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CLASS 10 · PHYSICS

SOUND

Chapter 11

Complete Exercise Solutions — Solved MCQs with Explanations, Review, Conceptual & Numerical Questions

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MCQs	Review Q's	Conceptual	Numericals

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A MULTIPLE CHOICE QUESTIONS

7 MCQs

MCQ · i **Which is an example of a longitudinal wave?**

- **a** **sound wave** ✓ Correct
- b light wave
- c radiowave
- d water wave

Explanation

Longitudinal waves are those in which the particles of the medium vibrate parallel to the direction of wave propagation. Sound waves travel through a medium (like air) via compressions and rarefactions, making them longitudinal. Light, radio, and water waves are transverse waves.

MCQ · ii **How does sound travel from its source to your ear?**

- **a** **by changes in air pressure** ✓ Correct
- b by vibrations in wires or strings
- c by electromagnetic wave
- d by infrared waves

Explanation

Sound is a mechanical wave. When an object vibrates, it pushes nearby air molecules, creating regions of high pressure (compressions) and low pressure (rarefactions). These pressure changes travel through the air to your ear, causing your eardrum to vibrate.

MCQ · iii **Which form of energy is sound?**

(a) electrical

(b) **mechanical** ✓ Correct

(c) thermal

(d) chemical

Explanation

Sound requires a material medium to travel and involves the physical vibration of particles. Therefore, it carries mechanical energy from one place to another.

MCQ · iv **Astronauts in space need to communicate with each other by radio links because**

(a) sound waves travel very slowly in space

(b) sound waves travel very fast in space

(c) **sound waves cannot travel in space** ✓ Correct

(d) sound waves have low frequency in space

Explanation

Sound waves are mechanical waves and require a material medium (solid, liquid, or gas) to propagate. Space is a vacuum (mostly empty space with no particles), so sound waves cannot travel through it. Radio waves, being electromagnetic waves, do not require a medium and can travel through space.

MCQ · v **The loudness of a sound is most closely related to its**

(a) frequency

(b) period

(c) wavelength

(d) **amplitude** ✓ Correct

💡 **Explanation**

The loudness of a sound is directly proportional to the square of the amplitude of the sound wave. A larger amplitude means the wave carries more energy, which our ears perceive as a louder sound. Frequency determines pitch.

MCQ · vi **For a normal person, audible frequency range for sound wave lies between**

(a) 10 Hz and 10 kHz

(b) **20 Hz and 20 kHz** ✓ Correct

(c) 25 Hz and 25 kHz

(d) 30 Hz and 30 kHz

💡 **Explanation**

The normal human ear can detect sound waves with frequencies ranging from 20 Hz (low pitch) to 20,000 Hz (or 20 kHz, high pitch). Sounds below 20 Hz are infrasonic, and above 20 kHz are ultrasonic.

MCQ · vii **When the frequency of a sound wave is increased, which of the following will decrease?**

i. wavelength
ii. period
iii. amplitude

a) i only

b) ii only

c) **i and ii only** ✓ Correct

d) i and iii only

Explanation

- **Wavelength (i):** Since wave speed $v = f \times \lambda$, if frequency (f) increases and speed (v) remains constant, wavelength (λ) must decrease.
- **Period (ii):** Period (T) is the inverse of frequency ($T = 1/f$). If frequency increases, the time taken for one cycle (period) decreases.
- **Amplitude (iii):** Amplitude is independent of frequency; it relates to loudness, not pitch.

B REVIEW QUESTIONS

18 Questions

REVIEW · 11.1 **What is the necessary condition for the production of sound?**

Answer

The necessary conditions for the production of sound are:

1. A vibrating source (e.g., vocal cords, guitar string, tuning fork).
2. A material medium (solid, liquid, or gas) to transmit the vibrations.

REVIEW · 11.2 **What is the effect of the medium on the speed of sound? In which medium sound travels more faster: air, solid or liquid? Justify your answer.**

Answer

The speed of sound depends on the nature of the medium, specifically its elasticity and density.

- Sound travels fastest in **solids**, slower in **liquids**, and slowest in **gases** (like air).
- **Justification:** Solids have strong intermolecular forces (high elasticity) and their particles are packed closely together. This allows them to transfer vibrational energy much more quickly and efficiently than the loosely packed particles in liquids and gases.

REVIEW · 11.3 **How can you prove the mechanical nature of sound by a simple experiment?**

Answer

Place an electric bell inside a sealed glass jar (bell jar) connected to a vacuum pump. When the bell is rung, you can hear the sound. As the vacuum pump removes the air from the jar, the sound gradually becomes fainter. When a vacuum is created (no air), the sound becomes inaudible, even though the bell is still ringing. This proves that sound requires a material medium to travel and is therefore a mechanical wave.

