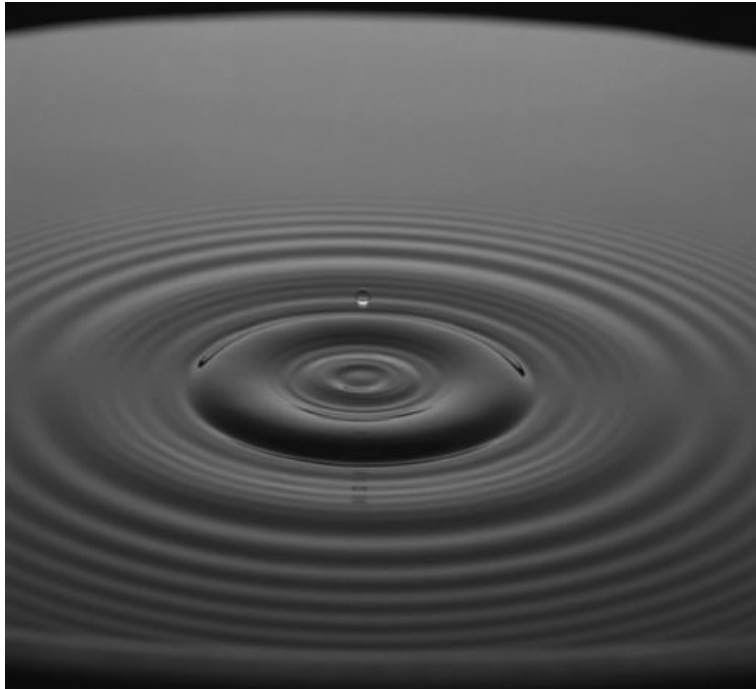


# Waves

## Teacher's Guide Grades 5-9



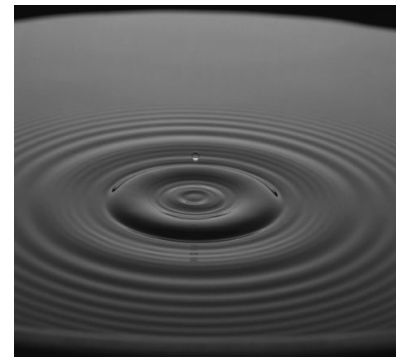
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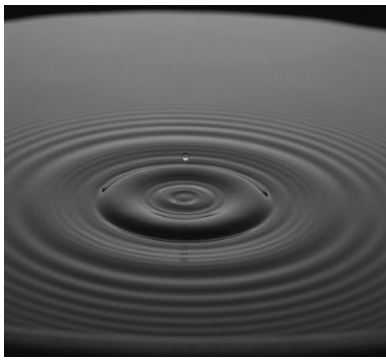
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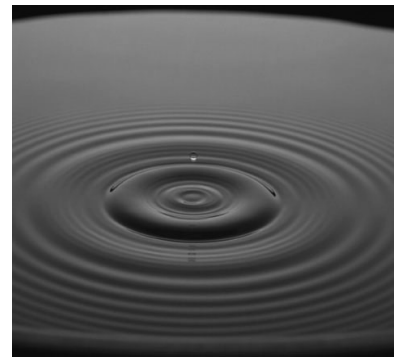
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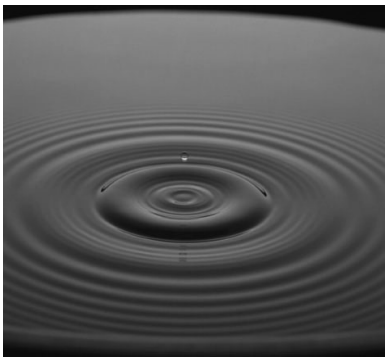
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# A Message from our Company . . .

Dear Educator:

Thank you for your interest in the educational videos produced by the *Visual Learning Company*. We are a Vermont-based, family owned and operated business specializing in the production of quality educational science videos and materials.

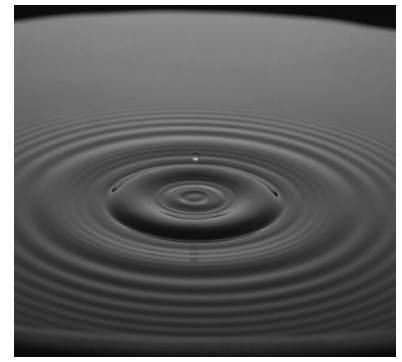
We have a long family tradition of education. Our grandmothers graduated from normal school in the 1920's to become teachers. Brian's mother was an elementary teacher and guidance counselor, and his father was a high school teacher and superintendent. This family tradition inspired Brian to become a science teacher and to earn a Ph.D. in education, and lead Stephanie to work on science educational programs at NASA.

In developing this video, accompanying teacher's guide, and student activities, our goal is to provide educators with the highest quality materials, thus enabling students to be successful. In this era of more demanding standards and assessment requirements, supplementary materials need to be curricular and standards based - this is what we do!

Our videos and accompanying materials focus on the key concepts and vocabulary required by national and state standards and goals. It is our mission to help students meet these goals and standards, while experiencing the joy and thrill of science.

Sincerely,

Brian and Stephanie Jerome



---

# National Standards Correlations

## National Science Education Standards

(Content Standards: 5-8, National Academy of Sciences, c. 1996)

Science as Inquiry - Content Standard A:

As a result of activities in grades 5-8, all students should develop:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

As a result of their activities in grades 9-12, all students should develop understanding of how:

- Waves, including sound and seismic waves on water, and light waves, have energy and transfer energy when they interact with matter.
- Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.

## Benchmarks for Science Literacy

(Project 2061 - AAAS, c. 1993)

The Physical Setting - Motion (4F)

By the end of the 8th grade, students should know that:

- Waves can bend around corners, reflect off surfaces, be absorbed by materials they enter and change direction when entering a new material.
- Waves can move at different speeds in different materials.

