# A Certain Radio Wave Has A Frequency Of 2.0 X 106106 Hz. What Is Its Wavelength?

**A Certain Radio Wave Has A Frequency Of 2.0 X 106 Hz. What Is Its Wavelength?**

In the fascinating world of electromagnetic waves, radio waves hold a special place due to their widespread applications in communication, broadcasting, navigation, and many other technological domains. Understanding the fundamental properties of radio waves, such as their frequency and wavelength, is essential for scientists, engineers, and students alike. Today, we explore a specific scenario: determining the wavelength of a radio wave with a given frequency of 2.0 × 106 Hz. This question not only enhances our understanding of wave physics but also highlights the practical importance of these calculations in real-world applications.

## Understanding Radio Waves and Their Properties

### What Are Radio Waves?

Radio waves are a type of electromagnetic radiation with wavelengths longer than infrared light. They are part of the electromagnetic spectrum, which includes gamma rays, X-rays, ultraviolet, visible light, infrared, and microwaves. Radio waves are characterized by their low frequency and long wavelength, making them ideal for wireless communication.

### Key Properties of Radio Waves

- Frequency (f): The number of wave cycles that pass a point per second, measured in Hertz (Hz).
- Wavelength (□): The distance between consecutive crests or troughs of the wave, measured in meters (m).

- Speed (c): Radio waves travel at the speed of light in a vacuum, approximately 3.0 × 108 meters per second.

Understanding the relationship between these properties allows us to perform calculations such as determining the wavelength when the frequency is known.

# The Relationship Between Frequency and Wavelength

## The Fundamental Equation

The primary relationship between the speed (c), frequency (f), and wavelength (λ) of electromagnetic waves is expressed by the equation:

$$
c = \lambda \times f
$$

Where:
- c is the speed of light (~3.0 × 108 m/s),
- λ (lambda) is the wavelength in meters,
- f is the frequency in Hertz.

This equation states that the wavelength is inversely proportional to the frequency when the wave travels at a constant speed.

## Rearranged Equation for Wavelength

To find the wavelength, rearrange the equation:

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

This simple formula allows us to calculate the wavelength directly, given the frequency.

# Calculating the Wavelength of the Radio Wave

## Given Data

- Frequency, $f = 2.0 \times 10^6$ Hz (which is 2.0 MHz),
- Speed of light, $c = 3.0 \times 10^8$ m/s.

## Step-by-Step Calculation

Applying the formula:

$$
\lambda = \frac{3.0 \times 10^8 \text{ m/s}}{2.0 \times 10^6 \text{ Hz}}
$$

Perform the division:

$$
\lambda = \frac{3.0 \times 10^8}{2.0 \times 10^6} = \frac{3.0}{2.0} \times \frac{10^8}{10^6}
$$

Simplify:

$$
\lambda = 1.5 \times 10^{8-6} = 1.5 \times 10^2
$$

Final calculation:

$$
\lambda = 150 \text{ meters}
$$

Therefore, the wavelength of the radio wave with a frequency of 2.0 MHz is approximately 150 meters.

## Practical Implications of Wavelength in Radio Communication

### Why Wavelength Matters

Understanding the wavelength helps in designing antennas, choosing transmission media, and optimizing communication systems. Different applications require different wavelength ranges for efficient transmission.

### Applications of 150-Meter Wavelength Radio Waves

- AM Radio Broadcasting: Many AM radio stations operate within the wavelength range of hundreds of meters, often around 200 meters, which aligns well with the calculated wavelength.
- Long-distance Communication: Longer wavelengths, such as 150 meters, can reflect off the ionosphere, enabling radio signals to travel beyond the horizon.
- Navigation and Maritime Communication: Vessels often rely on radio waves within this wavelength range for reliable communication over vast distances.

# Factors Influencing Radio Wave Wavelength and Propagation

## Environmental Factors

- Ionosphere: The ionosphere acts as a reflective layer for certain radio frequencies, affecting how waves propagate.
- Terrain and Obstacles: Mountains, buildings, and other obstacles can absorb or reflect radio waves, influencing their effective wavelength and coverage.

## Technological Considerations

- Antenna Design: The size of antennas is often related to the wavelength; for example, a quarter-wave antenna is approximately one-quarter of the wavelength.
- Frequency Allocation: Different frequency bands are allocated for various purposes, balancing wavelength and propagation characteristics.

# Additional Examples and Practice Problems

## Example 1: Calculating Wavelength for Different Frequencies

Suppose a radio wave has a frequency of 100 MHz (which is common for FM radio). How long is its wavelength?