REVIEW · 11.4 **What do you understand by the longitudinal wave? Describe the longitudinal nature of sound waves.**

Answer

A longitudinal wave is a wave in which the particles of the medium vibrate parallel to the direction of wave propagation.

- Sound waves are longitudinal because when a sound source vibrates, it creates regions of high pressure and density called **compressions** (where particles are pushed together) and regions of low pressure and density called **rarefactions** (where particles are spread apart). These regions travel parallel to the direction the sound is moving.

REVIEW · 11.5 **Sounds form of wave. List at least three reasons to support the idea that sound is a wave.**

Answer

Three reasons sound behaves as a wave are:

1. **Reflection:** Sound can bounce off surfaces (e.g., echoes).
2. **Refraction:** Sound changes direction when it passes from one medium to another (e.g., from cool air to warm air).
3. **Diffraction:** Sound can bend around corners and obstacles.
4. **Interference:** Two sound waves can interact to create louder or softer sounds.

REVIEW · 11.6 **We know that waves manifest phenomenon of reflection, refraction and diffraction. Does sound also manifest these characteristics?**

Answer

Yes, sound manifests all of these characteristics:

- **Reflection:** Echoes are a common example of sound reflecting off hard surfaces.
- **Refraction:** Sound bends when it travels through air layers of different temperatures. On a hot day, sound bends upwards because it travels faster in warmer air near the ground.
- **Diffraction:** You can hear sounds from around a corner because sound waves diffract (bend) around obstacles.

REVIEW · 11.7 **What is the difference between the loudness and intensity of sound? Derive the relationship between the two.**

Answer

- **Intensity:** It is an objective, physical quantity. It is defined as the sound energy passing through a unit area per unit time (measured in W/m^2).
- **Loudness:** It is a subjective, psychological sensation. It is how our ears perceive the intensity of sound.
- **Relationship:** The human ear's response to sound intensity is not linear. According to the Weber-Fechner law, the perceived loudness (L) is directly proportional to the logarithm of the sound intensity (I).
- Formulaically:

$$L \propto \log(I)$$

REVIEW · 11.8 **On what factors does the loudness of sound depend?**

Answer

The loudness of a sound depends on:

1. The **amplitude** of the vibrating source (greater amplitude = louder sound).
2. The **distance** of the listener from the source (intensity decreases with distance).
3. The **surface area** of the vibrating body (larger area produces louder sound).
4. The **sensitivity** of the listener's ear.

REVIEW · 11.9 **What do you mean by the term intensity level of the sound? Name and define the unit of intensity level of sound.**

Answer

The intensity level of sound is a logarithmic measure used to compare the intensity of a particular sound to a standard reference intensity (the threshold of hearing, $I_0 = 10^{-12}$ W/m^2).

- **Unit:** The unit is the **Decibel (dB)**.
- **Definition:** It is defined as 10 times the logarithm (base 10) of the ratio of the sound's intensity (I) to the reference intensity (I_0). Formula:

$$\boldsymbol{L(\text{dB}) = 10 \log_{10}(I / I_0)}$$

REVIEW · 11.10 **What are the units of loudness? Why do we use logarithmic scale to describe the range of the sound intensities we hear?**

Answer

Loudness is a subjective sensation, but its practical unit is the **Decibel (dB)** (technically, loudness is measured in 'sones', but decibels measure the intensity level that we perceive as loudness).

- We use a logarithmic scale because the range of sound intensities the human ear can handle is massive (from 10^{-12} W/m^2 to 1 W/m^2, a trillion-fold increase). A logarithmic scale compresses this huge range into a manageable 0–120 dB scale, matching how the human ear naturally perceives relative changes in sound.

REVIEW · 11.11 **What is difference between frequency and pitch? Describe their relationship graphically.**

Answer

- **Frequency:** An objective physical property measured in Hertz (Hz), representing the number of vibrations per second.
- **Pitch:** A subjective psychological sensation of how “high” or “low” a sound is.
- **Relationship:** Pitch is directly proportional to frequency. As frequency increases, pitch increases.
- **Graphically:** If you draw a graph with Frequency on the x-axis and Pitch on the y-axis, it would be a straight line starting from the origin, showing a linear relationship (within the human audible range).

REVIEW · 11.12 **Describe the effect of change in amplitude on loudness and the effect of change in frequency on pitch of sound.**

Answer

- **Amplitude:** Increasing the amplitude of a sound wave increases its energy, making the sound louder. Decreasing amplitude makes it softer.
- **Frequency:** Increasing the frequency of a sound wave makes the pitch higher (squeakier). Decreasing the frequency makes the pitch lower (deeper).

