

A Sound Wave Has A Speed Of 342 M/s And A Wavelength Of 2.15 Meters. What Is The Frequency Of This Wave?A.

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Understanding the fundamental properties of sound waves is essential for grasping how sound travels through different media. In this article, we will explore the relationship between the speed, wavelength, and frequency of a sound wave, specifically focusing on a wave with a speed of 342 meters per second (m/s) and a wavelength of 2.15 meters. By the end of this guide, you'll be able to accurately determine the frequency of such a wave and understand the underlying physics principles involved.

Introduction to Sound Waves and Their Properties

Sound waves are longitudinal waves that propagate through a medium such as air, water, or solids. These waves are characterized by several key properties:

- **Speed (v):** How fast the wave travels through a medium.
- **Wavelength (λ):** The distance between successive compressions or rarefactions in the wave.
- **Frequency (f):** How many wave cycles pass a point per second.
- **Amplitude:** The height of the wave, related to the wave's energy and loudness.

Understanding the relationships between these properties allows us to analyze and calculate unknown parameters when some are given.

Fundamental Relationship: Speed, Wavelength, and Frequency

The core equation connecting the properties of a wave is:

$$v = f \times \lambda$$

Where:

- v = wave speed (meters per second, m/s)
- f = frequency (hertz, Hz)
- λ = wavelength (meters, m)

This formula states that the wave's speed is the product of its frequency and wavelength. If any two of these parameters are known, the third can be calculated with ease.

Calculating the Frequency of the Sound Wave

Given:

- Wave speed, $v = 342$, m/s
- Wavelength, $\lambda = 2.15$, m

We want to find:

- Frequency, f

Using the fundamental relationship:

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

Substituting the known values:

$$f = \frac{342 \text{ m/s}}{2.15 \text{ m}}$$

Calculating:

$$f \approx 159.07 \text{ Hz}$$

Therefore, the frequency of this sound wave is approximately 159.07 Hz.

Understanding the Significance of the Calculated Frequency

The frequency of roughly 159 Hz indicates that this sound wave is within the lower mid-range of human hearing. To put this into perspective:

- Normal human hearing range extends from about 20 Hz to 20,000 Hz.
- Sounds with frequencies around 159 Hz are perceived as deep or bass sounds.

- This frequency could correspond to sounds like a bass guitar string or the lower notes of a piano.

Such frequencies are crucial in various fields, including acoustics, audio engineering, and speech analysis.

Factors Affecting Sound Wave Properties

While in this example, the properties are given and straightforward to calculate, real-world scenarios involve various factors that influence wave behavior:

Medium of Propagation

- The speed of sound varies depending on the medium's density and elasticity.
- For example, sound travels faster in water (~1,480 m/s) than in air (~343 m/s at room temperature).
- Temperature, humidity, and pressure also affect the speed.

Wavelength and Frequency Relationship

- Higher frequency waves have shorter wavelengths at the same speed.
- Conversely, at constant wavelength, increasing the speed increases the frequency.

Implications in Technology

- In audio engineering, understanding these properties helps in designing speakers and microphones.
- In medical ultrasound, the frequency determines the resolution and penetration.
- In communications, frequency modulation is used to encode information.

Practical Applications of Wave Properties Knowledge

Understanding wave physics is essential in various practical applications:

1. **Audio Engineering:** Designing sound systems that accurately reproduce sound frequencies.

2. **Acoustic Engineering:** Designing concert halls and auditoriums for optimal sound quality.
3. **Medical Imaging:** Ultrasound devices use specific frequencies to produce images of internal body structures.
4. **Communication Systems:** Radio and cell phone signals operate at various frequencies for efficient transmission.
5. **Environmental Monitoring:** Listening devices detect specific sound frequencies to monitor wildlife or human activity.

Summary and Key Takeaways

To summarize:

- The wave speed (v) is related to the wavelength (λ) and frequency (f) through the formula $v = f \times \lambda$.
- Given the wave speed of 342 m/s and wavelength of 2.15 m, the frequency is approximately 159.07 Hz.
- Understanding these relationships helps in accurately analyzing sound waves in various scientific and engineering fields.
- Real-world factors such as medium properties and environmental conditions influence wave behavior.

