Catch A Wave

CRABTREE Plus

The **Catch A Wave** series gives readers an in-depth look at the relationship between the various properties of light and sound waves, how they travel to our eyes and ears, and how they are used to transmit information, sometimes over long distances.

Each book includes an investigation or hands-on project that provides readers with an opportunity reinforce and demonstrate their learning. In addition, a code printed in the back of each book provides access to supplemental online content. This guide reinforces the big ideas and main concepts that are common across the series, while relating to real-world examples.

Use this guide to engage readers as they learn about waves and their properties. Readers will also learn about how they can see or hear waves and the similar patterns found in light and sound waves. Participation in these lessons will help students develop a better understanding of key vocabulary and be able to identify the properties of waves. They will examine the transfer of light energy and sound energy through hands-on activities, and connect to real-world examples to show understanding of concepts.

The lesson plans in this guide are tailored for grades 3-6 with varying levels of support, and cover Next Generation Science Standards as well as state and provincial science standards. Each lesson plan is designed to stand alone. As such, they do not need to be presented in sequential order. Helpful reproducible worksheets appear at the end of this guide. The following titles are referenced throughout this guide:

What are Waves

The Science of Sound Waves

The Science of Light Waves

Waves and Information Transfer

As students investigate the topics addressed in the guide and become more knowledgeable about waves, they will sharpen their understanding of the relationships between the properties of light waves and sound waves, and how wave patterns can facilitate communication.

In addition to this guide, the following learning materials are available:

- **Investigations and Projects:** Each title in the Catch A Wave series includes an investigation or hands-on project that gives readers an opportunity to reinforce and demonstrate their learning.

- **Digital Materials:** A code printed in the back of each book provides access to Crabtree Plus—a safe, online learning environment with supplemental digital content, including simulations and interactive activities that reinforce and extend key series concepts.

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Appendices

Making Waves

Curriculum Correlations:

Next Generation Science Standards

PS4.A:	**Wave Properties**	•Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. •Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).
	Developing and Using Models	•Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. •Develop a model using an analogy, example, or abstract representation to describe a scientific principle.
	Patterns	•Similarities and differences in patterns can be used to sort and classify natural phenomena. (4-PS4-1)

Common Core State Standards
ELA/Literacy

- RI.4.1 - Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.
- RI.4.3 - Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.
- RI.4.9 - Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.

Learning Objectives:

This lesson is designed to reinforce and extend students' understanding of the properties of waves. They will observe and compare wave patterns as they create waves varying in amplitude, wavelength, and frequency.

Prerequisites:

Students should read the book *What are Waves* to familiarize themselves with the different properties of waves.

Multiple Intelligences:

The following intelligences will be activated throughout the lesson:

- Bodily-Kinesthetic
- Logical-Mathematical
- Visual-Spatial
- Interpersonal

Materials:

- Getting to know waves activity page for each student (appendix ii)
- 35 Wood skewers
- 70 JuJubes (two per skewer)
- 10-10½ feet of duct tape (plus extra pieces needed to securely affix tape to solid structure)

Creative Inquiry:

Setting the Stage

Explain to students that, as a class, you will create a model that shows the movement of waves. Roll out 10-10½ feet, or about 3 meters, (plus extra pieces, which are needed for securely attaching to solid structure) of duct tape. Lay it sticky side up (you can do this on the floor and lift into place after). Have students collect one wood skewer and two JuJubes each (adjust according to class size to ensure 35 skewers are prepared to be placed). *Be careful when handling the wood skewers as they are sharp on both ends.*

Students will need to find and mark the center point on their skewer. Have students put a JuJube on each end of the skewer. The skewers are now ready to be placed on the duct tape.

Each skewer should be placed across the tape in its center. Students should use the marked center point and plac the skewers approximately 3-4" (7.5-10 cm) apart from the skewer next to it. Make sure to keep the distance between skewers consistent. Students will need to take turns and place their skewers one at a time to ensure proper distance between skewers is maintained. Students will also need to work together to steady the duct tape as others are placing and securing their skewers.

Once every skewer has been placed, the duct tape with skewers attached will need to be secured in place on a solid structure. Attach the tape sticky-side up with the two extra pieces of tape. Be careful when lifting it up to avoid twisting of the tape. If the wood skewers become lopsided, you can adjust the JuJubes by sliding along the skewer in the necessary direction to counterbalance. After you have determined that the duct tape is securely attached to a solid structure, you are ready to begin exploring waves in a wonderfully visual way.