Solution:

$$
f = 100 \times 10^6 \text{ Hz}
$$

$$
\lambda = \frac{3.0 \times 10^8}{100 \times 10^6} = \frac{3.0 \times 10^8}{1.0 \times 10^8} = 3 \text{ meters}
$$

Result: The wavelength is approximately 3 meters.

## Practice Problem

Calculate the wavelength of a radio wave with a frequency of 1.5 GHz.

Answer:

$$
f = 1.5 \times 10^9 \text{ Hz}
$$

$$
\lambda = \frac{3.0 \times 10^8}{1.5 \times 10^9} = 0.2 \text{ meters}
$$

Wavelength: 20 centimeters.

# Conclusion

Understanding the relationship between frequency and wavelength is fundamental in the study and application of electromagnetic waves, especially radio waves. In this case, a radio wave with a frequency of 2.0 × 106 Hz has a wavelength of approximately 150 meters. This knowledge is crucial for designing effective communication systems, choosing appropriate antennas, and optimizing signal propagation.

By mastering these concepts, engineers and scientists can improve existing technologies and innovate new solutions for wireless communication, broadcasting, navigation, and beyond. Whether working with longwave, medium wave, or shortwave radio frequencies, the core principles remain the same, guided by the elegant relationship encapsulated in the wave equation.

Remember: The key to solving problems involving wave properties is understanding the fundamental relationship between speed, frequency, and wavelength, and applying the correct formula with attention to units and scientific notation.

## Frequently Asked Questions

### What is the formula to find the wavelength of a radio wave when its frequency is known?

The wavelength ($\lambda$) can be calculated using the formula $\lambda = c / f$, where c is the speed of light (approximately $3.0 \times 10^8$ m/s) and f is the frequency.

### Given a radio wave with a frequency of $2.0 \times 10^6$ Hz, what is its wavelength?

Using $\lambda = c / f$, $\lambda = (3.0 \times 10^8 \text{ m/s}) / (2.0 \times 10^6 \text{ Hz}) = 150$ meters.

### Why does a higher frequency radio wave have a shorter wavelength?

Because wavelength and frequency are inversely related ($\lambda = c / f$), increasing the frequency results in a shorter wavelength.

### Is a radio wave with a frequency of $2.0 \times 10^6$ Hz considered low or

### high frequency?

It is considered a low-frequency radio wave, as typical radio frequencies range from about 10^3 Hz to 10^9 Hz.

### How does the wavelength of a radio wave affect its transmission range?

Generally, longer wavelengths (lower frequencies) can travel longer distances and penetrate obstacles better, while shorter wavelengths have higher resolution but shorter range.

### What is the significance of knowing the wavelength of a radio wave?

Knowing the wavelength helps in designing antennas, understanding signal propagation, and avoiding interference with other signals.

### Can the wavelength of a radio wave be adjusted, and if so, how?

The wavelength is determined by the frequency; changing the frequency (by tuning the transmitter) adjusts the wavelength accordingly.

### Are all radio waves with the same frequency the same wavelength?

Yes, radio waves with the same frequency have the same wavelength, regardless of their source or power.

## Additional Resources

A Certain Radio Wave Has A Frequency Of 2.0 x 10^6 Hz. What Is Its Wavelength?

Understanding the relationship between the frequency and wavelength of a radio wave is fundamental in the fields of physics, telecommunications, and electronics. When we encounter a statement like "A certain radio wave has a frequency of 2.0 x 10^6 Hz," it prompts us to explore how this frequency translates into the wave's wavelength, a key parameter that determines how radio signals propagate, how antennas are designed, and how various communication systems operate. This article provides a comprehensive guide to understanding this relationship, complete with step-by-step calculations, relevant concepts, and practical examples.

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## Fundamentals of Wave Properties

Before diving into the calculation, it’s essential to understand the basic properties of waves:

- Frequency (f): The number of wave cycles that pass a point per second, measured in Hertz (Hz). For the given radio wave, f = 2.0 x 10^6 Hz.
- Wavelength (λ): The distance between successive crests or troughs of the wave, measured in meters.
- Speed of Wave (v): The rate at which the wave propagates through a medium. For electromagnetic waves like radio waves, the speed in a vacuum is approximately the speed of light, c ≈ 3.00 x 10^8 meters per second.

The fundamental relationship connecting these properties is:

$$v = \lambda \times f$$

For electromagnetic waves traveling through free space, this simplifies to:

$$c = \lambda \times f$$

---

## Understanding the Relationship: Speed, Frequency, and Wavelength

The core equation:

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

indicates that the wavelength is inversely proportional to the frequency—meaning, as the frequency increases, the wavelength decreases, and vice versa.

