Teacher: Mr. Cox Subject: Physics

Options for credit this week

Suggested online resources

- *If you have Google Classroom, please complete the assignment online, however here is a paper copy of the material.*
- *All online resources for this week will be through CK12.org. Please explore the different options below the adaptive practices, such as the PLIX, Simulations, and Real World Demonstrations.*

No-Tech/Low-Tech Activities

- *Notes have been provided for WaveLength, Wave Frequency, and Wave Speed.*
- *Complete the end of note questions on a separate sheet of paper with any additional questions you may have about the section.*
- *Lastly, complete the 10 Question Practices to show understanding of the work. The answers to the odd number problems have been provided for WaveLength and Wave Frequency.*
- *COVID-19 journal - Write 3-5 sentences on what Science you have seen this week in regards to COVID-19. Be specific and remember to document where you received your information.*

Instructions for Attached Assignments

- *Complete the end of note questions in GOOGLE DOCS and attach it to the assignment within Google Classroom along with any additional questions you may have about the section. For those receiving paper copies, write the answers to the questions on the back of the Adaptive Practice question sheets toward the end of the packet.*

- *Next, complete the Adaptive Practice Question to show understanding of the work. The answers to the odd number problems have been provided for WaveLength and Wave Frequency.*

- *COVID-19 journal - Write 3-5 sentences on what Science you have seen this week in regards to COVID-19. Be specific and remember to document where you received your information.*

Waves

Physics

Big Picture

Waves transfer energy between two points in space without transferring any actual matter. For example, when a rock is dropped into a pond, the waves that emanate from the point of impact are transferring the rock's kinetic energy to the edge of the pond. All waves are the result of some sort of vibration. Sound waves result from the macroscopic vibrations of objects, and electromagnetic waves result from the vibrations of electrons in atoms. Similar to simple harmonic motion, the motion of waves can be mathematically modeled by sine and cosine curves.

Key Terms

Note: Some of the terms from the *Simple Harmonic Motion* study guide are also used in the description of waves. The explanations for period, frequency, and amplitude can be found there.

Mechanical Wave: Needs a medium to travel through.

Transverse Wave: Energy is transferred by particles vibrating perpendicular to the direction the wave is traveling.

Longitudinal Wave: Energy is transferred by particles vibrating in the same direction as the wave's motion.

Interference: When two waves of the same type meet, they combine to create a larger or smaller wave.

Destructive Interference: When two waves meet, if one is at the highest point in its vibration (crest) and another is at its lowest (trough), they cancel each other out so no wave appears at this point.

Constructive Interference: If the waves meet when they are both at their crests, their amplitudes will add together so that there appears to be a very large wave at that point.

Beat Frequency: The difference in frequencies when waves with two different frequencies interfere.

Standing Wave: A wave that stays in a constant position. They are the result of interference between two waves traveling in different directions.

Node: Location of complete destructive interference between the the incident (initial) wave and the reflected wave. The wave does not move at a node.

Antinode: Location of complete constructive interference. The wave will have the greatest displacement at an antinode.

Resonance: When an object is shaken or pushed at a frequency that matches its natural frequency.

Doppler Effect: When there is an apparent change in a wave's frequency due to the relative motion of either the source of the wave or the observer.

Mechanical Waves

Mechanical waves travel through a substance called a medium.

- Examples include sound waves (travel through air), and seismic waves (travel through the ground).
- Mechanical waves cannot transfer energy if there is no medium between the origin of the wave and its destination.
- Speed of a wave depends on the medium.

Two main types of mechanical waves are **transverse waves** and **longitudinal waves**.

Waves on the surface of water are an example of transverse waves. The water molecules move perpendicular to the surface of the water (up and down) to transfer the energy, while the wave itself moves along the surface.

