in vibrations.
   - Due to the multiple reflections, the reflected sound waves are focused at all focuses of curved surfaces.
   - Since, the amplitude of vibration of air molecules is greater than liquid molecules; therefore empty vessel produces louder sound than the filled vessel.

3. Air temperature in the Rajasthan desert can reach 46°C. What is the velocity of sound in air at that temperature?

   $V_T = (V_0 + 0.61\ T)$

   $T = 46°C$; $V_0 = 331\ ms^{-1}$

   $V_T = 331 + (0.61 \times 46) = 331 + 28.06 = 359.06\ ms^{-1}$

4. Explain why, the ceilings of concert halls are curved.
   - In elliptical surfaces, sound from one focus will always be reflected to the other focus, no matter where it strikes the wall.
   - The ceilings of concrete halls are made curved so that sound after reflection from the ceiling reaches all the parts of the hall.
   - A curved ceiling actually acts like a large concave sound board and reflects sound down onto the audience sitting in the hall.
   - Sound boards work on the multiple reflection of sound.
5. Mention two cases in which there is no Doppler effect in sound?
   - When source (S) and listener (L) both are at rest.
   - When S and L move in such a way that distance between them remains constant.
   - When source S and L are moving in mutually perpendicular directions.
   - If the source is situated at the center of the circle along which the listener is moving.

VIII. Problem corner:

1. $n = 200\ Hz$; $V = 400\ ms^{-1}$

$\lambda = ?$

$V = n\lambda$

$\lambda = \frac{V}{n} = \frac{400}{200} = 2m$

$\boxed{\lambda = 2m}$

2. $t = 9.8\ s$; $c = 330\ ms^{-1}$

$d = ?$

$c = \frac{d}{t}$

$d = c \times t = 330 \times 9.8$

$\boxed{d = 3234\ m}$

4. $2t = 1.6\ s$, $V = 1400\ ms^{-1}$

$t = \frac{1.6}{2} = 0.8\ s$

Depth $(d) = V \times t = 1400 \times 0.8$

$\boxed{\text{Depth } (d) = 1120\ m}$

3. $n = 600\ Hz$; $T = ?$

$T = \frac{1}{n} = \frac{1}{600}$

$T = 0.00166\ s$

$T = 1.66 \times 10^{-3}\ s$ (or)

$\boxed{T = 1.7 \times 10^{-3}\ s}$

5. $d = 680\ m$; $t_1 = 0.9\ s$; $t_2 = 1.1\ s$

$d_1 = \frac{V \times t_1}{2}$ — ① $\left[\because t_1 = \frac{t}{2}\right]$

$d_2 = \frac{V \times t_2}{2}$ — ②

① + ②

$d_1 + d_2 = \frac{V \times t_1}{2} + \frac{V \times t_2}{2}$

$d = d_1 + d_2$

$\therefore d = \frac{V(t_1 + t_2)}{2}$

$V = \frac{2d}{(t_1 + t_2)} = \frac{2 \times 680}{(0.9 + 1.1)}$

$V = \frac{1360}{2} = 680\ ms^{-1}$

$\boxed{V = 680\ ms^{-1}}$

6. $d = 4.5\ km = 4500\ m$; $t = 3\ s$

$s = \frac{d}{t} = \frac{4500}{3}$

$\boxed{s = 1500\ ms^{-1}}$

$\therefore$ Speed of sound $= 1500\ ms^{-1}$

7. Depth = velocity × time

$V = 1450\ m/s$; $2t = 1\ s$

$t = 0.5\ s$

Depth $= 1450 \times 0.5$

$\boxed{d = 725\ m}$

IX. Answer in detail:

1. What are the factors that affect the speed of sound in gases?

   The following factors affect the velocity of sound waves.

   Effect of density:

   The velocity of sound in a gas is inversely proportional to the square root of the density of the gas. Hence, the velocity decreases as the density of the gas increa

   $$v \propto \sqrt{\frac{T}{d}}$$

   Effect of temperature:

   The velocity of sound in a gas is directly proportional to the square root of its temperature. The velocity of sound in a gas increase with the increase in temperature. V α √T.

   Velocity at temperature T is given by the following equation:

   $$V_T = (V_0 + 0.61\ T)\ ms^{-1}$$

   Here, V_0 is the velocity of sound in the gas at 0°C. for air, V_o = 331 ms^{-1}. Hence the velocity of sound changes by 0.61 ms^{-1}. When the temperature changes by one degree Celsius.

   Effect of relative humidity:

   When humidity increases, the speed of sound increases. That is why you can hear sound from long distances clearly during rainy seasons.