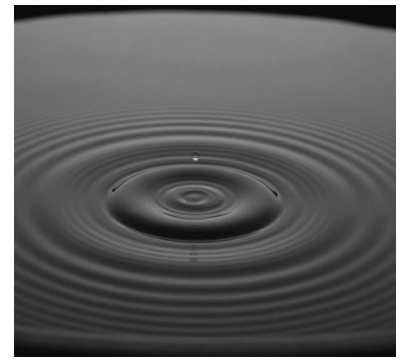


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# Student Learning Objectives

Upon viewing the video and completing the enclosed student activities, students should be able to do the following:

- Explain that a wave is a disturbance that carries energy through matter;
- Identify the parts of a wave, using the terms *amplitude*, *wavelength*, *frequency*, and *crest*;
- Understand that the substance or matter through which a wave travels is called a medium;
- Differentiate between transverse waves and longitudinal waves;
- Understand that the speed of a wave varies depending on the type of wave and the medium through which the wave travels;
- Calculate the speed of a wave using the equation:  $wave\ speed = frequency \times wavelength$ ;
- Identify the four main types of wave interactions and provide an example of each; and
- Differentiate between constructive interference and destructive interference between waves.



# Assessment

## Preliminary Test:

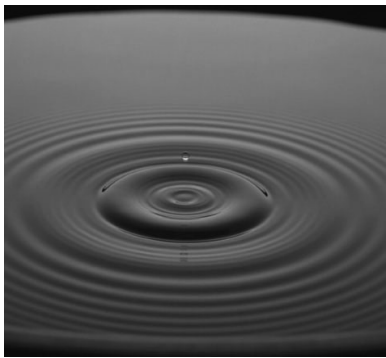
The Preliminary Test, provided in the Student Masters section, is an assessment tool designed to gain an understanding of student preexisting knowledge. It can also be used as a benchmark upon which to assess student progress based on the objectives stated on the previous pages.

## Video Review:

The Video Review, provided in the Student Masters section, can be used as an assessment tool or as a student activity. There are two main parts. The first part contains questions titled “You Decide” that can be answered during the video. The second series of ten questions consists of a video quiz to be answered at the conclusion of the video.

## Post-Test:

The Post-Test, provided in the Student Masters section, can be utilized as an assessment tool following student completion of the video and student activities. The results of the Post-Test can be compared against the results of the Preliminary Test to assess student progress.



---

# Introducing the Video

Ask the students what they think of when they hear the term *waves*. As a class, brainstorm the many different types of waves. Remind students that there are waves we can see with the human eye and waves that are invisible to us. Create a list on the chalkboard of all the examples of different waves. Allow the list to remain on the board throughout the video. After viewing the program, have each student write down a new example of one wave that they learned from the video. Call on students at random to read aloud the new examples and add them to the list on the chalkboard. Discuss the new examples as a class.

## Video Viewing Suggestions

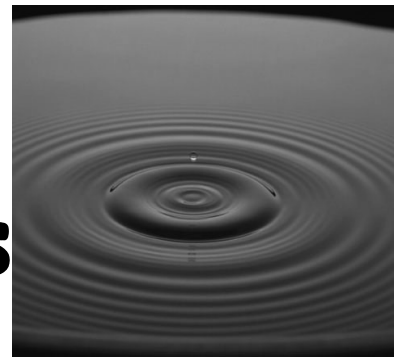
You may want to photocopy and distribute the Student Master, “Video Review.” You may choose to have your students complete this Master while viewing the program or to do so upon its conclusion.

The program is approximately 20-minutes in length and includes a ten-question video quiz. Answers are not provided to the Video Quiz on the video, but are included in this teacher’s guide. You may want to grade student quizzes as an assessment tool or to review the answers in class.

The video is content-rich with numerous vocabulary words. For this reason you may want to periodically stop the video to review and discuss new terminology and concepts.

---

# Student Assessments and Activities

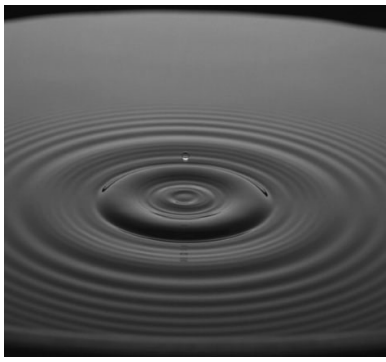


## Assessment Masters:

- Preliminary Test
- Video Review
- Post-Test

## Student Activity Masters:

- Anatomy of a Wave
- Wave Speed
- Everyday Waves
- Rogue Waves
- Wave Interactions
- Vocabulary of *Waves*

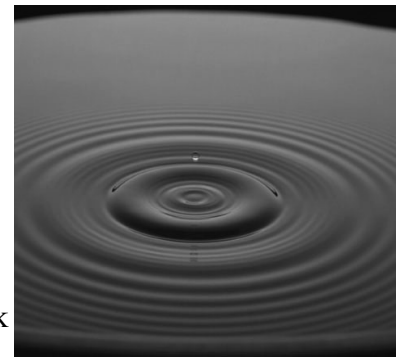


# Video Script- Waves

1. Surfing powerful ocean waves like these takes tremendous skill and strength.
2. Paddling through waves is also a difficult thing to do.
3. What forces create these waves?
4. Why are waves bigger some days than others?
5. And what gives waves such tremendous power?
6. The waves generated by earthquakes are powerful enough in some instances to topple large buildings like this one.
7. And waves generated by explosive devices like these....
8. ...have enough power to blow apart huge slabs of rock.
9. During the next few minutes we are going to explore some of the different types of waves,....
10. ...while also taking a look at the characteristics of waves...
11. ...and how we use waves in our everyday lives.
12. **Graphic Transition – The Nature of Waves**
13. Notice how this grass blowing in the wind creates wavelike patterns.
14. And notice how the waves pound the shore on this stormy day.
15. What is a wave? A wave is a disturbance that carries energy through matter.
16. A wave does not necessarily move the matter, or medium, but instead flows through, or creates a disturbance, in it.
17. Take a look at this ball as the motorboat creates a wave.
18. Notice that the ball does not move forward with the wave but merely moves up and down as the wave moves under it.
19. This demonstrates how a wave carries energy from one place to another through a medium.
20. This can also be illustrated by watching this rope tied to a post. When we shake the rope, notice how...
21. ...it creates a wavelike pattern – transferring energy from one end of the rope to the other.
22. You Decide! What force creates these waves?
23. That's right – wind. If you have ever been to the beach on a windy day, you may have noticed that the waves tend to be bigger...
24. ...than on a calm day.
25. That's because the wind is transferring its energy to the water, causing it to move. You have also probably created waves yourself by kicking your feet in the water.
26. Energy, often in the form of vibration, is necessary to produce waves.
27. For example, when this guitar string is plucked it vibrates back and forth quite quickly.
28. The resulting vibration creates sound waves, which are waves that we can hear as music.