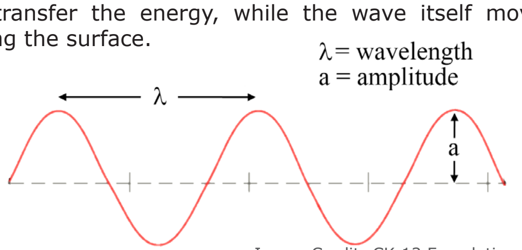


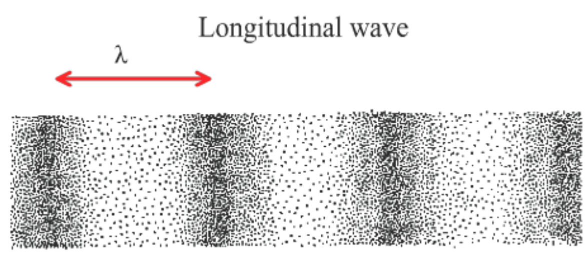
Image Credit: CK-12 Foundation CC-BY-NC

- crest - highest point of the wave
- trough - lowest point of the wave
- amplitude - distance between the equilibrium position and the crest (or trough)
- wavelength - distance between identical positions on two successive waves

Have you ever seen people in a stadium do the wave? The wave travels around the stadium, but the people do not.

We can visualize a longitudinal wave by laying a spring (such as a Slinky) on the ground, stretching it out, then pushing one end of the spring. The compression travels up the spring.

Sound waves are longitudinal mechanical waves that propagate through air. Sound waves are caused by vibrations in objects and exist as differences in pressure. They can be thought of as vibrations in the medium the sound waves are traveling through. The vibrations in air cause our ear drums to vibrate, which our brain interprets as sound. The speed at which sound waves travel depends on the medium which they're passing through. Sound travels fastest through solids, and slowest through gases, but it varies with each substance. Below is a diagram of a sound wave, where the dots represent air molecules.



Waves cont.

Wave Behavior

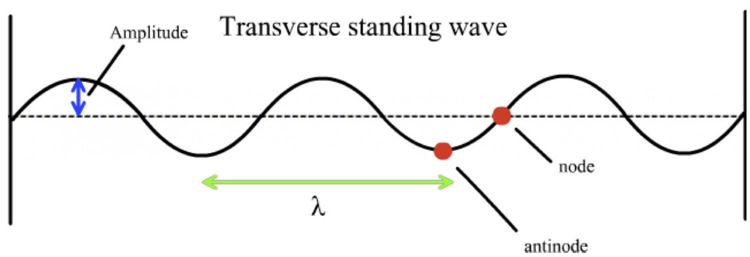
Two waves can interact by **interference**. Interference does not create any lasting change in either wave, but at the place where the waves meet, the amplitude of the two waves will merge.

Image Credit: Wjh31, Quibik, CC-BY-SA 3.0

In physics, beats are the result of interference between sound waves. When two slightly different frequencies are emitted together, there will be both constructive and destructive interference which results in the sound alternating between loud and soft. The **beat frequency** is the difference of the two frequencies.

When a wave reaches a barrier, it is reflected and travels back the way it came.

- If the wave is not allowed to move at the barrier (a hard boundary), the wave will invert when it reflects back. Under the right conditions, a **standing wave** can be created. There are two important points in a standing wave: **nodes** and **antinodes**.



- If the wave is allowed to move at the barrier (a soft boundary), the wave will reflect back with the same orientation.

Resonance

All objects have a natural frequency at which they vibrate when struck. We can force an object to vibrate at a specific frequency by sending a sound wave at it. **Resonance** occurs when this forced frequency matches the natural frequency, causing the amplitude of vibration to increase. The idea that high notes can shatter glass comes from this idea - if a singer hits the right frequency, she can cause glass to resonate and shatter.

Doppler Effect

The **Doppler effect** occurs when either the wave or an observer is moving.

- If the observer and the source of the wave are moving toward each other, the wave will appear to have a higher frequency. In the case of a sound wave, the wave will seem to have a higher pitch.
- If they're moving away from each other, the wave will appear to have a lower frequency. In the case of a sound wave, the wave will seem to have a lower pitch.

The Doppler effect explains why a police siren sounds higher in pitch when the vehicle is moving towards you.

Important Equations

$v = f\lambda$ v - velocity f - frequency λ - wavelength

$T = \frac{1}{f}$ T - period

Sample

At this level, problems with waves usually involve using the given information about a wave to find its other characteristics.

Sample

If a mechanical wave traveling down a slinky has a period of .5 s, and a wavelength of 1 m, what is the wave's frequency and speed?

