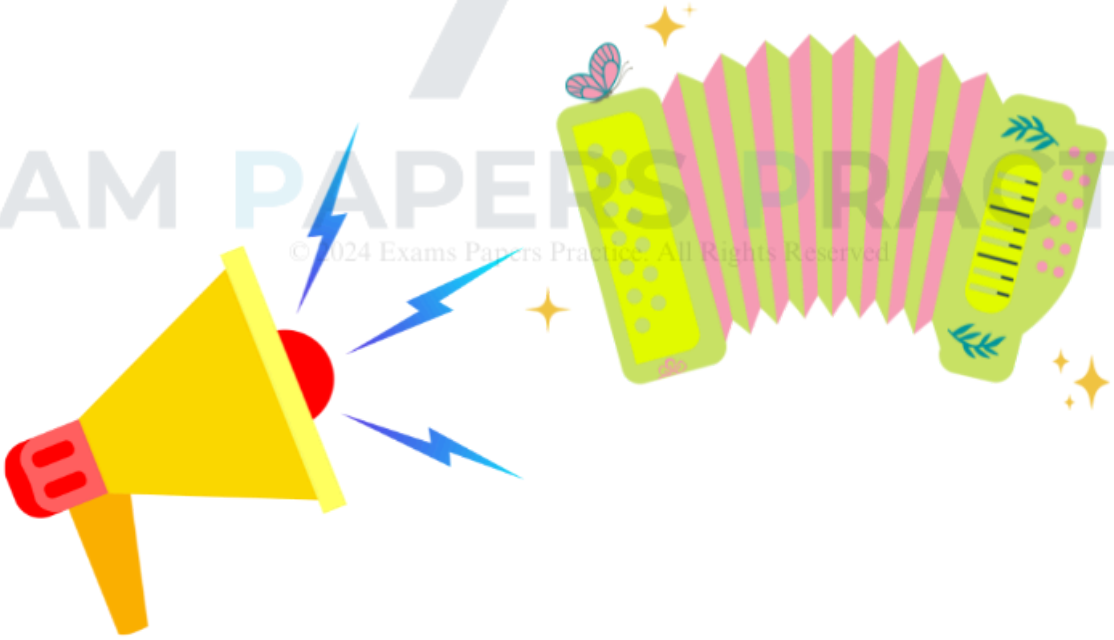
Chapter 12
Sound



Getting started activity (5 minutes): Discussion

Questions	Your thoughts
How are sounds made?	
How does sound travel?	
How fast is sound?	
How do we detect sound?	
How do sounds differ from each other	
Are there sound we cannot hear	

12.1 Making sounds

12.1.1 What makes sound?

1. Sound originates from vibrations.
2. Vibrating sources create vibrations in the surrounding air.
3. These vibrations travel through the air to our ears, causing the eardrum to vibrate and enabling us to perceive sound. The air particles themselves do not move significantly; they merely transmit the vibrations as a medium.
4. Examples:
   a. Striking a gong with a hammer causes it to vibrate.
   b. Vocal folds in the human throat vibrate to produce speech.

12.1.2 Musical sound

1. **String Instruments**
    a. String instruments produce sound by plucking or bowing strings, causing them to vibrate.
    b. The body of the instrument and the air inside also vibrate, contributing to its unique sound characteristics.
    c. This explains why instruments like the oud and violin can produce the same note but sound distinctly different.

2. **Wind Instruments**
    a. Wind instruments generate sound by blowing air into them, causing the column of air inside to vibrate.
    b. Players manipulate the pitch by covering and uncovering holes to alter the length of the vibrating air column.
    c. This variation in column length directly affects the pitch of the notes produced.

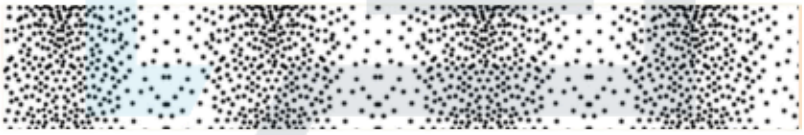
12.2 How does sound travel?

12.2.1 Sound Wave

1. The origin of sound vibrates, causing the surrounding air particles to oscillate back and forth in the direction of the sound's propagation.
2. These oscillation create a sound wave
3. This kind of wave is known as a longitudinal wave.

Spring view:

Air particle view:



Definition:

1. Compression: the region in a longitudinal wave where the particles are densely packed
2. Rarefaction: A region of a sound wave where the particles are spread out.

12.2.2 What can a sound travel through?

1. Sound waves are vibrations caused by particles oscillating back and forth. Sound requires a medium through which to propagate.