Activity

Begin with a single pulse. To do this, lift one skewer up from one end and release, allowing it to fall back in line with the other skewers. This will cause a disturbance which moves from one end to the other. Discuss with the class what they are observing.

Prompt students to notice the relation of the movement to frequency and amplitude. To change the amplitude, lift the JuJube higher. To change the frequency, wiggle the JuJube up and down faster. When amplitude is increased, students should observe waves that have shorter wavelengths and higher frequency.

To change the speed of the waves, try removing the JuJubes from both ends of the wood skewers from one half of the length. Discuss with the class what they are observing after each type of pulse. When the waves cross over the boundary of JuJube skewers to plain skewers, students should observe the waves speed up.

Discussion and Reflection

Have a class discussion and prompt students to understand the following concepts:

- Students should observe that frequency and amplitude depend on the force placed on the wave. Speed and wavelength are dependant on the medium (with or without JuJubes).
- Students should recognize through the demonstration that the vibration sends a disturbance through the medium. The wave travels as energy passes through it, but the medium stays the same—the skewers do not move from the tape, nor does the tape move from its place. This is similar to a buoy in water.

Have students complete the getting to know waves activity page (appendix ii) to reinforce their knowledge.

Accommodations and Extensions

Ensure that students are familiar with amplitude, wavelength, and frequency. Anchor charts could be used for students to reference.
To extend, students could change various factors such as space between skewers, number of JuJubes and placement on each skewer, width or thickness of tape, etc. to explore how the waves change.

Assessment

Use teacher observation and anecdotal notes to record student participation in class discussion. Collect getting to know waves activity page (appendix ii) and assess understanding.

The Science of Sound Waves

Curriculum Correlations:

Next Generation Science Standards

PS4.A:

Wave Properties	•Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. •Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).
Developing and Using Models	•Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. •Develop a model using an analogy, example, or abstract representation to describe a scientific principle.
Patterns	•Similarities and differences in patterns can be used to sort and classify natural phenomena.

Common Core State Standards
ELA/Literacy

- RI.4.1 - Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.
- RI.4.3 - Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

Learning Objectives:

This lesson is designed to reinforce and extend students' understanding of the properties of waves. They will learn how noises create sound waves that are not visible, and experience how sound travels through vibrations in the air to their ears.

Prerequisites:

Students should read the book *The Science of Sound Waves* to familiarize themselves with the different properties of sound waves.

Multiple Intelligences:

The following intelligences will be activated throughout the lesson:

- Bodily-Kinesthetic
- Logical-Mathematical
- Visual-Spatial
- Interpersonal

Materials:

- PEOE Chart for each student (appendix i)
- Pencil
- Metal Serving Spoon
- Wood Ruler
- String
- Plastic Ruler
- Wooden Spoon
- Teaspoon
- Yarn

Creative Inquiry:

Activity

Cut a piece of string approximately twice the length of your arm. The string should be long enough to hang an object centered on the string at approximately waist height or a bit lower, with the tails of string being equal length on each side reaching up to the top of your head. Secure the metal serving spoon to the string. Either make a loop in the center to slip the spoon handle through or use the hole in the handle or spoon if there is one. Make sure the spoon is centered on the string. Hold up the ends of the string at the height of your head, and tap the metal spoon with a ruler or pencil. What do you hear? Describe the sound using appropriate vocabulary, such as volume and pitch.

Wrap an end of the string around your left pointer finger. Wrap the other end of the string around your right pointer finger. *Do not wrap the string too tightly—if the tip of your finger changes color, you have wrapped it too tightly.* With the string wrapped around your two pointer fingers, press the string against your ears (not inside). The spoon should be hanging freely below the waist once your fingers press the wrapped string against your ears. Now have someone tap the metal spoon with a pencil or ruler. What do you hear? Describe the sound using appropriate vocabulary, such as volume and pitch.

Predict and Observe

Have students record their predictions and results on the Predict, Explain, Observe, Explain (PEOE) Chart (appendix i) for the following:

- *What do you think will happen if you make the string shorter or longer?*
- *What do you think will happen if you change the spoon size?*
- *What would happen if you change the tapping stick to a plastic or metal ruler?*
- *What other materials could you use and how do you think the different materials will affect the way the sound vibrates and travels?*
- *Does the sound get louder if you tap the spoon harder, or softer if you tap lightly?*

Now, facilitate an exploration of student's predictions. You may choose to pair or group students. Record the results.