Solution

First we'll find the frequency: $f = \frac{1}{T} = \frac{1}{.5\text{ s}} = 2\text{ Hz}$

Then, using the frequency, we can find the speed of the wave. $v = f\lambda = 2\text{ Hz} \cdot 1\text{ m} = 2\text{ m/s}$

CHAPTER 1 Wavelength

Learning Objectives

- Define wavelength.
- Describe the wavelength of transverse and longitudinal waves.
- Relate wavelength to the energy of a wave.

Nobody really has such colorful eyes! The colors were added digitally after the photo was taken. They represent all the different colors of light. Light is a form of energy that travels in waves. Light of different colors has different wavelengths.

Defining Wavelength

Wavelength is one way of measuring the size of waves. It is the distance between two corresponding points on adjacent waves, and it is usually measured in meters. How it is measured is a little different for transverse and longitudinal waves.

- In a transverse wave, particles of the medium vibrate up and down at right angles to the direction that the wave travels. The wavelength of a transverse wave can be measured as the distance between two adjacent crests, or high points, as shown in the **Figure** 1.1.

- In a longitudinal wave, particles of matter vibrate back and forth in the same direction that the wave travels. The wavelength of a longitudinal wave can be measured as the distance between two adjacent compressions, as shown in the **Figure** 1.2. Compressions are the places where particles of the medium crowd close together as the energy of the wave passes through.

