

chapter 26 sound physics answers

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Chapter 26 Sound Physics Answers: A Complete Guide

Sound physics is a cornerstone of modern physics, bridging the gap between abstract theory and everyday experience. Whether you're a student tackling a challenging textbook, a teacher preparing a lesson, or an enthusiast curious about the mechanics of sound, having reliable answers to **Chapter 26 sound physics** is essential. This guide provides a thorough exploration of the chapter's core concepts, step by step solutions to typical problems, and practical tips for mastering the material. By the end of this article, you'll have a solid grasp of the physics of sound and the confidence to tackle any question that comes your way.

1. Overview of Chapter 26: The Physics of Sound

Chapter 26 typically covers the fundamental principles governing sound waves in various media. The key topics include:

- Wave characteristics: frequency, wavelength, amplitude, and speed.
- Propagation of sound in gases, liquids, and solids.
- Reflection, refraction, diffraction, and interference.
- Standing waves and resonant phenomena.
- The Doppler effect and its applications.
- Sound intensity, pressure, and energy transfer.
- Practical aspects: acoustics, noise control, and musical applications.

Understanding these concepts is crucial for solving the problems that appear in the chapter's exercises.

2. Core Concepts and Definitions

2.1 Frequency and Wavelength

Frequency (f) is the number of wave cycles per second, measured in hertz (Hz). Wavelength (λ) is the spatial period of the wave. The relationship between frequency, wavelength, and wave speed (v) is given by:

$$v = f \times \lambda$$

For sound in air at 20 °C, the speed is approximately 343 m/s.

2.2 Amplitude and Sound Pressure

Amplitude reflects the maximum displacement of particles in the medium. In acoustics, we often express sound level in terms of sound pressure (p) and sound pressure level (SPL) in decibels (dB):

$$\text{SPL (dB)} = 20 \log_{10}(p/p_0)$$

where p_0 is the reference pressure (20 μPa).

2.3 Sound Intensity and Power

Sound intensity (I) is the power per unit area, defined as:

$$I = p^2 / (\rho \times b)$$

with ρ being the medium's density. The total power emitted by a source is the integral of intensity over a closed surface.

2.4 Reflection and Refraction

When a sound wave encounters a boundary between two media, part of it is reflected and part transmitted (refracted). The reflection coefficient depends on the acoustic impedance mismatch.

2.5 Diffraction and Interference

Diffraction describes the bending of waves around obstacles, while interference arises from the superposition of two or more waves, leading to constructive or destructive patterns.

2.6 Standing Waves and Resonance

Standing waves occur when two waves of the same frequency travel in opposite directions, producing nodes and antinodes. Resonance amplifies the wave amplitude when the driving frequency matches a natural frequency of the system.

2.7 The Doppler Effect

The Doppler effect describes the change in frequency observed when there is relative motion between source and observer. The observed frequency f' is:

$$f' = f \times (v \pm v_o) / (v \pm v_s)$$

where v_o and v_s are the observer's and source's velocities relative to the medium.

3. Common Problem Types in Chapter 26

Exercises in Chapter 26 often revolve around the following problem categories:

- Calculating wave speed given frequency and wavelength.
- Determining sound intensity from pressure measurements.
- Analyzing reflection and transmission at interfaces.
- Predicting interference patterns in double slit setups.
- Finding resonant frequencies of pipes and cavities.
- Applying the Doppler formula to moving sources or observers.

Below, we present representative problems and detailed solutions.

4. Sample Problem 1: Speed of Sound in a Medium

Problem: A sound wave in water has a frequency of 10 kHz and a wavelength of 0.015 m. What is the speed of sound in water?

Solution:

1. Use the relation $v = f \times \lambda$
2. Plug in the values: $v = 10\,000 \text{ /Hz} \times 0.015 \text{ /m} = 150 \text{ /m/s}$.
3. Answer: The speed of sound in water is 150 /m/s.

This result aligns with typical speeds for sound in cold water (~1500 m/s); the lower value indicates a simplified example or a different medium.

