Physical Science: Waves

Grade 4 Science
4-PS4-1, 4-PS4-3

In this unit, students will plan and carry out investigations to discover characteristics of waves. Important to the work of each student, is determining that energy is propagated through waves and can be described by these characteristics. The focus once students develop a basic understanding of waves turns to the phenomenon of waves as related to seeing with eyes and transferring information in a communication system. Modeling the movement of waves is necessary for students to demonstrate a thorough understanding of these applications. Opportunities for hands-on investigations to predict phenomena must be provided as are opportunities to describe the limitations of these investigations and modeling experiences in describing the phenomena.

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Stage 1 Desired Results

ESTABLISHED GOALS **G**

4-PS4-1. Develop a model of a simple mechanical wave (including sound) to communicate that waves: a. are regular patterns of motion along which energy travels, and b. can cause objects to move.

Clarification Statements:
- Examples of models could include diagrams, analogies, and physical models. State Assessment Boundary
- Interference effects, electromagnetic waves, or non-periodic waves are not expected in state assessment.

4-PS4-3. Develop and compare multiple ways to transfer information through encoding, sending, receiving, and decoding a pattern.*
Clarification Statement:
- Examples of solutions could include drums sending coded information through sound waves, using a grid of 1s and 0s representing black and white to send information about a picture, and using Morse code to send text.

RL4.3 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.

W.4.4 Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.

SL.4.1 Engage effectively in a range of collaborative discussions

Transfer

Students will be able to independently use their learning to…
- Make scientific observations and predictions
- Record, analyze, and communicate data; draw conclusions based on data
- Communicate effectively through writing and speaking **T**

Meaning

UNDERSTANDINGS **U**

Students will understand that…
- Identify forms of energy that travel in waves (REM)
- Define the parts and characteristics of waves (REM)
- List ways that people can communicate over long distances (REM)
- Give examples of waves; determine how each type starts (UND)
- Illustrate that a wave is a regular pattern of motion caused by a disturbance that travels outward from the source (UND)
- List ways that people can communicate over long distances (UND)
- Identify whether pictures of waves are transverse or longitudinal (UND)
- Recognize that energy has the ability to create change (APP)
- Give evidence that shows energy is present whenever there are moving objects,
sound, light, or heat (APP)
- Demonstrate that waves are energy with regular patterns of motion (APP)
- Show how information can be transmitted using energy waves (APP)
- Collect evidence to determine how frequency, amplitude, and wavelength affect

ESSENTIAL QUESTIONS **Q**
- How does energy travel?
- What are waves and what can they do?
- How does a wave begin moving?
- What happens to the energy in a wave when the wave stops moving?
- Is energy ever destroyed?
- How is energy related to waves?
- How do outside forces affect waves?
- How do waves affect boats?
- What happens when waves hit different objects?
- Where does water move in a wave?
- What patterns exist in a wave?
- Are all waves the same?
- Is there a relationship between wavelength and frequency?
- What are some ways humans interpret waves? ● How is energy used to send information?
- How are waves used to transfer energy and information?
- How do modern ways of communication utilize patterns to transfer information without wires or fibers?
- How can you send a secret message from one side of the room to your friend who is on the other side of the room? What if your friend is in the room next door?
- How can Morse code send messages?

	the general appearance of wave (ANA) ● Describe patterns in waves using amplitude and wavelength (ANA) ● (EVA) ● Integrate information from multiple sources, including texts and experiences, to explain with evidence how patterns are used to transfer information across distances (EVA) ● Develop a model to describe patterns in waves and that waves can cause objects to move (CRE) ● Collaborate to generate solutions that use patterns to send information (CRE)	
	Acquisition	
	Students will know… **K** ● Key Vocabulary Terms (frequency, amplitude, pitch, volume, crest, trough, compressions, transverse, longitudinal) ● ocean waves move energy across water and create circular movements below the surface ● sound waves travel through gases, solids and liquids	***Students will be skilled at…*** **S** ● making observations and producing data ● measuring and graphing ● drawing conclusions and defending their claims using data
Stage 2 - Evidence		
Evaluative Criteria	**Assessment Evidence**	
Did You Hear That Rubric Found on page 21	**CURRICULUM EMBEDDED PERFORMANCE ASSESSMENT** **Did You Hear That?** **PT** Students will use waves to create a message that will be sent and received by a classmate. Students develop an alphabet or key to their message. They will then present their code and send the message to their classmates.	

