Calculating the Speed of Mechanical Waves

Content and Vocabulary Support

Period, Frequency, and Wavelength

Any motion that repeats at regular time intervals is called periodic motion. An example of periodic motion is an ocean wave. One complete motion that returns to its starting point is called a cycle. The time needed for one cycle is called the period. The frequency of a periodic motion is the number of cycles in a given time. Frequency is measured in cycles per second, or hertz (Hz). The frequency of the vibrating source producing a wave determines the wave’s frequency.

Wavelength, usually measured in meters, is the distance between a point on a wave and the same point on the next cycle of the wave. For transverse waves, wavelength is the distance between adjacent crests or troughs. For longitudinal waves, wavelength is the distance between adjacent compressions or rarefactions. Increasing the frequency of a wave decreases its wavelength. In other words, when wavelength is shorter, crests or compressions are closer together.

Wave Speed

Recall that you can calculate the speed of a moving object by dividing the distance it travels by the time it takes to travel that distance. In a similar way, you can calculate the speed of a wave. Wave speed is wavelength divided by period:

\[ \text{Speed} = \frac{\text{Wavelength}}{\text{Period}} \]

Because period is the inverse of frequency (Period = \( \frac{1}{\text{Frequency}} \)), you can also calculate the speed of a wave by multiplying its wavelength by its frequency:

\[ \text{Speed} = \text{Wavelength} \times \text{Frequency} \]

Knowing any two variables in one of the speed equations allows you to find the third variable.
Section 17.2 Properties of Mechanical Waves

Solved Examples

Example 1: A wave in a spring has a wavelength of 0.1 meters and a period of 0.2 seconds. What is the speed of the wave?

Given: Wavelength = 0.1 m
       Period = 0.2 s

Unknown: Speed

Equation: \( \text{Speed} = \frac{\text{Wavelength}}{\text{Period}} \)

Solution: \( \text{Speed} = \frac{0.1 \text{ m}}{0.2 \text{ s}} = 0.5 \text{ m/s} \)

Example 2: What is the speed of an ocean wave that has a wavelength of 4.0 meters and a frequency of 0.5 hertz?

Given: Wavelength = 4.0 m
       Frequency = 0.5 Hz

Unknown: Speed

Equation: \( \text{Speed} = \text{Wavelength} \times \text{Frequency} \)

Solution: \( \text{Speed} = 4.0 \text{ m} \times 0.5 \text{ Hz} = 2.0 \text{ m/s} \)

Example 3: Find the wavelength of a wave in a rope that has a frequency of 2.0 hertz and a speed of 0.4 meters per second.

Given: Frequency = 2.0 Hz
       Speed = 0.4 m/s

Unknown: Wavelength

Equation: \( \text{Speed} = \text{Wavelength} \times \text{Frequency} \)

Solution: Solve the equation for wavelength:

\[ \text{Wavelength} = \frac{\text{Speed}}{\text{Frequency}} \]

Substitute the given values:

\[ \text{Wavelength} = \frac{0.4 \text{ m/s}}{2.0 \text{ Hz}} \]
Practice Exercises

Exercise 1: What is the speed of an ocean wave that has a wavelength of 0.30 meters and a frequency of 1.80 hertz?

Exercise 2: Calculate the frequency of a wave in a spring toy. The wave has a speed of 1.1 meters per second and a wavelength of 0.1 meters.

Exercise 3: A wave ripples through a large flag when the wind blows steadily. What is the wavelength of the wave if its frequency is 12.0 hertz and its speed is 1.2 meters per second?

Exercise 4: If a wave in a long rope has a period of 1.0 second and a wavelength of 0.2 meters, what is its speed?

Exercise 5: What is the period of a wave generated by an earthquake, if it has a wavelength of 500 meters and a speed of 5,000 meters per second?