Discussion and Reflection

In class discussion, students should answer the following question: *How do different combinations of materials change the sound?*

Faciliate students' understanding of the following concepts:

- Sound waves are created when the pencil or ruler taps the metal spoon. Tapping the spoon at first is heard as a faint single clang because the sound waves spread out in the air.
- Once the string is pressed to the ears, the sound waves travel up the string. The string is a medium. Sound waves need a medium to travel. A medium is any matter that carries waves of energy.
- The string allows the sound to travel and that is why the sound continues to echo in your ear after the initial clang of the spoon.
- The size of the spoon, and length of the string change the sound (smaller spoon = higher pitch, larger spoon = lower pitch). Using different forces and types of materials create different amplitudes, or higher and lower volumes.

Accommodations and Extensions

Ensure that students are familiar with amplitude, wavelength, and frequency. They should also be familiar with volume and pitch as characteristics of sound. Support students by reviewing these terms prior to the lesson. Anchor charts could be used for students to reference.

Assessment

Use teacher observation and anecdotal notes to record student participation in class discussion. Collect PEOE chart (appendix i) and assess understanding.

The Science of Light Waves

Curriculum Correlations:

Next Generation Science Standards

PS4.A:

Wave Properties	•Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. •Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).
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Common Core State Standards Connections
ELA/Literacy

- RI.4.1 - Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.
- RI.4.3 - Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

Learning Objectives:
This lesson is designed to reinforce and extend students' understanding of the properties of waves. They will learn how light waves travel, and experience how various matter, mediums and liquids can change the way we see light.

Prerequisites:
Students should read the book *The Science of Light Waves* to familiarize themselves with the different properties of sound waves.

Multiple Intelligences:
The following intelligences will be activated throughout the lesson:

- Bodily-Kinesthetic
- Logical-Mathematical
- Visual-Spatial
- Interpersonal

Materials:

Station 1

- Transparent material, such as clear plastic cup, or saran wrap
- Translucent material, such as tinted plastic cup or waxed paper
- Opaque material, such as solid-colored plastic cups or aluminum foil
- Bristol board (or other surface to shine light onto)
- Flashlight

Station 2

- Picture, newspaper clipping or book page
- Magnifying Glass,
- Water Dropper or Syringe
- Plastic Lunch Baggie
- Drinking Glass
- Mirror

Station 3

- Pencils
- Empty Clear Cup
- Water-Filled Clear Cup

For class

- PEOE Chart for each student (appendix i)

Creative Inquiry:

Setting the Stage

Set up three stations for the students to explore. The students will experience self-directed learning while they are engaged and learning hands-on while making connections to the text. Each station will need to be set up prior to the lesson.

Activity

Give each student a PEOE chart (appendix i) to fill out at each station. Explain that before they begin each experiment, they need to predict what will happen and explain their reasons why. Then, after conducting the experiment, they need to write down their observations and explain why they think this happened.

Split the students into three groups (*Tip: if your class is large, set up six stations—two for each experiment—and divide the students into six groups to avoid crowding*). Give students a specified period of time at each station. It might be helpful to decide on a signal that will tell students when to move on, such as flashing lights or clapping hands. Arrange the groups at each station and begin. Each station is explained in the chart below.

Station 1
Moving Through Matter:

Explore how light travels through various materials.
Using PEOE chart, have students predict and record how the light will travel when shining the flashlight through each material.
Students will observe how light travels through a transparent, translucent, and opaque material. They will observe if the light passes easily, if the light is blurred, or if the light is blocked.
Students can then reflect on their predictions and comment on differences or explanations for why the light travelled the way it did.

Station 2
Magic Mirrors:

Explore how water, glass and mirrors effect light waves.
Using PEOE chart, have students predict and record how the different items light travels through will affect how they see the newspaper or book pages.
Students will observe how light travels through the glass, drop of water or mirror, compared to looking at the picture, newspaper or book pages directly.
Students should identify similarities and differences when observing the item through the different mediums.

Station 3
Bending Light Waves:

Explore how a pencil can be straight in a plastic cup and bent when adding water.
Using PEOE chart, have students predict and record how they think placing the pencil into water will change how light travels; therefore changing how they see the pencil.
Students will observe how the pencil looks when placed into an empty, clear plastic cup. They will then observe how the pencil looks when placing it into a water filled, clear plastic cup. Why does this occur?

Discussion and Reflection

After all of the students have had an opportunity to move around the classroom to each of the three stations, have a class discussion where students can share their findings on the PEOE chart.