5. Sample Problem 2: Sound Intensity from Pressure

Problem: A microphone records a sound pressure of 0.1 Pa in air at 20 °C. Calculate the intensity of the sound wave.

Solution:

1. Air density at 20 °C: $\rho = 1.204 \text{ kg/m}^3$
2. Speed of sound in air: $v = 343 \text{ m/s}$
3. Use $I = p^2 / (2 \rho v)$
4. Compute: $I = (0.1 \text{ Pa})^2 / (1.204 \text{ kg/m}^3 \times 343 \text{ m/s}) = 0.01 \text{ Pa}^2 / 413.292 \text{ Pa} \cdot \text{s/m} = 2.42 \times 10^{-5} \text{ W/m}^2$
5. Answer: The sound intensity is approximately $24 \text{ } \mu\text{W/m}^2$.

6. Sample Problem 3: Reflection Coefficient at a Boundary

Problem: Sound travels from air into a steel plate. The acoustic impedances are $Z_{\text{air}} = 400 \text{ Pa} \cdot \text{s/m}$ and $Z_{\text{steel}} = 40,000 \text{ Pa} \cdot \text{s/m}$. What fraction of the wave's intensity is reflected?

Solution:

1. Reflection coefficient for intensity: $R = [(Z_2 - Z_1) / (Z_2 + Z_1)]^2$
2. Insert values: $R = [(40,000 - 400) / (40,000 + 400)]^2 = (39,600 / 40,400)^2 \approx (0.9802)^2 \approx 0.9608$
3. Answer: About 96% of the intensity is reflected; only 4% transmits into steel.

7. Sample Problem 4: Interference Pattern in a Double Slit Experiment

Problem: Two identical slits separated by 0.1 m are illuminated by a 500 nm light source. What is the distance between the first-order bright fringes on a screen 2 m away?

Solution:

1. Use the formula for bright fringes: $d \sin \theta = m \lambda$ where d is slit separation, $m = 1$ for first order.
2. For small angles, $\sin \theta \approx \theta \approx y / L$, where y is fringe distance on the screen and $L = 2 \text{ m}$.
3. Compute: $y = (m \lambda L) / d = (1 \times 500 \times 10^{-9} \text{ m} \times 2 \text{ m}) / 0.1 \text{ m} = 10 \times 10^{-9} \text{ m} = 10 \text{ } \mu\text{m}$
4. Answer: The first order bright fringes are $10 \text{ } \mu\text{m}$ apart.

8. Sample Problem 5: Resonant Frequency of an Open Closed Pipe

Problem: An open closed cylindrical pipe has a length of 0.5 m. What is its fundamental resonant frequency in air at 20 °C?

Solution:

1. The fundamental frequency for an open closed pipe is $f = v / (4L)$, where $v = 343 \text{ m/s}$.
2. Compute: $f = 343 \text{ m/s} / (4 \times 0.5 \text{ m}) = 343 / 2 = 171.5 \text{ Hz}$
3. Answer: The fundamental resonant frequency is approximately 172 Hz.

9. Sample Problem 6: Doppler Shift from a Moving Source

Problem: A police car emits a 2 kHz siren while moving toward a stationary observer at 30 m/s. What frequency does the observer hear?

Solution:

1. Use the Doppler formula for a moving source: $f' = f \times (v / (v - v_s))$, where $v_s = 30 \text{ m/s}$.

2. Compute: $f' = 2000 \text{ /Hz} \times (343 \text{ /m/s} / (343 \text{ /m/s} - 30 \text{ /m/s})) = 2000 \times (343 / 313) \text{ "H } 2000 \times 1.096 = 2192 \text{ /Hz.}$

3. Answer: The observer hears approximately 2.19 /kHz.

10. Common Mistakes to Avoid

- Mixing up frequency and wavelength units (Hz vs. m).
- Using the wrong sign for velocities in the Doppler equation.
- Neglecting the acoustic impedance mismatch when calculating reflection.

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