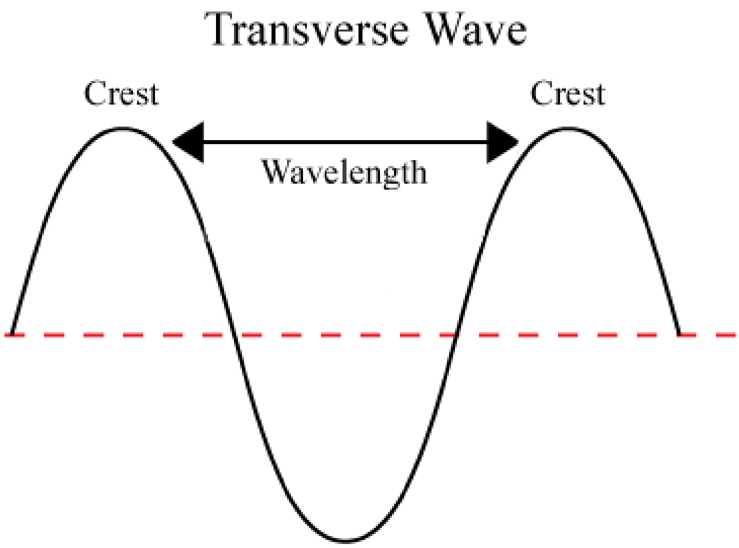


FIGURE 1.1

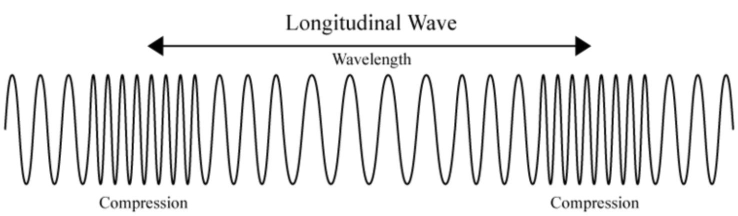


FIGURE 1.2

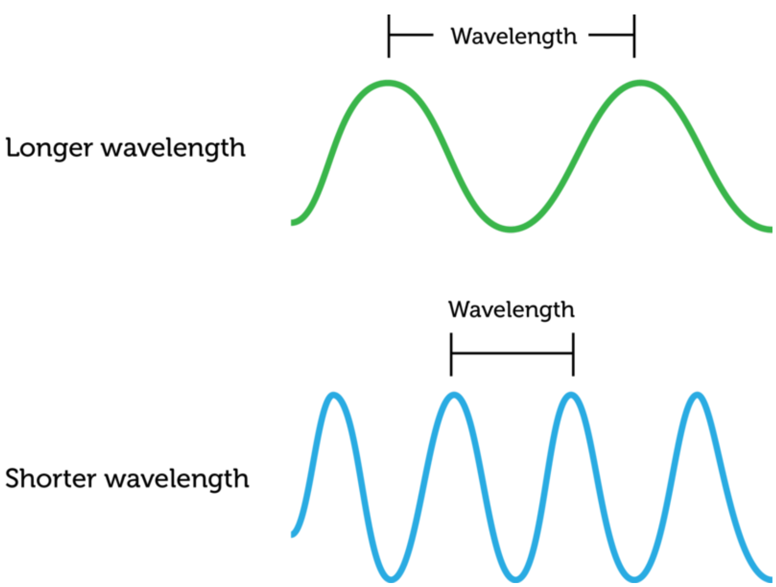


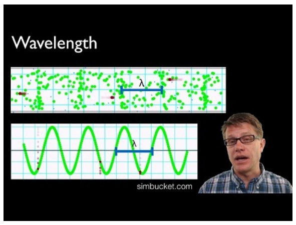
FIGURE 1.3

Wavelength and Wave Energy

The wavelength of a wave is related to the wave's energy. Short-wavelength waves have more energy than long-wavelength waves of the same amplitude. (Amplitude is a measure of how far particles of the medium move up and down or back and forth when a wave passes through them.) You can see examples of transverse waves with shorter and longer wavelengths in the **Figure** 1.3.

Q: Of all the colors of visible light, red light has the longest wavelength and violet light has the shortest wavelength. Which color of light has the greatest energy?

A: Violet light has the greatest energy because it has the shortest wavelength.



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URL: http://www.ck12.org/flx/render/embeddedobject/187517

Summary

- Wavelength is one way of measuring the size of waves. It is the distance between two corresponding points on adjacent waves, usually measured in meters.
- The wavelength of a transverse wave can be measured as the distance between two adjacent crests. The wavelength of a longitudinal wave can be measured as the distance between two adjacent compressions.
- Short-wavelength waves have more energy than long-wavelength waves of the same amplitude.

Review

1. What is the wavelength of a wave?
2. Draw a simple transverse wave and label the wavelength.

References

1. Zachary Wilson. CK-12 Foundation . CC BY-NC 3.0
2. Zachary Wilson;Christopher Auyeung;Selma Broeder. CK-12 Foundation;http://www.flickr.com/photos/selma90/3675162262/ . CC BY-NC 3.0;CC BY 2.0
3. Zachary Wilson;Christopher Auyeung;Selma Broeder. CK-12 Foundation;http://www.flickr.com/photos/selma90/3675162262/ . CC BY-NC 3.0;CC BY 2.0
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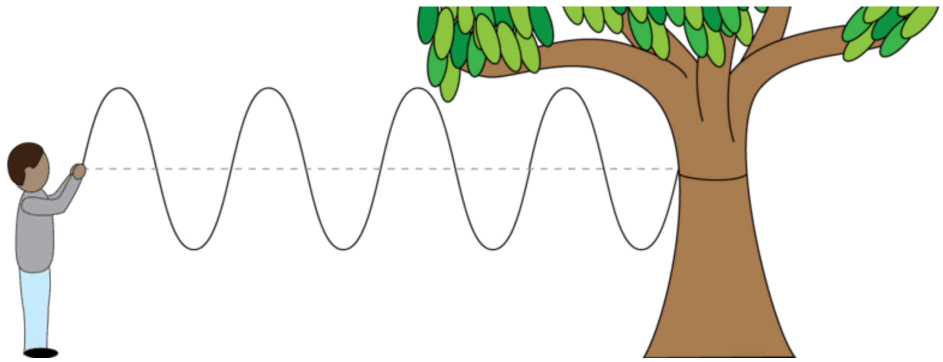
CHAPTER 1 Wave Frequency

Learning Objectives

- Define wave frequency.
- Identify the SI unit for wave frequency.
- Explain how wave frequency is related to the energy of a wave.



Imagine making transverse waves in a rope, like the person in the sketch above. You tie one end of the rope to a tree or other fixed point, and then you shake the other end of the rope up and down with your hand. You can move the rope up and down slowly or quickly. How quickly you move the rope determines the frequency of the waves.

What Is Wave Frequency?