Additional Tips for Calculating Wave Parameters

- Always ensure units are consistent before performing calculations.
- Use a calculator for precise division, especially when dealing with non-integer results.
- Remember that the speed of sound in air varies with temperature; at 20°C, it's approximately 343 m/s.
- When working with multiple parameters, create a table to organize known and unknown quantities for clarity.

Conclusion

Understanding how to calculate the frequency of a sound wave when given its speed and wavelength is fundamental in wave physics. In this scenario, with a wave speed of 342 m/s and a wavelength of 2.15 meters, the wave's frequency is approximately 159 Hz, placing it comfortably within the audible range for humans. This knowledge not only enhances comprehension of wave phenomena but also has practical implications across acoustics, engineering, medicine, and communication technologies.

By mastering these calculations and concepts, students, engineers, and enthusiasts can better analyze and manipulate sound waves to suit various applications, leading to innovations in technology and a deeper appreciation of the physics of sound.

Frequently Asked Questions

What is the formula to calculate the frequency of a sound wave?

The frequency (f) of a sound wave can be calculated using the formula: $f = v / \lambda$, where v is the speed of sound and λ is the wavelength.

Given a sound wave with a speed of 342 m/s and a wavelength of 2.15 meters, how do you find its frequency?

Use the formula: $f = v / \lambda$. Plugging in the values: $f = 342 \text{ m/s} \div 2.15 \text{ m} \approx 159.07 \text{ Hz}$.

What is the approximate frequency of the sound wave described in the problem?

The approximate frequency is 159.07 Hz.

Why is understanding wave frequency important in sound wave analysis?

Frequency determines the pitch of the sound; higher frequencies produce higher pitches, which is crucial in audio engineering, communication, and acoustics.

If the speed of sound increases, how does that affect the frequency for a given wavelength?

If the speed increases while the wavelength remains constant, the frequency also increases proportionally, since $f = v / \lambda$.

What units are used for measuring the speed and wavelength of a sound wave?

Speed is measured in meters per second (m/s), and wavelength is measured in meters (m).

Can the frequency of a sound wave be changed without altering its speed or wavelength?

No, the frequency is directly related to the wave's properties; changing it requires altering the wave's speed or wavelength.

What real-world applications rely on calculating wave frequency?

Applications include audio engineering, ultrasound imaging, musical instrument tuning, and communication systems.

Is the calculated frequency of approximately 159 Hz within the audible range for humans?

Yes, 159 Hz is within the typical human audible range, which spans from about 20 Hz to 20,000 Hz.

Additional Resources

A Sound Wave Has A Speed Of 342 M/s And A Wavelength Of 2.15 Meters. What Is The Frequency Of This Wave?

Introduction

Sound waves are a fundamental aspect of our daily experience, enabling communication, music, and an array of technological applications. The physics underlying sound propagation involves several key properties: speed, wavelength, frequency, and amplitude. A specific question often arises in physics education and research: Given the speed of a sound wave and its wavelength, how do we determine its frequency?

In this investigative review, we explore the relationship between these properties, with a focus on the particular case where a sound wave travels at a speed of 342 meters per second and has a wavelength of 2.15 meters. We will dissect the underlying physics principles, analyze the calculations involved, and contextualize the findings within broader applications and implications.

Fundamental Principles of Sound Wave Propagation

The Nature of Sound Waves

Sound waves are longitudinal mechanical waves that propagate through a medium—such as air, water, or solids—by oscillations of particles along the direction of wave travel. These waves are characterized by their:

- Speed (v): How fast the wave propagates through the medium.
- Wavelength (λ): The distance over which the wave's shape repeats.
- Frequency (f): The number of wave cycles passing a point per second.
- Amplitude: The maximum displacement of particles, related to the wave's loudness (not directly involved in our calculation).