2. What is mean by reflection of sound? Explain:

   a) Reflection at the boundary of a rarer medium

   b) Reflection at the boundary of a denser medium

   c) Reflection at curved surfaces

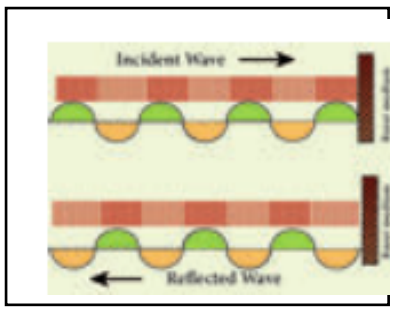
   Reflection of Sound:

   Sound travels in a given medium, it strikes the surface of another medium and bounces back in some other directions, this phenomenon is called the reflection of sound.

   a) Reflection at the boundary of a rarer medium:

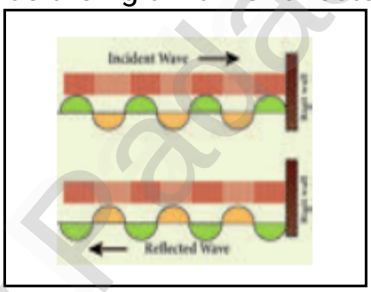
   - A wave travelling in a solid medium striking on the interface between the solid and the air. The compression exerts a force F on the surface of the rarer medium.
   - As a rarer medium has smaller resistance for any deformation, the surface of separation is pushed backwards.

- As the particles of the rarer medium are free to move, a rarefaction is produced at the interface. Thus, a compression is reflected as a rarefaction and a rarefaction travels from right to left.



b) Reflection at the boundary of a denser medium:

- A longitudinal wave travels in a medium in the form of a compression and rarefaction. Suppose a compression travelling in air from left to right reach a rigid wall.
- The compression exerts a force F on the rigid wall. In turn, the wall exerts an equal and opposite reaction R = -F on the air molecules. This results in a compression near the rigid wall. Thus, a compression travelling towards the rigid wall is reflected back as a compression.



c) Reflection at curved surface:

- The sound waves are reflected from the curved surfaces, the intensity of the reflected waves is changed.
- Sound is reflected from a convex surface, the reflected waves are diverged out and the intensity is decreased.
- Sound is reflected from a concave surface; the reflected waves are converged and focused at a point. Therefore, the intensity of reflected waves is concentrated at a point.

3. a) What do you understand by the term 'ultrasonic vibration'?

   b) State three uses of ultrasonic vibrations.

   c) Name three animals which can hear ultrasonic vibrations.

   a) These are sound waves with a frequency greater than 20 kHz. Human ear cannot detect this wave.

   b) Uses:

   - Used in SONAR to measure the depth of sea and to locate under water object.
   - Used for scanning and imaging the position of stones in the gall bladder and kidney.
   - To make an image of a person's internal body structure.

   c) Mosquito, Dogs, Dolphin and Bats.

4. What is an echo?

   a) State two conditions necessary for hearing an echo.

   b) What are the medical applications of echo?

   c)How can you calculate the speed of sound using echo?

   Echo:

   An echo is the sound reproduced due to the reflection of the original sound from various rigid surfaces such as walls, ceilings, surfaces of mountains, etc.

   a) Two conditions:

   - The minimum time gap between the original sound and an echo must be 0.1 s.
   - The minimum distance required to hear an echo is $1/20^{th}$ part of the magnitude of the velocity of sound in air. The minimum distance required to hear an echo is 17.2 m.

   b) Echo is used in obstetric ultrasonography, which is used to create real – time visual images of the developing embryo or fetus in the mother's uterus. This is a safe testing tool, as it does not use any harmful radiations.

c) Calculation of speed of sound:

The sound pulse emitted by the source travels a total distance of 2d while travelling from the source to the wall and then back to the receiver. The time taken for this has been observed to be 't'. Hence, the speed of sound wave is given by:

$$\text{Speed of sound} = \frac{\text{distance travelled}}{\text{time taken}} = \frac{2d}{t}$$

X. HOTs questions:

1. Suppose that a sound wave and a light wave have the same frequency, then which one has a longer wavelength?

   a) sound b) light c) both a and b d) data not sufficient

   b) Light

   $V = n \lambda$.

   If 'n' is equal in both sound and light. $\lambda \alpha V$.

   Velocity of light is greater than sound. Therefore, Light has longer wavelength.

2. When sound is reflected from a distant object, an echo is produced. Let the distance between the reflecting surface and the source of sound remain the same, Do you hear an echo sound on a hotter day? Justify your answer.

   No, because the temperature increase during hotter day. So the velocity of sound increases. It come back after reflection earlier than 0.1 s. however, condition for echo, the minimum time gap between the original sound and an echo must be 0.1 s.