The number of waves that pass a fixed point in a given amount of time is **wave frequency**. Wave frequency can be measured by counting the number of crests (high points) of waves that pass the fixed point in 1 second or some other time period. The higher the number is, the greater the frequency of the waves. The SI unit for wave frequency is the **hertz (Hz)**, where 1 hertz equals 1 wave passing a fixed point in 1 second. The **Figure** 1.1 shows high-frequency and low-frequency transverse waves.

Q: The wavelength of a wave is the distance between corresponding points on adjacent waves. For example, it is the distance between two adjacent crests in the transverse waves in the diagram. Infer how wave frequency is related to wavelength.

A: Waves with a higher frequency have crests that are closer together, so higher frequency waves have shorter wavelengths.

Wave Frequency and Energy

The frequency of a wave is the same as the frequency of the vibrations that caused the wave. For example, to generate a higher-frequency wave in a rope, you must move the rope up and down more quickly. This takes more energy, so a higher-frequency wave has more energy than a lower-frequency wave with the same amplitude. You can see examples of different frequencies in the **Figure** 1.2 (Amplitude is the distance that particles of the medium move when the energy of a wave passes through them.)

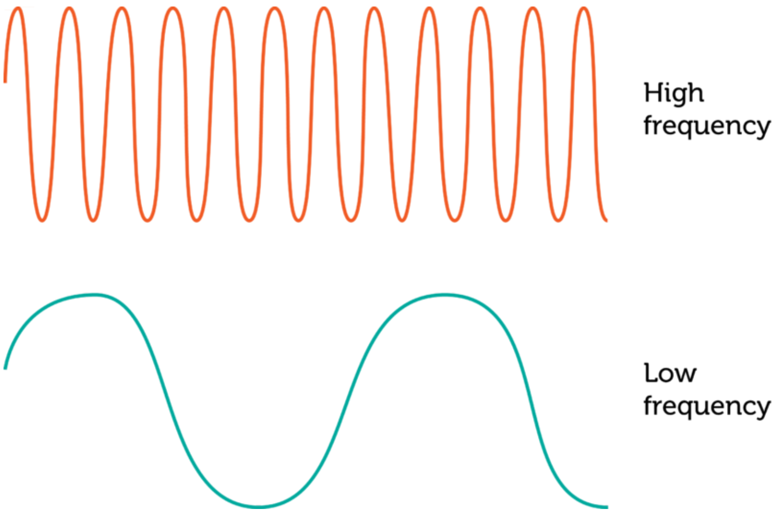


FIGURE 1.1

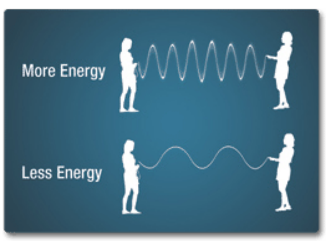
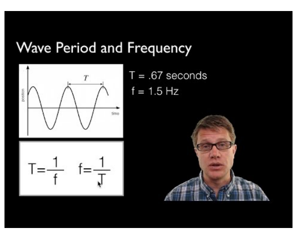


FIGURE 1.2



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Summary

- Wave frequency is the number of waves that pass a fixed point in a given amount of time.
- The SI unit for wave frequency is the hertz (Hz), where 1 hertz equals 1 wave passing a fixed point in 1 second.
- A higher-frequency wave has more energy than a lower-frequency wave with the same amplitude.