The following points for each station should be noted if not brought out in the class discussion.

Station 1:
Moving through Matter

Light waves move through different types of matter in different ways.

- Transparent objects do not block the path of light—the light waves shine through them.
- Translucent objects are not completely clear so only some of the light waves are able to pass through.
- Opaque objects do not allow any light waves to pass through them.

Station 2:
Magic Mirrors

Light changes shape when it moves through different mediums.

- Looking at the newspaper through the glass, mirror, or drop of water, the light waves are passing through air plus the added medium which causes the material to look larger.
- The light is bending because of the water drop, mirror, or glass is preventing it from traveling straight down.
- The image is not actually any bigger. The water drop, mirror, or glass just acts as a magnifier.

Station 3:
Bending Light Waves

When we look at the pencil through the side of the glass it looks straight. But when we add water it looks bent.

- This is because light travels slower through the water than the air. As the light enters the glass of water it slows down and as it leaves the glass it speeds up again— this tricks our eyes into thinking the pencil looks bent!

Accommodations and Extensions

Ensure that students are familiar with the properties of light waves prior to this lesson, such as the fact that light waves travel in straight lines. They should be familiar with the terms transparent, translucent, and opaque. Support students by reviewing these terms prior to the lesson. Anchor charts could be used for students to reference.

Assessment

Use teacher observation and anecdotal notes to record student participation in class discussion.
Collect PEOE chart (appendix i) and assess understanding.

Waves and Information Transfer

Curriculum Correlations:

Next Generation Science Standards

PS4.A:

Wave Properties	•Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. •Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).
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Common Core State Standards Connections
ELA/Literacy

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- RI.4.3 - Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

Learning Objectives:
This lesson is designed to reinforce and extend students' understanding of information transfer through use of binary and ascii code, necessary for communication in our digital world.

Prerequisites:
Students should read the book *Waves and Information Transfer* to familiarize themselves with the different properties of information transfer.

Multiple Intelligences:
The following intelligences will be activated throughout the lesson:

- Bodily-Kinesthetic
- Logical-Mathematical
- Visual-Spatial
- Interpersonal

Materials

- ASCII - Binary Character Code Table (appendix iii)
- Binary Code Activity Page (appendix iv)
- Lego Bricks, Wood Blocks, or Binary Code fringe (appendix v)
- Scissors
- Pencils

Creative Inquiry:

Setting the Stage

Have students think about how we usually communicate. We speak a language. What happens when someone speaks a different language than you do? It is probably difficult to understand someone who speaks a different language than you do. You may be able to pick up on some visual cues if the person is standing in front of you. But what if the person you are trying to communicate with is somewhere else in the town or city you live in or even somewhere else in the world? They may be sending you an email or text message.

Students will explore how emails and text messages are sent using codes transmitted by waves. Computers send information in 0's and 1's. This is called binary code. Each 0 or 1 is called a bit.

Early on in computers, each company used the code in a different way. This meant the information sent from one computer would not received by another computer in the same way. They were not speaking the same language.
Computer companies eventually agreed to use a set of standards. American Standard Code for Information Interchange (ASCII) was developed.

ASCII is an 8-bit code, meaning it uses a combination of 0's and 1's in groups of eight characters total to represent letters and punctuation. Eight bits are called a byte. When you send a text or email, the information is broken down into bits and sent as bytes.

For example, Ava becomes 01000001 01110110 01100001

Activity

Using the ASCII - Binary Character Code Table (appendix iii) and Binary Activity Page (appendix iv), start exploring.

1. Write your initials in binary numbers (first name initial, last name initial, both uppercase)

2. Write your first name in binary numbers (begin with uppercase and continue in lower case for the remainder of the letters in your name)

3. Write a short message to a friend and de code each other's messages.

4. Do you compare the 0's and 1's to find your letter or do the math to find the ASCII code?

5. Try setting up some words in a visual repre sentation using the binary code fringe (appendix v), lego bricks, or wooden blocks, and have a friend try to decipher what you have displayed.

Accommodations and Extensions

Support students by walking through an example together on the board.
Teachers may choose to strategically pair or group students based on ability.
Extend the activity by applying their knowledge of binary codes to a real-world situation. For example, when you send a tweet, you are confined to a maximum of 140 characters. How many binary numbers is a tweet of 140 characters? (8 x 140 =1,120 binary numbers). Can you imagine how many binary numbers represent the text of your favorite book!?