2. These mediums include:

    a. **Solids** – Sound can travel through solids. For example, we can hear sounds from outside a classroom.

    b. **Liquids** – Sound can travel through liquids. Marine animals like dolphins and whales use sound to communicate and navigate underwater.

    c. **Gases** – Sound also travels through gas particles in the air.

3. Can sound be heard in a vacuum? What do you think and why?

Sound cannot be heard in a vacuum because sound needs a medium to travel.

4. Bell inside a vacuum experiment

1. When the battery is connected, the bell is visible and audible.
2. Vibrations from the bell travel through the air inside the jar, through the glass, and then through the air to reach your ear.
3. When the pump removes the air from the jar, the bell continues to vibrate visibly but cannot be heard.

12.3 The Speed of Sound

1. Question to ponder: Let's say you see lightning, however, you hear the thunderclap only 7 seconds later. Why is that?

Answer: It takes time for sound of the thunder to travel to us.

2. Sound travels at between 330 m/s - 350 m/s in air, 1500 m/s in liquid. In solid, it depends on the materials of the solid.
3. The speed changes depending on the temperature and humidity of the air.
4. Speed measuring experiment
    a. Recap formula to calculate speed:

$\text{Speed} = \frac{\text{distance}}{\text{time}}$

Work Example

1. A child yells in a canyon and hears the echo after 1.8 seconds. How far away is the canyon wall from the child? Assume the speed of sound in air is 343 m/s.

2. A hiker sees a lightning strike on a mountain peak, and then hears the thunder 3.5 seconds later. How far is the spectator? The speed of sound in air is 330 m/s.

3. Sound travels at 1500 m/s in fresh water and at 1530 m/s in salt water. Explain the difference in speeds?

12.4 Seeing sounds

a. A cathode ray oscilloscope and microphone can be used to represent sounds on a display screen.

b. The microphone picks up the sound and converts it to an electrical signal.

c. The oscilloscope converts this to a line which represents the vibrations that make up the sound wave.

d. The oscilloscope is used to observe 2 important things about the wave.

i. Amplitude is the maximum displacement or distance moved by a point on a vibrating body or wave from its equilibrium position.

ii. Frequency is the number of occurrences of a repeating event per unit of time, often measured in hertz (Hz), which is cycles per second.

Wave diagram:

12.5 Hearing sounds

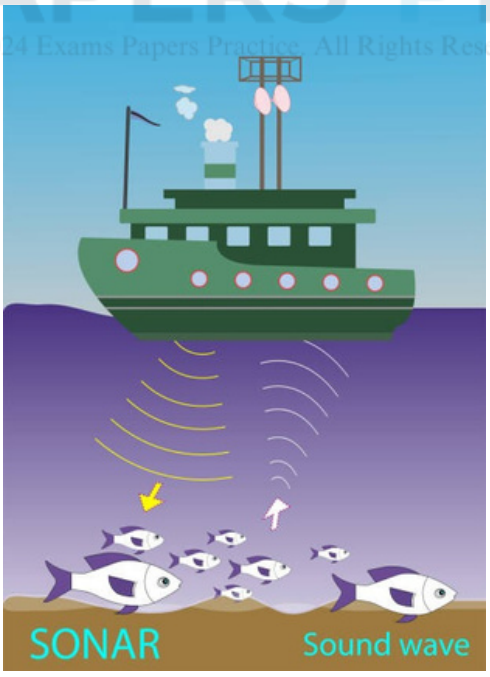
1. Young humans can perceive sounds ranging from 20 Hz to 20,000 Hz.
2. As we age, the sensory cells in the ear that detect vibrations deteriorate. Additionally, these cells can be damaged by repeated exposure to very loud
3. Sounds with frequencies higher than 20,000 Hz are too high-pitched to be heard noises.
4. Many animals, such as dolphins, can detect and use high-frequency sounds for by the human ear and are known as ultrasound.

communication.

12.6 Applications of ultrasound

Application 1: Sonar

1. Sonar is a method used to measure the depth of water or to locate an underwater object.
2. How it works?
    a. A pulse of ultrasound is emitted from a boat and reflects off the seabed.
    b. The time it takes for the reflected pulse to return is measured.
    c. Using the known speed of sound in water, this time measurement is used to calculate the depth of the water.



Worked Example:

A submarine uses sonar to detect a target underwater. If the sonar pulse travels at 1450 m/s and the time taken for the pulse to return after hitting the target is 4.5 seconds, what is the distance from the submarine to the target?

Application 2: Material Testing

1. Ultrasound is utilized to detect flaws within materials.
2. Here's how it works:
   a. Ultrasound is directed through the material to identify any cracks or imperfections.
   b. If there is a crack, the ultrasound will reflect back sooner than expected, indicating the presence of a flaw in the material.