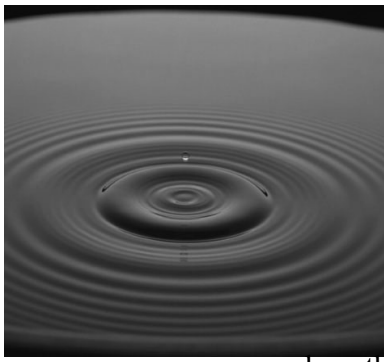
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# Script



## 29. **Graphic Transition – Mediums**

30. Perhaps in the movies you've seen someone put his ear on a train track to listen for a distant, oncoming train. Why?
31. The sound waves from the train travel more quickly through solid materials, such as the train tracks, than they do through the air. Therefore, you can hear the train through the metal tracks before you can hear it through the air.
32. The substance, or matter, through which a wave travels is called a medium.
33. Ocean waves use water as a medium.
34. But water can also serve as a medium for sound waves.
35. For example, whales can hear each other for miles through the water.
36. Mechanical waves require a medium through which to travel.
37. And sound is a type of mechanical wave.
38. There are also waves that do not need a medium through which to travel. These are called electromagnetic waves.
39. You Decide! Can a mechanical wave, such as sound, travel in the vacuum of space?
40. Mechanical waves, such as sound, require a medium or matter to travel through. In space there is little or no medium through which to travel.
41. However, light, such as that from our sun, is an example of an electromagnetic wave that has the ability to travel through the vacuum of space.
42. **Graphic Transition – Wavelength and Frequency.**
43. While there are many different types of waves, all waves have the following characteristics: amplitude, wavelength, and frequency.
44. By studying these parts of waves, we can see what makes different kinds of waves unique.
45. You've probably heard the term wavelength before. It's the distance between a point on one wave and an identical point on the next wave.
46. If you measured the distance between the crest of this wave...
47. ...and the crest on the next wave, you would find the wavelength.
48. Wavelength is usually measured in meters or centimeters.
49. The amount of time it takes for a wave to travel the distance of one wavelength is called the period.
50. You can find the period of the wave by calculating the time it takes for a wave's crest and the crest of the next wave to pass by a point.
51. Frequency is the number of complete waves per unit of time.
52. You can think of frequency as the number of crests that pass a point per second.
53. Frequency is measured in a unit called hertz. One hertz is equivalent to one wave per second and it is symbolized by the letters Hz.
54. The numbers on an FM radio dial are in units of megahertz, symbolized by the term MHz.
55. **Graphic Transition – Amplitude**
56. It's easiest to visualize waves by drawing them on a graph. This horizontal line represents the X-axis and this vertical line represents the Y-axis.



# Script

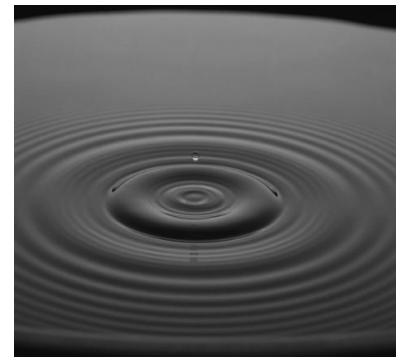
57. This is a wave with a regular pattern.
58. This wave pattern illustrates the rhythmic sound of crickets which produce this sound by rubbing their legs together.
59. This distance from the X-axis to the top of the wave is called amplitude.
60. Amplitude is a measure of the amount of energy carried by a wave.
61. This wave pattern illustrates the sound made by little frogs called peepers. This sound is louder than the cricket's and therefore has greater or higher amplitude.
62. **Graphic Transition – Transverse waves.**
63. You Decide! What do the x-rays that created this image of a hand...
64. ...the microwaves used to cook this food,...
65. ...and radio waves all have in common?
66. These waves are all electromagnetic waves, which are a type of transverse waves.
67. We'll use this rope to illustrate how transverse waves work.
68. Notice that when one end of the rope is shaken, a moving wave forms and the energy is transferred along the rope.
69. While a given piece of the rope moves up and down, the wave moves horizontally.
70. It can be said that the movements are perpendicular or at right angles to each other.
71. This is the defining characteristic of transverse waves – the direction of a transverse wave is at a right angle to the direction the wave travels.
72. Earthquakes are produced when the plates of rocks beneath the surface of the earth move, releasing built-up energy.
73. This energy is transferred throughout the earth in the form of seismic waves.
74. **Graphic Transition – Longitudinal Waves**
75. This slinky is a common toy that easily illustrates longitudinal waves.
76. Watch the slinky closely as one end is pushed. Notice how the wave doesn't move up and down but instead moves horizontally.
77. This diagram describes the action of longitudinal waves in more detail.
78. As the wave moves from left to right, particles collide. This forms an area where particles compress. This collision of particles is called compression.
79. When the particles separate this is called rarefaction. While the particles compress and separate, the wave moves forward.
80. Sound waves are a type of longitudinal wave.
81. Some sound waves can be extremely powerful, such as those produced by airplanes,...
82. ...or explosions from a firecracker, ...
83. ...or in special hammers that are powered by cartridges of gunpowder. All these examples utilize longitudinal waves.
84. **Graphic Transition – Waves Speed**
85. You Decide! Why do you hear the clap of thunder after you see the bolt of lightning?
86. Even though the bolt of lightning and the clap of thunder are produced

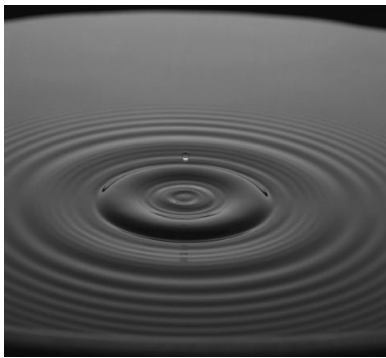
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# Script

at nearly the same time, their waves travel at different speeds.