Assessment

Use teacher observation and anecdotal notes to record student participation. Teachers may choose to collect worksheets from students to assess understanding.

PEOE Chart

Description Of Activity/ Question	**Predict** What do you think will happen happen	**Explain** Write the reasons you think this will happen	**Observe** Draw or describe what happend	**Explain** Add to or change your first explanation
ie: What will happen if I make the string shorter?				

Getting to Know Waves

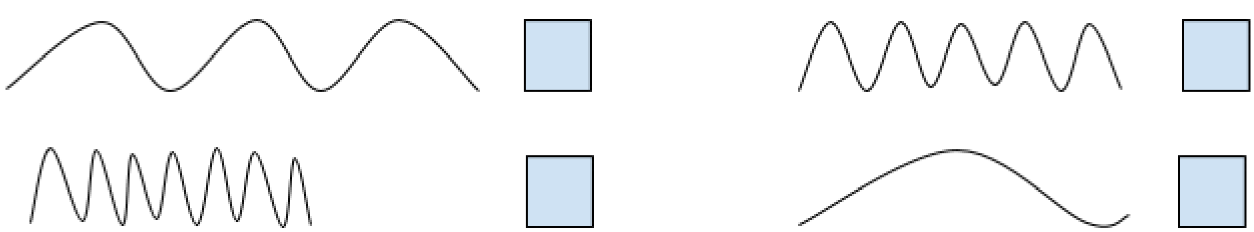
Match the following vocabulary to the appropriate definition:

A high point in a wave	wavelength
A low point in a wave	amplitude
The height of a wave (from rest position to crest or from rest position to trough)	trough
The distance from a point on one wave to the same point on the next wave	frequency
The number of crests or troughs within a certain period of time	crest

Fill in the blanks:

A bright light is the result of high ________________________.
A longer or shorter wavelength will affect the sound's ________________________.
Longer wavelengths result in a _______________________ pitch.
Shorter wavelengths result in a ______________________ pitch.
When you whisper in your friend's ear, this is a ___________________ amplitude sound.
You can measure _____________________ by determining how many waves happen, or pass by, per second.

Identifying Wavelengths
Label the pitch of each wavelength A, B, C, or D—The highest pitch is A, and the lowest is D



Explain the characteristics of wavelength that help you determine the pitch:
____
____
____

ASCII - Binary Character Code Table

Lowercase Letter	ASCII Code	Binary	Uppercase Letter	ASCII Code	Binary
a	97	1100001	A	65	1000001
b	98	1100010	B	66	1000010
c	99	1100011	C	67	1000011
d	100	1100100	D	68	1000100
e	101	1100101	E	69	1000101
f	102	1100110	F	70	1000110
g	103	1100111	G	71	1000111
h	104	1101000	H	72	1001000
i	105	1101001	I	73	1001001
j	106	1101010	J	74	1001010
k	107	1101011	K	75	1001011
l	108	1101100	L	76	1001100
m	109	1101101	M	77	1001101
n	110	1101110	N	78	1001110
o	111	1101111	O	79	1001111
p	112	1110000	P	80	1010000
q	113	1110001	Q	81	1010001
r	114	1110010	R	82	1010010
s	115	1110011	S	83	1010011
t	116	1110100	T	84	1010100
u	117	1110101	U	85	1010101
v	118	1110110	V	86	1010110
w	119	1110111	W	87	1010111
x	120	1111000	X	88	1011000
y	121	1111001	Y	89	1011001
z	122	1111010	Z	90	1011010
blank space	32	100000			

Binary Code Activities

1.Write your initials in binary numbers (first name initial, last name initial, both uppercase)

2.Write your first name in binary numbers (begin with uppercase and continue in lowercase for the remainder of the letters in your name)

Letter	Binary Code for Letter							

3. Write a short message to a friend and decode each other's messages.

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	Value per Bit								
	128	64	32	16	8	4	2	1	
Letter	Binary Code For Letter								ASCII
Here is an example of how to calculate ASCII code (for 1's add values per bit together)									
	0	1	0	0	0	0	0	1	
A		64						1	=65
	0	1	1	1	0	1	1	0	
v		64	32	16		4	2		=118
	0	1	1	0	0	0	0	1	
a		64	32					1	=97

v

Binary Code Fringe

(cut along dotted lines, each sheet provides 8 fringe pieces to represent 8 bits of information in 0's and 1's)

For 0's - keep fringe tab flat

For 1's - fold fringe tab up