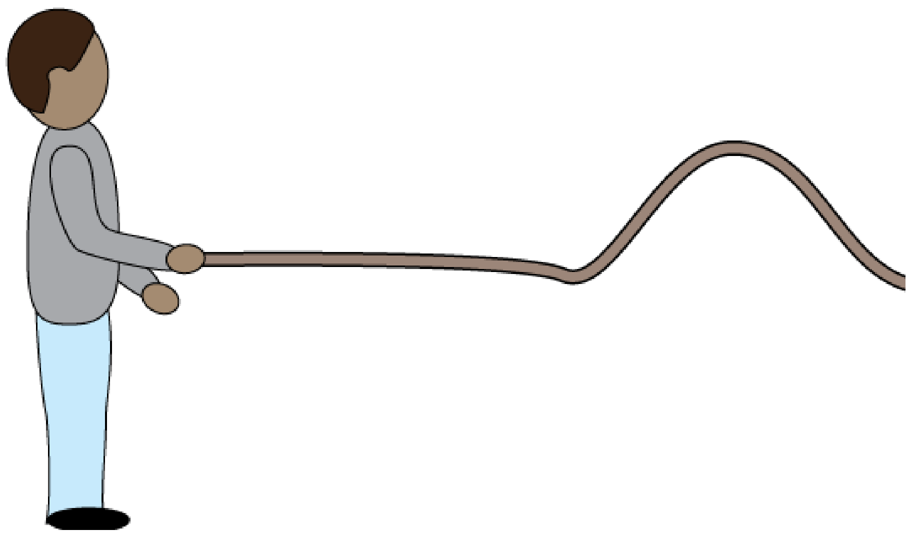
Review

1. What is wave frequency?
2. What is the SI unit for wave frequency?
3. Assume that 10 waves pass a fixed point in 5 seconds. What is the frequency of the waves in hertz?
4. Relate wave frequency to the energy of waves.

CHAPTER 1 Wave Speed

Learning Objectives

- Define wave speed.
- Relate wave speed to wavelength and wave frequency.
- Show how to calculate wave speed.
- Explain how wave speed is related to the medium of a wave.



Assume that you move one end of a rope up and down just once to generate a wave in the rope. How long will take the wave to travel down the rope to the other end? It depends on the speed of the wave.

The Speed of a Wave

Wave speed is the distance a wave travels in a given amount of time, such as the number of meters it travels per second. Wave speed (and speed in general) can be represented by the equation:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Wave Speed, Wavelength, and Wave Frequency

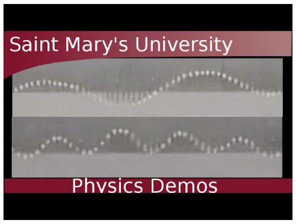
Wave speed is related to both wavelength and wave frequency. Wavelength is the distance between two corresponding points on adjacent waves. Wave frequency is the number of waves that pass a fixed point in a given amount of time. This equation shows how the three factors are related:

$$\text{Speed} = \text{Wavelength x Wave Frequency}$$

In this equation, wavelength is measured in meters and frequency is measured in hertz (Hz), or number of waves per second. Therefore, wave speed is given in meters per second, which is the SI unit for speed.

Q: If you increase the wavelength of a wave, does the speed of the wave increase as well?

A: Increasing the wavelength of a wave doesn't change its speed. That's because when wavelength increases, wave frequency decreases. As a result, the product of wavelength and wave frequency is still the same speed.



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Calculating Wave Speed from Wavelength and Wave Frequency

The equation for wave speed can be used to calculate the speed of a wave when both wavelength and wave frequency are known. Consider an ocean wave with a wavelength of 3 meters and a frequency of 1 hertz. The speed of the wave is:

Speed = 3 m x 1 wave/s = 3 m/s

Q: Kim made a wave in a spring by pushing and pulling on one end. The wavelength is 0.1 m, and the wave frequency is 2 hertz. What is the speed of the wave?

A: Substitute these values into the equation for speed:

Speed = 0.1 m x 2 waves/s = 0.2 m/s

Calculating Wave Frequency or Wavelength from Wave Speed

The equation for wave speed (above) can be rewritten as:

$$\text{Frequency} = \frac{\text{Speed}}{\text{Wavelength}} \text{ or Wavelength} = \frac{\text{Speed}}{\text{Frequency}}$$

Therefore, if you know the speed of a wave and either the wavelength or wave frequency, you can calculate the missing value. For example, suppose that a wave is traveling at a speed of 2 meters per second and has a wavelength of 1 meter. Then the frequency of the wave is:

$$\text{Frequency} = \frac{2\text{m/s}}{1\text{m}} = 2 \text{ waves/s, or } 2 \text{ Hz}$$

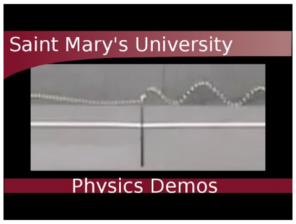
Q: A wave is traveling at a speed of 2 m/s and has a frequency of 2 Hz. What is its wavelength?