87. The electromagnetic waves of light from the bolt travel more quickly than the mechanical sound waves of the thunder,...
88. ...causing the flash of light to reach your eyes before the sound reaches your ears.
89. Wave speed varies with the type of waves and with the medium through which waves travel.
90. It's possible to calculate the speed of a wave if we know its frequency and wave length.
91. Wave speed = frequency X wavelength.
92. **Graphic Transition- Reflection**
93. There are four main ways that waves interact with other mediums. These are reflection, refraction, diffraction and interference.
94. You Decide! What happens when you yell across this valley?
95. If you said that you hear an echo, then you're correct.
96. An echo occurs when sound waves bounce back off of an object, like these mountains. This process is called reflection.
97. Reflection is the bouncing back of a wave after it strikes something that does not absorb all of the wave's energy.
98. The incoming wave is called an incident wave.
99. The wave that bounces back is called a reflected wave.
100. Reflection also occurs when you look in a mirror...
101. ...or when you see the reflection of objects in water.
102. **Graphic Transition- Refraction**
103. Waves usually travel in a straight line...
104. ...but what happens when waves pass at an angle from one medium to another?
105. As you can see, the wave bends.
106. When the light wave moves from the air to the water, the wave slows down causing it to bend.
107. The bending of waves due to a change in speed is called refraction.
108. As waves pass at an angle from one medium to another, such as light entering and exiting this diamond, they may speed up or slow down.
109. The speeding up or slowing down of light is what causes refraction.
110. **Graphic Transition- Diffraction**
111. Waves can also bend around the edge of an object.
112. You Decide! What enables you to hear the horn from this car on the other side of this brick building?
113. The answer is diffraction.
114. For example, when you stand in water...
115. ...and you look down at the waves, you notice that some small waves are reflected.
116. But when you look behind your legs, notice how the waves have reformed.
117. This is an example of diffraction.





# Script

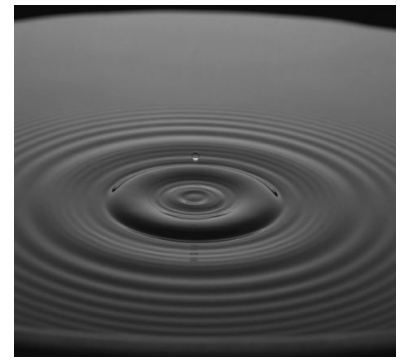
## 118. Graphic Transition- Interference

119. Sometimes two waves meet and combine to form one wave.
120. This is called interference.
121. Constructive interference happens when the crest of one wave meets the crest of the other wave.
122. Destructive interference occurs when two waves combine in such a way that the new wave is smaller than either of the original waves.
123. **Graphic transition- Summing Up**
124. Waves are part of our everyday lives.
125. They allow us to surf on the ocean.
126. They also allow us to hear other people talking...
127. ...and to sense our environment.
128. During the past few minutes we have examined some of the basic characteristics of waves,...
129. ...beginning with the nature of waves.
130. We studied how waves carry energy from one place to another by flowing through a medium.
131. And we took a look at different types of waves, including transverse waves and longitudinal waves.
132. We took a look at the different parts typical of a wave, including wavelength,...
133. ...frequency,...
134. ... and amplitude...
135. ...and how waves interact with matter and each other.
136. So the next time you go to the beach or hear a sound, think about some of the concepts of waves. You just might look at waves a little differently.

## Video Quiz

Fill in the correct word when you hear this tone \_\_\_\_\_. Good luck, and let's get started.

1. A \_\_\_\_\_ is a disturbance that carries energy through a material or medium.
2. \_\_\_\_\_ is necessary to produce waves.
3. The substance or matter through which a wave travels is called a \_\_\_\_\_.
4. \_\_\_\_\_ is the distance in a wave, from the medium to the crest or trough.
5. \_\_\_\_\_ is the distance between the crest and the trough of a wave.
6. \_\_\_\_\_ is the number of complete waves per unit of time.
7. A \_\_\_\_\_ wave is always at a right angle to the direction of the wave.
8. \_\_\_\_\_ is the bouncing back of a wave after it strikes a boundary.
9. \_\_\_\_\_ is the bending of light due to a change in speed.
10. When two waves meet and combine to form one wave it is called \_\_\_\_\_.



---

# Answers to Student Assessments

## Preliminary Test

1. amplitude
2. hertz
3. seismic
4. rarefaction
5. faster
6. incident
7. refracting
8. diffraction
9. constructive
10. energy
11. false
12. true
13. false
14. true
15. true
16. true
17. false
18. false
19. false
20. true

## Video Review

### **You Decide:**

- A. Wind creates the waves at the beach.
- B. No, a mechanical wave requires a medium to travel through.
- C. They are all examples of electromagnetic waves.
- D. Light waves travel faster than sound waves.
- E. The sound waves bounce back off an object to create an echo.
- F. Diffraction allows sound waves produced by the car horn to bend around the brick building.

## **Video Quiz:**

1. wave
2. energy
3. medium
4. amplitude
5. half a wavelength
6. frequency
7. transverse
8. reflection
9. refraction
10. interference

## Post Test

1. true
2. false
3. true
4. true
5. false
6. false
7. false
8. true
9. true
10. false
11. refracting
12. faster
13. energy
14. hertz
15. constructive
16. rarefaction
17. amplitude
18. seismic
19. incident
20. diffraction



# Answers to Student Activities

**Anatomy of a Wave**

Part 1:

1. line of origin
2. trough
3. wavelength
4. amplitude
5. crest

Part 2:

Drawings will vary by student.

**Conclusions:**

- A. Waves with high frequencies tend to have short wavelengths. The wave with the shortest wavelength is wave #4, indicating that it will probably have the highest frequency.
- B. Waves with the low frequencies tend to have long wavelengths. Wave #3 has the longest wavelength, indicating that wave #3 will probably have the lowest frequency.

**Wave Speed****Conclusions:**

1. Wavelength = 3 meters  
Speed = 6 meters/sec  
Frequency = 2 hertz
2. Wavelength = 1 meter  
Speed = 6 meters/sec  
Frequency = 6 hertz
3. Wavelength = 0.7 meters  
Speed = 240.8 meters/sec  
Frequency = 344 Hertz
4. You would have 6 seconds to make it to higher ground.