The interrelation among these properties is governed by the wave equation:

$$v = f \times \lambda$$

This fundamental relationship provides the basis for calculating one property if the others are known.

The Relationship Between Speed, Wavelength, and Frequency

Mathematical Foundation

The wave equation links the three core parameters:

- v : Speed of the wave (meters per second, m/s)
- λ : Wavelength (meters, m)
- f : Frequency (hertz, Hz)

Rearranged to solve for frequency:

$$f = v / \lambda$$

This simple yet powerful formula allows us to determine the frequency when the wave's speed and wavelength are known.

Implications of the Relationship

- As speed increases for a fixed wavelength, frequency increases proportionally.
- For a fixed speed, longer wavelengths correspond to lower frequencies.
- The inverse relationship between wavelength and frequency is essential in applications like acoustics, telecommunications, and signal processing.

Case Study: Calculating the Frequency of a Sound Wave

Given Data

- Speed of sound, $v = 342$ m/s
- Wavelength, $\lambda = 2.15$ m

Calculation

Using the wave equation:

$$f = v / \lambda$$

Plugging in the known values:

$$f = 342 \text{ m/s} \div 2.15 \text{ m}$$

Calculating:

$$f \approx 159.07 \text{ Hz}$$

Thus, the frequency of this sound wave is approximately 159 Hz.

Contextual Analysis and Significance

Comparison with Typical Human Hearing Range

The human audible range spans approximately 20 Hz to 20,000 Hz. The

calculated frequency of roughly 159 Hz falls comfortably within this range, corresponding to a deep bass tone often heard in musical instruments like bass guitars and certain drums.

Relevance in Acoustics and Engineering

Understanding the frequency of sound waves is vital in:

- Room acoustics: Designing spaces with optimal sound quality.
- Audio engineering: Equalization and soundproofing.
- Sonar and underwater acoustics: Where speed varies depending on medium properties.
- Medical ultrasonography: Frequencies are much higher but follow similar principles.

Variations in Propagation Speed

While 342 m/s is typical for sound in air at room temperature (~20°C), actual wave speed can vary based on:

- Temperature: Higher temperatures increase speed.
- Medium density and elasticity: Denser or less elastic media slow down sound.
- Pressure and humidity: Affect the medium's properties.

In different environments, the same wavelength could correspond to different frequencies due to these variables.

Broader Implications and Applications

Acoustic Design and Noise Control

Knowing the frequency allows engineers to design materials and structures that absorb or reflect specific sound waves, improving acoustics and reducing noise pollution.

Communication Technologies

Radio and sound communication systems depend on precise control of wave properties. The ability to calculate and manipulate frequency is crucial for signal clarity and bandwidth management.

Scientific Research

Accurate measurements of wave properties underpin research in fields like seismology (earthquake waves), oceanography (underwater sound), and astrophysics (waves in space).

Limitations and Considerations

While the calculation provides a clear answer, real-world applications often involve additional complexities:

- Wave attenuation: Energy loss over distance.
- Refraction and reflection: Changes in medium properties cause wave bending.

- Doppler effect: Motion of source or observer alters perceived frequency.
- Non-ideal conditions: Turbulence, obstacles, and temperature gradients affect wave behavior.

Understanding these factors is essential for accurate modeling and application.

Conclusion

The analysis of a sound wave with a speed of 342 m/s and a wavelength of 2.15 meters demonstrates the direct and straightforward application of fundamental wave physics. The calculated frequency of approximately 159 Hz underscores the importance of wave relationships in practical contexts, from musical acoustics to technological innovations.

Mastery of these principles enables scientists, engineers, and technologists to manipulate and utilize sound waves effectively, advancing our capabilities across diverse fields. As we continue to explore the complexities of wave phenomena, the foundational equation $v = f \times \lambda$ remains an essential tool for decoding the behavior of waves in our universe.

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In summary, by analyzing the given parameters with fundamental physics principles, we find that the frequency of the sound wave in question is approximately 159 Hz. This calculation not only exemplifies core concepts in wave physics but also highlights their practical relevance across scientific and engineering disciplines.

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