A: Substitute these values into the equation for wavelength:

$$\text{Wavelength} = \frac{2\text{m/s}}{2\text{waves/s}} = 1 \text{ m}$$

The Medium Matters

The speed of most waves depends on the medium, or the matter through which the waves are traveling. Generally, waves travel fastest through solids and slowest through gases. That's because particles are closest together in solids and farthest apart in gases. When particles are farther apart, it takes longer for the energy of the disturbance to pass from particle to particle through the medium.



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URL: http://www.ck12.org/flx/render/embeddedobject/82409

Launch the Doppler Ducks simulation below to visualize how wave speed is related to both wavelength and wave frequency. Adjust the duck velocity slider to change how quickly the duck moves through the water. Remember that positive velocities are rightward and negative velocities are leftward. Try playing around with having the duck go faster or slower than the wave speed, or towards or away from the boat.

SIMULATION

Learn about the Doppler Effect in the context of a duck swimming across a pond.

URL: http://www.ck12.org/physics/doppler-effect/simulationint/Doppler-Ducks

Further Reading

- Wave Equation
- Types of Waves
- Mechanical Wave
- Surface Wave

Summary

- Wave speed is the distance a wave travels in a given amount of time, such as the number of meters it travels per second.
- Wave speed is related to wavelength and wave frequency by the equation: Speed = Wavelength x Frequency. This equation can be used to calculate wave speed when wavelength and frequency are known.
- The equation for wave speed can be written to solve for wavelength or frequency if the speed and the other value are known.
- The speed of most waves depends on the medium, or the matter through which they are traveling. Generally, waves travel fastest through solids and slowest through gases.

Review

1. What is wave speed?

2. What is the speed of a wave that has a wavelength of 2 m and a frequency of 1.5 Hz?
3. Calculate the frequency of a wave that is traveling at a speed of 3.0 m/s and has a wavelength of 1.2 m.
4. Sound energy travels through matter in waves. Do sound waves travel faster through air or water? Explain your answer.

- **Wave speed:** the distance a wave travels in a given amount of time, such as the number of meters it travels per second.

References

1. Zachary Wilson. CK-12 Foundation . CC BY-NC 3.0

Wavelength Practice Worksheet

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1. If an ocean wave has a frequency of 2 waves/s and a speed of 4 m/s, what is its wavelength?
   _____m

   Answer:

2. Wavelength usually is measured in meters.

   TRUE or FALSE:

3. In a transverse wave, wavelength can be measured as the distance between

   a. two adjacent crests.
   b. a crest and the adjacent trough.
   c. a crest and the resting position.
   d. none of the above.

4. _____ describes the length of one complete wave cycle.

   Answer:

5. In a longitudinal wave, wavelength can be measured as the distance between

   a. two adjacent compressions.
   b. a compression and the next resting place.
   c. both.
   d. none of the above.

6. For waves of the same amplitude, shorter wavelength waves have less energy than longer wavelength waves.

   TRUE or FALSE:

7. The wavelength of visible light determines its color.

   TRUE or FALSE:

8. Fill in the blank(s):
   The wavelength of a transverse wave can be measured as the distance between two adjacent _____________-_______.

9. _____ is the distance between two corresponding points of adjacent waves.

   Answer:

10. The speed of light in air is $3.00 \times 10^8 m/s$. If a light wave has a wavelength of $5.80 \times 10^{-7} m$, what is its frequency?

    a. $4.17 \times 10^4 Hz$
    b. $5.17 \times 10^{-14} Hz$
    c. $5.17 \times 10^{14} Hz$
    d. $2.17 \times 10^{15} Hz$

Answer Keys to Odd problems

1. 2 , 2 m , 2 meter , 2 meters
2. ....
3. two adjacent crests.
4. ....
5. two adjacent compressions.
6. ....
7. TRUE
8. ....
9. Wavelength
10. ....

Wave Frequency Practice Worksheet

Visit CK12.org for Free Online Practice

1. The frequency of four different waves is listed below. Which wave has the most energy?
   a. 20 Hz.
   b. 1000 Hz.
   c. 200 Hz.
   d. 2000 Hz.