**Everyday Waves**

Answers will vary.

**Rogue Waves****Conclusions:**

Part I

1. B
2. D
3. C
4. E

Part II

1. F
2. T
3. T
4. F
5. F

Part III

Answers will vary.

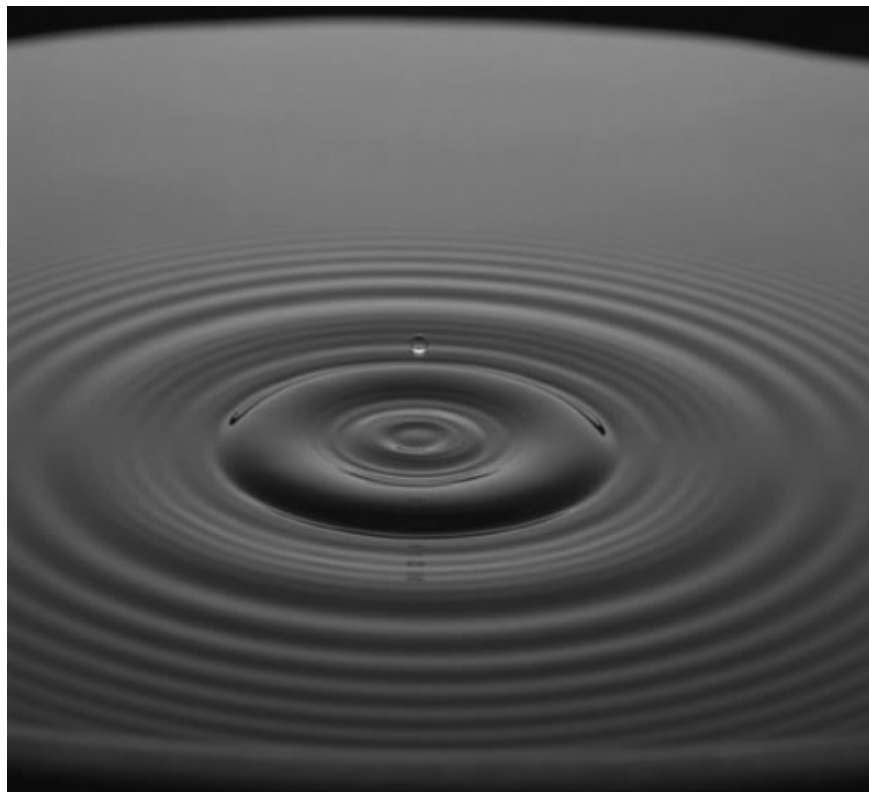
**Wave Interactions****Conclusion:**

- A. The angles of entrance and exit are the same. With reflection, light bounces off objects at the same angle with which they hit, regardless of speed and starting point.
- B. With the first attempt, the students' aim should have been off, causing the penny to drop to the side of the cup. This occurs because refraction bends the light when it changes mediums. When the light passes from air into water, the ray of light bends and makes the cup appear to be in a different spot than it actually is.

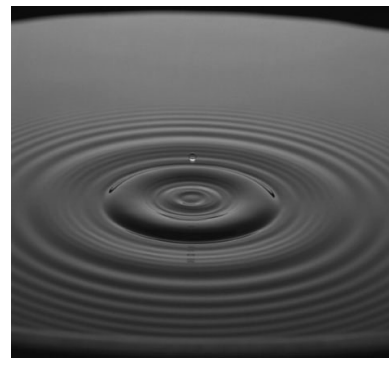
**Vocabulary**

1. period, j
2. constructive, f
3. wave speed, g
4. refraction, h
5. frequency, c
6. reflection, a
7. diffraction, e
8. vacuum, b
9. transverse wave, i
10. rarefaction, d

# **Assessment and Student Activity Masters**



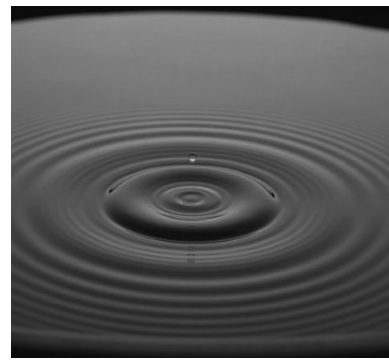
# Preliminary Test



**Directions:** Fill in the blank with the correct word. A list of possible answers is provided at the bottom of the page.

1. \_\_\_\_\_ is a measure of the amount of energy carried by a wave.
2. Frequency is measured in units called \_\_\_\_\_.
3. A \_\_\_\_\_ wave transfers energy throughout the earth.
4. \_\_\_\_\_ refers to the separation of particles in a compression wave.
5. Light travels \_\_\_\_\_ than sound.
6. An \_\_\_\_\_ wave is an incoming wave.
7. A \_\_\_\_\_ wave is a wave that bends.
8. \_\_\_\_\_ is the bending of light around an object.
9. The joining of two separate waves to create a larger wave is called \_\_\_\_\_ interference.
10. \_\_\_\_\_ is needed to produce waves.

faster	incident
diffraction	seismic
disturbance	refracting
slower	hertz
energy	rarefaction
amplitude	constructive



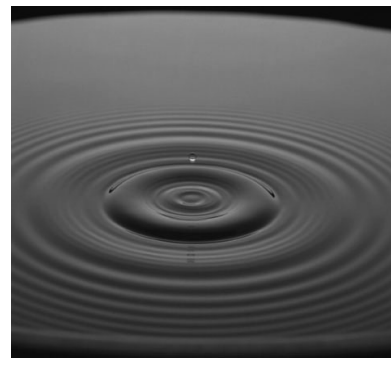
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# Preliminary Test

**Directions:** Decide whether the answer is True (T) or False (F).

- |                                                                                                                     |   |   |
|---------------------------------------------------------------------------------------------------------------------|---|---|
| 11. Sound travels faster than light.                                                                                | T | F |
| 12. Some form of energy is needed to create a wave.                                                                 | T | F |
| 13. Electromagnetic waves cannot travel through a vacuum.                                                           | T | F |
| 14. Amplitude measures the amount of energy carried by a wave.                                                      | T | F |
| 15. A longitudinal wave is a wave that compresses and rarefacts.                                                    | T | F |
| 16. An earthquake produces seismic waves.                                                                           | T | F |
| 17. The combining of two waves to form one wave is called diffraction.                                              | T | F |
| 18. Light travels at the same speed through different mediums.                                                      | T | F |
| 19. Sound waves can travel in a vacuum.                                                                             | T | F |
| 20. Wavelength can be found by measuring the distance between the crest of one wave and the crest of the next wave. | T | F |