REVIEW · 11.13 **If the pitch of sound is increased, what are the changes in the following?**

Answer

a **the frequency:** Increases.

b **the wavelength:** Decreases (because $v = f\lambda$, and speed is constant).

c **the wave velocity:** Remains constant (it depends on the medium, not the pitch).

d **the amplitude of the wave:** Remains unaffected (amplitude relates to loudness, not pitch).

REVIEW · 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 you explain how does this happen?**

Answer

This phenomenon is called an **echo**. When sound waves hit the hard surface of the building, they reflect back towards the source. If the distance is greater than 17.2 meters, the reflected sound reaches our ears after more than 0.1 seconds. Because the human ear can distinguish between two sounds separated by at least 0.1 seconds, we perceive the returning sound as a distinct repetition of the original sound.

REVIEW · 11.15 **What is the audible frequency range for human ear? Does this range vary with the age of people? Explain.**

Answer

The normal audible frequency range for a human ear is **20 Hz to 20,000 Hz**.

- Yes, this range varies with age. Young children can hear frequencies up to 20,000 Hz. As people age, their ability to hear high-frequency sounds diminishes. Elderly people might only hear up to 10,000 Hz or 15,000 Hz due to the natural wear and tear of the sensory hair cells in the inner ear.

REVIEW · 11.16 **Explain that noise is a nuisance.**

Answer

Noise is an irregular, random, and unpleasant sound that causes discomfort. It is a nuisance because it causes noise pollution, which can lead to:

1. Annoyance and stress.
2. Hearing loss (if exposed to loud noise for long periods).
3. Increased blood pressure and heart rate.
4. Disruption of sleep, concentration, and communication.

REVIEW · 11.17 **Describe the importance of acoustic protection.**

Answer

Acoustic protection (or soundproofing) is crucial for creating healthy environments. It is important for:

1. Reducing noise pollution in residential and commercial areas.
2. Protecting workers in loud factories from hearing damage.
3. Providing privacy (e.g., in offices or doctors' rooms).
4. Ensuring high-quality sound recording in studios by blocking outside noise.

REVIEW · 11.18 **What are the uses of ultrasound in medicine?**

Answer

Ultrasound (frequencies above 20 kHz) has numerous medical uses:

1. **Sonography:** To safely image internal organs and monitor fetal development during pregnancy.
2. **Echocardiography:** To examine the heart's structure and function.
3. **Lithotripsy:** To break down kidney stones without invasive surgery.
4. **Physiotherapy:** To generate deep heat in tissues to relieve pain and promote healing.

C CONCEPTUAL QUESTIONS

4 Questions

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

Answer

Because a stretched string is a solid medium, and sound travels much faster and with less energy loss in solids than in gases like air. The string directs the vibrations directly to the second can, preventing the sound from scattering in the air and making the communication clearer and more efficient over a distance.

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

Answer

This is possible due to the **quality** or **timbre** of the sound. Even if two people speak at the same loudness (amplitude) and pitch (frequency), their vocal cords and vocal tracts have different shapes and sizes. This causes them to produce different combinations of overtones (harmonics) alongside the fundamental frequency, giving each voice a unique, recognizable signature.

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

Answer

This is due to **diffraction**. Sound waves have relatively long wavelengths (comparable to the size of everyday objects and corners), which allows them to bend around obstacles and reach your ears. Light waves have extremely short wavelengths, so they travel in straight lines and cannot bend around the corner to reach your eyes.

CONCEPTUAL · 11.4 **Why must the volume of a stereo in a room with wall-to-wall carpet be tuned higher than in a room with a wooden floor?**

Answer

Wall-to-wall carpet is a porous, soft material that heavily absorbs sound waves, reducing reverberation and reflections. A wooden floor is hard and reflects sound waves. Because the carpet absorbs much of the sound energy, the stereo must be turned up louder to achieve the same perceived loudness that would easily be achieved in a reflective room with a wooden floor.

D NUMERICAL PROBLEMS

8 Problems

NUMERICAL · 11.1 **A normal conversation involves sound intensities of about 3.0×10^{-6} W m^{-2}. What is the decibel level for this intensity? What is the intensity of the sound for 100 dB?**

Solution

Given

- Intensity (I) = 3.0×10^{-6} W m^{-2}
- Reference intensity (I_0) = 10^{-12} W m^{-2}

Part 1: Decibel level

Formula	$L = 10 \log_{10}(I / I_0)$
Substitute	$L = 10 \log_{10}(3.0 \times 10^{-6} / 10^{-12})$
Simplify	$L = 10 \log_{10}(3.0 \times 10^{6})$
Expand	$L = 10 (\log_{10} 3 + 6) = 10 (0.477 + 6) = 10 (6.477)$