2. A higher-frequency wave has more energy than a lower-frequency wave with the same amplitude.

   TRUE or FALSE:

3. For waves of the same amplitude, a higher frequency wave has less energy than a lower frequency wave.

   TRUE or FALSE:

4. Assume that 10 waves pass a fixed point in 5 seconds. What is the frequency of the waves in hertz?
   a. 5 Hz
   b. 2 Hz
   c. 4 Hz
   d. 10 Hz

5. What is the SI unit for wave frequency?

   Answer:

6. The SI unit of hertz equals one wave passing a fixed point in one __________.

   Answer:

7. What is the SI unit for wave frequency? (Spell out the answer. Do not give the symbol.)

   Answer:

8. If 20 waves pass a fixed point in 10 seconds, the frequency of the waves is
   a. 2 Hz.
   b. 20 Hz.
   c. 200 Hz.
   d. 100 Hz.

9. The frequency of a wave is the same as the frequency of vibrations that caused the wave.

   TRUE or FALSE:

10. Fill in the blank(s):
    Wave ____________________ is the number of waves that pass a fixed point in a given amount of time.

Answer Keys

1. 2000 Hz.
2. ....
3. FALSE
4. ....
5. Hertz , Hz
6. ....
7. hertz
8. ....
9. TRUE
10. ....

Wave Speed Practice Worksheet

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1. Which of the following can cause the change in the velocity of a sound wave?
   a. the change in temperature of the medium that the wave travels in
   b. the loudness of sound
   c. the amplitude of the wave
   d. the medium that the wave travels in
   e. More than one of the above.

2. Which type of wave requires a material medium through which to travel?
   a. sound
   b. television
   c. radio
   d. x ray
   e. none of the above

3. Speed can be calculated with the equation
   a. Speed $=$ Distance $\times$ Time.
   b. Speed $=$ Distance$/$Time.
   c. Speed $=$ Time$/$Distance.
   d. None of the above

4. Which of the following is the main factor affecting the speed of a sound wave?
   a. the frequency of sound
   b. the loudness of sound
   c. the wavelength of the wave
   d. the medium that the wave travels in
   e. None of the above

5. If the sound wave changing medium from a steel to water, which of the following will happen?
   a. It will travel faster.
   b. It will travel slower.
   c. The speed of the wave will stay the same.
   d. The frequency will change.
   e. None of the above.

6. What is the speed of a wave that has a wavelength of 2 m and a frequency of 1.5 Hz?

a. 5 m/s
b. 2 m/s
c. 3 m/s
d. 8 m/s

7. If the temperature of water in which the sound wave travels increases from 10[U+2103] to 50[U+2103], what will happen?

a. It will travel faster.
b. It will travel slower.
c. The speed of the wave will stay the same.
d. The frequency will change.
e. None of the above.

8. If the wavelength of a water wave decreases, what will happen to its velocity?

a. It will increase
b. It will decrease
c. It will stay the same
d. It will fluctuate
e. None of the above is correct

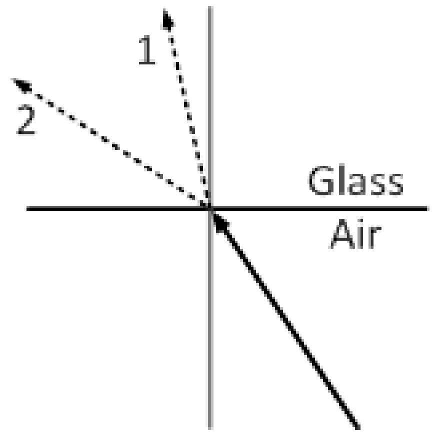
9. What is the length of a string with a mass of 2.5 kg, with a tension of 20 N, if the speed of wave on the string is 2 m/s?

a. 0.4 m
b. 1.0 m
c. 0.1 m
d. 0.8 m
e. 0.5 m

10.

Which of the following is most likely about the ray of light entering glass from air in the diagram?

a. It will take route 1 with a higher frequency



10. Which of the following is most likely about the ray of light entering glass from air in the diagram?

a. It will take route 1 with a higher frequency
b. It will take route 1 with a lower frequency
c. It will take route 1 with an unchanged frequency
d. It will take route 2 with a lower frequency
e. It will take route 2 with a higher frequency