# Video Review



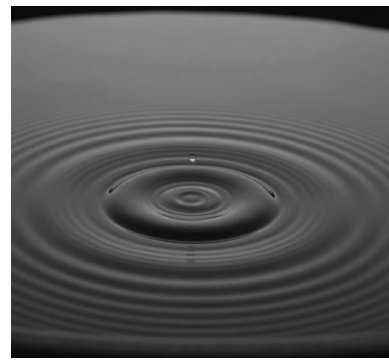
**Directions:** During the course of the program, answer the “You Decide” questions as they appear. Answer the Video Quiz questions at the end of the video.

**You Decide:**

- A. What force creates these waves? Answer: \_\_\_\_\_
- B. Can a mechanical wave, such as sound, travel in the vacuum of space? Answer: \_\_\_\_\_
- C. What do the x-rays that created the image of a hand, the microwaves used to cook this food, and radio waves all have in common? Answer: \_\_\_\_\_
- D. Why do you hear the clap of thunder after you see the bolt of lightning? Answer: \_\_\_\_\_
- E. What happens when you yell across this valley? Answer: \_\_\_\_\_
- F. What enables you to hear the horn from this car on the other side of this brick building? Answer: \_\_\_\_\_

**Video Quiz:**

1. A \_\_\_\_\_ is a disturbance that carries energy through a material or medium.
2. \_\_\_\_\_ is necessary to produce waves.
3. The substance or matter through which a wave travels is called a \_\_\_\_\_.
4. \_\_\_\_\_ is the distance in a wave from the medium to the crest or trough.
5. \_\_\_\_\_ is the distance between the crest and the trough of a wave.
6. \_\_\_\_\_ is the number of complete waves per unit of time.
7. A \_\_\_\_\_ wave is always at a right angle to the direction of the wave.
8. \_\_\_\_\_ is the bouncing back of a wave after it strikes a boundary.
9. \_\_\_\_\_ is the bending of light due to a change in speed.
10. When two waves meet and combine to form one wave it is called \_\_\_\_\_.

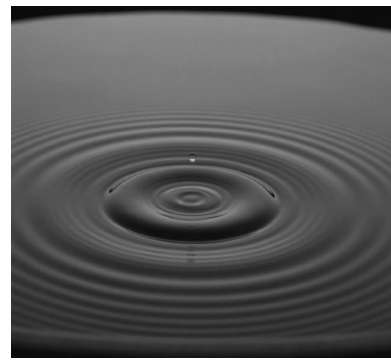


# Post Test

**Directions:** Decide whether the answer is True (T) or False (F).

1. A longitudinal wave is a wave that compresses and rarefacts. T F
2. Light travels at the same speed through different mediums. T F
3. Wavelength can be found by measuring the distance between the crest of one wave and the crest of the next wave. T F
4. Some form of energy is needed to create a wave. T F
5. Electromagnetic waves cannot travel through a vacuum. T F
6. Sound waves can travel in a vacuum. T F
7. Sound travels faster than light. T F
8. An earthquake produces seismic waves. T F
9. Amplitude measures the amount of energy carried by a wave. T F
10. The combining of two waves to form one wave is called diffraction. T F

# Post Test



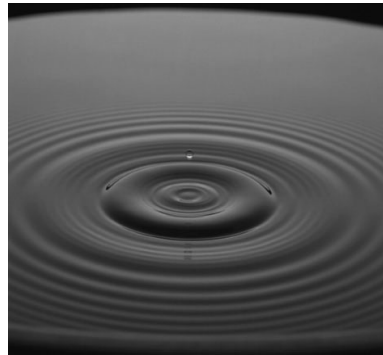
**Directions:** Fill in the blank with the correct word. A list of possible answers is provided at the bottom of the page.

11. A \_\_\_\_\_ wave is a wave that bends.
12. Light travels \_\_\_\_\_ than sound.
13. \_\_\_\_\_ is needed to produce waves.
14. Frequency is measured in units called \_\_\_\_\_.
15. The joining of two separate waves to create a larger wave is called \_\_\_\_\_ interference.
16. \_\_\_\_\_ refers to the separation of particles in a compression wave.
17. \_\_\_\_\_ is a measure of the amount of energy carried by a wave.
18. A \_\_\_\_\_ wave transfers energy throughout the earth.
19. An \_\_\_\_\_ wave is an incoming wave.
20. \_\_\_\_\_ is the bending of light around an object.

refracting  
seismic  
energy  
constructive  
rarefaction  
diffraction

slower  
hertz  
disturbance  
incident  
amplitude  
faster

# Anatomy of a Wave



**Objective:** In this lab you will identify the parts of a wave and draw your own diagram of a wave.

**Background:** There are many types of waves, such as electromagnetic waves and mechanical waves. Waves move in different ways and have different properties. Despite the wide variety of waves, there are certain characteristics that all waves share.

Part 1: In the diagram below identify the parts of a wave by using the provided definitions.

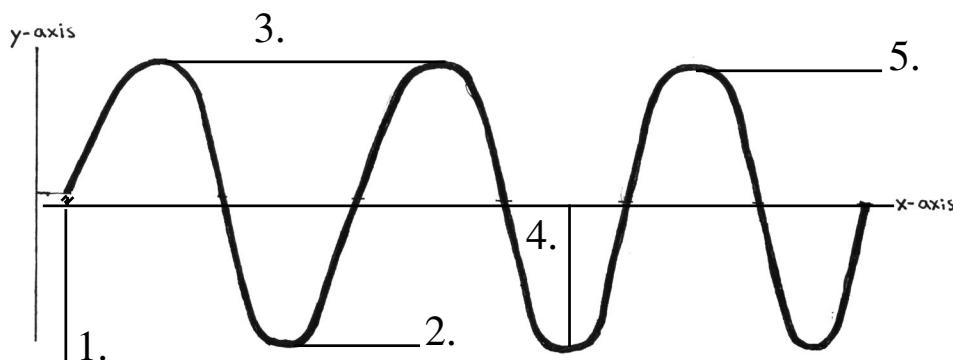
**Crest:** the highest point of the wave above the line of origin.