In the context of radio waves:

- The speed ($v$) is approximately the speed of light ($c$) in a vacuum, about $3.00 \times 10^8$ m/s.
- Since radio waves are electromagnetic, their speed in air or vacuum is practically the same as in free space.

Key Point:
The wavelength can be calculated directly once the frequency is known, using the speed of light for electromagnetic waves.

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## Calculating the Wavelength: Step-by-Step Guide

Given Data:

- Frequency, $f = 2.0 \times 10^6 \text{ Hz}$
- Speed of light, $c = 3.00 \times 10^8 \text{ m/s}$

Step 1: Write down the fundamental equation:

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

Step 2: Substitute the known values:

$$ \lambda = \frac{3.00 \times 10^8 \text{ m/s}}{2.0 \times 10^6 \text{ Hz}} $$

Step 3: Perform the division:

$$ \lambda = \frac{3.00 \times 10^8}{2.0 \times 10^6} $$

Divide the coefficients:

$$ \frac{3.00}{2.0} = 1.5 $$

Subtract exponents:

$$ 10^{8} / 10^{6} = 10^{2} $$

Combine:

$$ \lambda = 1.5 \times 10^{2} \text{ meters} $$

Step 4: Final answer:

$$ \boxed{\lambda = 150 \text{ meters}} $$

This indicates that a radio wave with a frequency of 2.0 MHz has a wavelength of approximately 150 meters.

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## Understanding the Significance of the Result

The calculated wavelength of 150 meters falls within the Very High Frequency (VHF) range of the radio spectrum, which spans from 30 MHz to 300 MHz. Although the example uses a frequency of 2 MHz, which is outside the typical VHF range and actually falls into the Longwave or AM broadcast bands, the principle remains the same across the spectrum.

Implications of the Wavelength:

- Propagation Characteristics: Longer wavelengths, such as 150 meters, tend to diffract around obstacles and follow the Earth's curvature, making them suitable for long-distance communication.
- Antenna Design: The wavelength influences the size of antennas; a common rule of thumb is that the length of a simple dipole antenna is approximately half the wavelength (~75 meters in this case).
- Frequency Allocation: Different frequencies and wavelengths are allocated for various applications like broadcasting, navigation, and emergency services.

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## Practical Examples and Applications

Example 1:
A radio station broadcasts at 2 MHz. What is the approximate size of the antenna needed?

- Using the calculated wavelength:

$$ \text{Antenna length} \approx \frac{\lambda}{2} = \frac{150 \text{ m}}{2} = 75 \text{ meters} $$

Example 2:

Understanding signal reach: Longer wavelengths can travel longer distances, especially at night, due to reflections off the ionosphere.

Application in Communications:

Knowing the wavelength helps engineers design antennas and transmission systems optimized for specific frequency bands to maximize coverage and clarity.

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## Extended Concepts for Deeper Understanding

1. Wavelengths and the Electromagnetic Spectrum:

Radio waves cover a broad spectrum from very long wavelengths (kilometers) to very short (millimeters). The calculated 150-meter wavelength places our example in the lower spectrum, used for AM radio, maritime navigation, and some communication systems.

2. Frequency Modulation and Wavelength:

Modulating the carrier wave's frequency or amplitude allows data transmission. The wavelength determines how the wave interacts with objects and how easily it can be focused or dispersed.

3. Wave Propagation Modes:

- Ground waves: follow the Earth's surface, effective at lower frequencies (longer wavelengths).
- Skywaves: reflected off the ionosphere, useful for long-distance communication at certain frequencies.

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## Summary and Key Takeaways

- The wavelength of a wave is inversely related to its frequency via the speed of light: \( \lambda = c/f \).
- For a radio wave with a frequency of 2.0 x 10^6 Hz, the wavelength is approximately 150 meters.
- This calculation is fundamental in designing antennas, understanding propagation characteristics, and optimizing communication systems.
- Recognizing the relationship between frequency and wavelength enables engineers and scientists to tailor wireless systems for specific applications.

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## Final Thoughts

Understanding how to calculate the wavelength of a radio wave from its frequency is a fundamental skill that bridges physics and engineering. Whether you're designing a new communication system, studying electromagnetic wave behavior, or simply exploring the nature of radio signals, grasping this relationship provides valuable insight into how electromagnetic waves operate in our daily lives. Remember, the key formula—wavelength equals speed of light divided by frequency—serves as a powerful tool across a wide spectrum of scientific and technological disciplines.

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Note: Always ensure your units are consistent when performing these calculations. For electromagnetic waves in a vacuum, using the speed of light (~3.00 x 10^8 m/s) simplifies the process.

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