✓ **$L = 64.77 \approx 64.8$ dB**

Part 2: Intensity for 100 dB

Step 1	$100 = 10 \log_{10}(I / 10^{-12})$
Step 2	$10 = \log_{10}(I / 10^{-12})$
Step 3	$10^{10} = I / 10^{-12}$
Step 4	$I = 10^{10} \times 10^{-12}$

✓ **$I = 10^{-2}$ W m^{-2} (or 0.01 W m^{-2})**

NUMERICAL · 11.2 **If at Anarkali Bazar Lahore, intensity level of sound is 80 dB, what will be the intensity of sound there?**

Solution

Given

- Intensity level (L) = 80 dB
- Reference intensity (I_0) = 10^{-12} W m^{-2}

Formula	$L = 10 \log_{10}(I / I_0)$
Substitute	$80 = 10 \log_{10}(I / 10^{-12})$
Divide by 10	$8 = \log_{10}(I / 10^{-12})$
Antilog	$10^8 = I / 10^{-12}$
Solve	$I = 10^8 \times 10^{-12}$

✓ $I = 10^{-4}$ W m^{-2}

NUMERICAL · 11.3 **At a particular temperature, the speed of sound in air is 330 m/s. If the wavelength of a note is 5 cm, calculate the frequency of the sound wave. Is this frequency in the audible range of the human ear?**

Solution

Given

- Speed of sound (v) = 330 m/s
- Wavelength (λ) = 5 cm = 0.05 m

Formula $v = f\lambda \implies f = v / \lambda$

Substitute $f = 330 / 0.05$

✅ **f = 6600 Hz (or 6.6×10^3 Hz)**

Audible Range Check: The audible range for humans is 20 Hz to 20,000 Hz. Since 6600 Hz falls within this range, **yes, this frequency is in the audible range.**

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

Solution

Given

- Number of beats = 72
- Time = 1 min = 60 s

Frequency f = Total beats / Total time = 72 / 60

✅ $f = 1.2$ Hz

Period $T = 1 / f = 1 / 1.2$

✅ $T = 0.833$ s ≈ 0.83 s

NUMERICAL · 11.5 **A marine survey ship sends a sound wave straight to the seabed. It receives an echo 1.5 s later. The speed of sound in seawater is 1500 m/s. Find the depth of the sea at this position.**

Solution

Given

- Total time for echo (t_{total}) = 1.5 s
- Speed (v) = 1500 m/s

Analysis The time taken to reach the seabed is half the total time.

Time $t = 1.5 / 2 = 0.75$ s

Formula Distance (d) = $v \times t$

Substitute $d = 1500 \times 0.75$

✔ **d = 1125 m**

NUMERICAL · 11.6 **A student clapped his hands near a cliff and heard the echo after 5 s. What is the distance of the cliff from the student if the speed of the sound is taken as 346 m/s?**

Solution

Given

- Total time (t_{total}) = 5 s
- Speed (v) = 346 m/s

Analysis Time to reach the cliff is half the total time.

Time $t = 5 / 2 = 2.5$ s

Formula $d = v \times t$

Substitute $d = 346 \times 2.5$

✅ $d = 865$ m

NUMERICAL · 11.7 **A ship sends out ultrasound that returns from the seabed and is detected after 3.42 s. If the speed of ultrasound through seawater is 1531 m/s, what is the distance of the seabed from the ship?**

Solution

Given

- Total time (t_{total}) = 3.42 s
- Speed (v) = 1531 m/s

Analysis Time to reach the seabed is half the total time.

Time $t = 3.42 / 2 = 1.71$ s

Formula $d = v \times t$

Substitute $d = 1531 \times 1.71$

✓ **$d = 2618.01$ m ≈ 2618 m**

NUMERICAL · 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 a temperature of 20°C? What is the wavelength of the lowest sounds we can hear of about 20 Hz? Assume the speed of sound in air at 20°C is 343 m/s.

Solution

Given

- Speed of sound (v) = 343 m/s
- Highest frequency (f_{high}) = 20,000 Hz
- Lowest frequency (f_{low}) = 20 Hz

Part 1: Wavelength of highest frequency

Formula $\lambda = v / f$

Substitute $\lambda_{high} = 343 / 20000$

✓ **$\lambda_{high} = 0.01715$ m (or 1.715 cm)**

Part 2: Wavelength of lowest frequency

Formula $\lambda_{low} = v / f$

Substitute $\lambda_{low} = 343 / 20$

✓ **$\lambda_{low} = 17.15$ m**

Thank You!

You have completed the Chapter 11 “Sound” exercise. Keep practising and keep learning with us.

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