**Trough:** the lowest point of the wave below the line of origin.

**Line of Origin:** signifies the original position of the medium.

**Wavelength:** the distance between two consecutive crests.

**Amplitude:** the distance from the line of origin to a crest or trough of a wave.

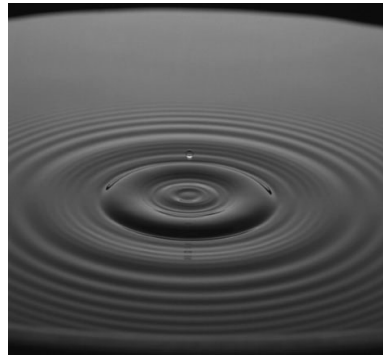


Part 2: On separate sheets of graph paper, draw four different waves with the following measurements. Label the parts and include the measurements.

1. Crest- 1 cm  
Trough- 1 cm  
Wavelength- 2 cm
2. Crest- 3.5 cm  
Trough- 3.5 cm  
Wavelength- 2.5 cm
3. Crest- 0.5 cm  
Trough- 0.5 cm  
Wavelength- 3 cm
4. Crest- 2 cm  
Trough- 2 cm  
Wavelength- 0.5 cm

**Conclusion:** State which wave you think has the highest frequency and which might have the lowest frequency. Explain the reason for your selection.

# Wave Speed



**Objective:** In this lab you will learn how to determine the frequency and speed of a wave.

**Background:** Different waves travel at different speeds. Light travels faster than sound, which is why you see lighting before you hear thunder. The waves in the ocean vary according to the strength of the wind. On a stormy day the waves tend to be much higher and faster than on a calm day.

The speed of any wave can be calculated using the formula:

$$\text{Speed} = \text{Frequency} \times \text{Wavelength}$$

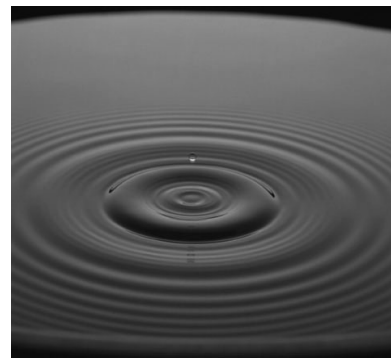
To find the **frequency** you need to know the number of wavelengths that pass a point in a given amount of time. Frequency is measured in hertz (Hz). One Hz is equal to one wave per second. The formula for the frequency of a wave is:

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

The **wavelength** is the distance between the crests of two consecutive waves.

**Directions:** Do the following calculations to find the wave speed and frequency of the specified waves. Show your work on the back of this sheet.

1. The speed of an oncoming ocean wave is 6 meters per second. The length between two successive wave crests is 3 meters. What is the wave's frequency?
2. The wake (wave) of a boat travels at 6 meters per second and the waves are 1 meter apart. What is the frequency of the wave?
3. Your best friend yells to you from across a field. The sound waves are traveling at you with a frequency of 344 Hz and a wavelength of 0.7 meters. What is the speed of sound?
4. You are standing on a rock down by the water. An ocean wave is approaching you from 300 meters away. Its frequency is 0.4 Hz and its wavelength is 125 meters. How long do you have to move to higher ground before the waves hits you?



# Everyday Waves

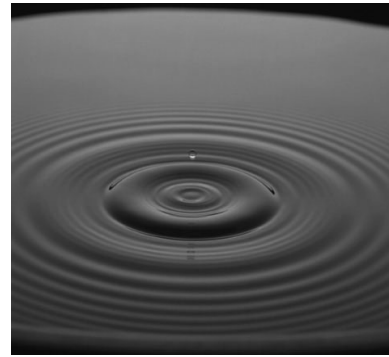
**Objective:** In this activity you will find examples of waves in your home, school, and neighborhood.

**Background:** Although we cannot see all the types of waves in action, they are moving around us at all times. We are surrounded by waves! In the first column of the table below, list examples of waves you observe. Decide whether the wave is a transverse wave or longitudinal wave. In the appropriate column, enter what medium the wave is traveling through: solid, liquid, or gas. Recall that sound waves are longitudinal waves and light and electromagnetic waves are transverse waves.

<u>Wave in Motion</u>	<u>Transverse</u>	<u>Longitudinal</u>
Example: Wave used by dolphins to communicate		Water - a liquid
Example: Waves from a microwave	Air - a gas	
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

---

# Rogue Waves



**Directions:** Read the passage below about rogue waves. Answer the questions that follow.

## Dangerous Waves

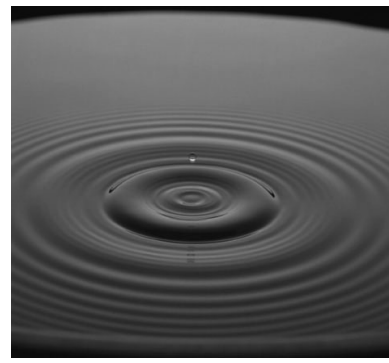
Rogue waves, sometimes referred to as “freak” waves, are natural occurring phenomena that can cause disasters at sea. On June 3, 1984, a ship known as the *Marques*, carrying a crew of twenty-eight people, sailed into a storm near Bermuda in the Atlantic Ocean. Suddenly, an enormous wave with incredible force inundated the ship. The *Marques* sank in less than one minute. Only eight crew members and Captain John Sefton survived the storm.

Rogue waves are massive waves that have been known to occur even in calm seas. In folklore these waves were referred to as “holes in the ocean.” Only in the past twenty years have they been defined as rogue waves. The mysterious sinking of many ships throughout history could be attributed to rogue waves.

Some characteristics of rogue waves are a deep, low trough and a very high crest, which results in a steep wave. It is not known exactly how rogue waves are formed in the ocean. The explanation for the cause of rogue waves is theoretical and controversial. It is generally agreed, however, that rogue waves are a result of an interference of waves. Many strong waves move at random in a fully developed sea. If two waves collide at exactly the same point on each wave, the crests and the troughs of the wave match up. This results in one wave with a very high crest, and is an example of constructive interference. Usually, when two waves meet their crests, their troughs do not match up. The waves then cancel each other out, causing destructive interference. Scientists have found that powerful ocean currents cause the onset of a rogue wave. The Agulhas Current is believed to be responsible for the common occurrence of rogue waves on the coast in southeast Africa.

A disproportionately high number of rogue waves occur off the coast of southeast Africa. They are also common, however, in the Gulf of Alaska and off the coast of Florida. The largest rogue wave ever recorded was 112 feet high, which is larger than a ten-story building. Crew members of a naval ship called the *Ramapo* recorded this wave near the coast of San Diego in 1933. As it was their duty to collect oceanographic data, they were prepared for large waves and rough seas. All of the crew members survived.

Scientists are currently working on the development of more advanced satellite-based radar systems which track rogue waves, so that ships can be forewarned about these dangerous waves.



# Rogue Waves (cont.)

**Directions:** Part I: Circle the correct multiple choice answer. Part II: Decide whether the statement is True (T) or False (F).

## Part I

1. A highly significant number of rogue waves occur in which region?

- A. Japan                      C. Bermuda  
B. southeast Africa      D. the Gulf of Mexico

2. Another term sometimes used to describe rogue waves:

- A. tidal waves              C. "holes in the ocean"  
B. freak waves              D. both B and C are correct

3. Which term best describes how rogue waves are formed?

- A. refraction                      C. constructive interference  
B. destructive interference    D. diffraction

4. Which are the characteristics of a rogue wave?

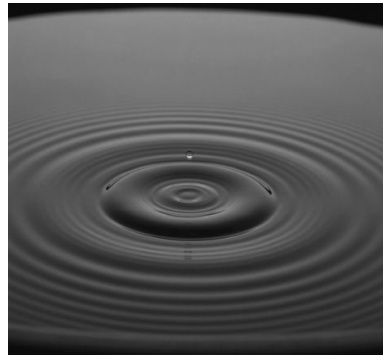
- A. high crest                      D. A and C are correct  
B. very steep                      E. A, B and C are correct  
C. low trough

## Part II

- |                                                                                     |   |   |
|-------------------------------------------------------------------------------------|---|---|
| 1. The term "rogue wave" has been around for centuries.                             | T | F |
| 2. When the Marques sank in 1984, some of its crew members did not survive.         | T | F |
| 3. Rogue waves can occur in calm seas.                                              | T | F |
| 4. Two waves that cancel each other out is an example of constructive interference. | T | F |
| 5. The crew members of the Marques recorded the largest rogue wave ever.            | T | F |

## Part III

Create a short story about a ship that encounters a rogue wave during a dangerous sea storm. Describe the appearance of the wave and include an account of what happens to the ship and its crew members. Create a name for the ship and a location of where the storm occurred.



# Wave Interactions

**Objective:** In this lab you will learn about the reflection and refraction of waves.

**Background:** In order to hear or see anything, a wave must go through a process in which it either reflects, diffracts, refracts, or interferes with a medium. **Reflection** is the bouncing back of a wave after it strikes an object. Light bounces off objects to enable you to see them. For example, in a mirror, your image is reflected back to your eyes, enabling you to see your appearance. Sound waves bounce off objects and into your ear, allowing you to hear. **Refraction** occurs when a wave passes from one medium to another, causing the wave to bend. When a wave enters a new medium it either slows down or speeds up to match the speed of the new medium, causing the wave to bend.

## Materials:

Part A: Reflection

Large sheet of white paper

Assortment of colored markers

Small ball

Part B: Refraction

Fish tank filled with water

Small cup

Pennies

## Directions:

Part A: Reflection

1. Line the sheet of paper up against the wall.
2. Roll the ball slowly on the paper so that it hits the wall and bounces off at an angle.
3. Trace the path in which the ball traveled.
4. Repeat this process several times using a variety of starting points and speeds. Trace each path with a different color marker.
5. Label and measure the angles of entrance and exit that the ball creates.

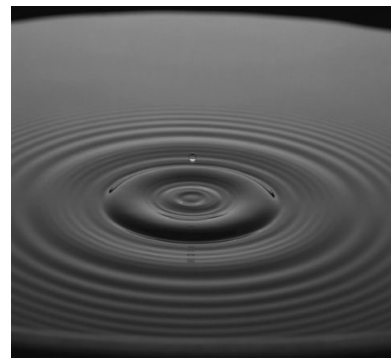
Part B: Refraction

1. Fill the fish tank with water
2. Place the cup in the water and anchor it to the bottom of the tank.
3. Drop a penny into the cup from directly above.
4. Repeat #3 until the penny falls into the cup. Pay attention to the place from which the penny was dropped.

## Conclusion:

A. What did you notice about the angles of entrance and exit that you traced on your paper? B. What happened the first time you tried to drop the penny in the cup? Why did this occur? Explain in your own words how this lab demonstrates the way in which waves are reflected.

# Vocabulary of Waves



**Directions:** Unscramble the following vocabulary words and match each word with its correct definition.

- |                        |                                                                                            |
|------------------------|--------------------------------------------------------------------------------------------|
| ___ 1. dropie          | a. the process of waves bouncing off objects                                               |
| ___ 2. scvreoutictn    | b. mechanical waves cannot travel through this                                             |
| ___ 3. vwea edpes      | c. the number of complete waves per unit of time                                           |
| ___ 4. farocenirt      | d. the separating of particles in a wave                                                   |
| ___ 5. uynreqefc       | e. bending of a wave around an object                                                      |
| ___ 6. ecleoifnrt      | f. the type of interference in which two waves combine to create one new, larger wave      |
| ___ 7. aodfictirfn     | g. the result of multiplying a wave's frequency by its wavelength                          |
| ___ 8. uaumvc          | h. when a wave changes from one medium to another, causing it to bend                      |
| ___ 9. eeatrsnvrs vewa | i. wave in which the motion of the medium is at a right angle to the direction of the wave |
| ___ 10. rfonctriaea    | j. the amount of time a wave takes to travel one wavelength                                |