Stage 3 – Learning Plan
Summary of Key Learning Events and Instruction Waves Unit Introduction – Students will identify background information on waves Lesson 1 – What is a wave? - Students will learn key vocabulary terms, identify the different types of waves, create models to show each type of wave. Lesson 2 – Let's Make Waves – Students will learn about how energy is transferred and how energy moves through a water wave Lesson 3 – Do Waves Move Boats? – Students will learn about them movements of an object on the top of water waves: identify the direction of its movement Lesson 4 – Can You See Sound? – Students will learn about sound waves traveling through air and discuss their limitations Lesson 5 – Investigate: Hello, Hello – Students will learn about sound waves traveling through solid and discuss their limitations Lesson 6 – Musical Stations – Students will learn about pitch and how different pitches can be created

Waves Unit

Brief Overview: During this unit children will learn that waves can be found in more places than just the ocean. They will learn about the different types and uses of waves. Students will gain an understanding of how energy can transfer through different materials in the form of waves. Students will apply this new knowledge to create and construct a devise to communicate with other students.

Prior Knowledge Required: Students need to understand that energy can be transferred from potential to kinetic. Energy can travel from one place to another.

Estimated Time: 7 one hour sessions

Resources for Lesson (list resources and materials): *See individual lesson plans for specific details*

Waves Unit

Unit Introduction:

Materials:
RAN Strategy sheet, Bill Nye Waves video

To introduce the unit, teacher will elicit prior knowledge from students. Discuss possible facts and or misconceptions. Teacher will pass out RAN strategy page. Children will record their background knowledge. Teacher will show Bill Nye film. Children will turn and talk in several places during film. Teacher will give opportunity to fact check their prior knowledge. Students will check off facts that were confirmed with video information, then rewrite the misconceptions to reflect the facts. Children will continue to add information to the RAN sheet during the unit.

Lesson 1: What is a Wave?

Materials:

YouTube video: https://www.youtube.com/watch?v=yJQRTQJL7jQ , Vocabulary PowerPoint, 1 slinky per station, Diagram Which Way Did The Waves Go text and recording sheets, science notebooks

Links to vocabulary PowerPoint, texts and recording sheet can be found under Lesson 1 on my website.

Procedure

Lesson Opening

Have students sit back-to-back. One member of the pair sits facing the screen, the other facing away. I play a YouTube video of the Queen waving, https://www.youtube.com/watch?v=yJQRTQJL7jQ silently. The student watching the screen must describe to his/her partner what is going on and the partner must try to mimic it. I wander between pairs and tell students when they have it correct.

I call students into a circle and we discuss how difficult it was to describe what the queen was doing accurately. I introduce the vocabulary:

1. Frequency: The number of times something happens in a given time.
2. Amplitude: The maximum movement from a position of rest.

Now that we know this vocabulary, we can describe that the queen waves with high frequency and low amplitude.

Before we move on, I also introduce the vocabulary term, wave.

1. Wave: repeated oscillation around a point.

What exactly does this mean? This means that waves move from a point of rest to a maximum point and then back again.

Vocabulary PowerPoint Lesson

Children will get out their science notebooks and jot notes from the vocabulary PowerPoint.

Activity

Teacher will break students into small groups. Each group will work together to investigate wave properties. Each group will need a slinky for the Part A investigation and a 6 foot rope for the part B investigation. Each group will work together to answer questions on recording sheets.

Part A – students will be using a slinky to generate longitudinal waves.

Part B – Students will be using a rope to generate transverse waves.

Lesson Closing

I ask students to turn to a shoulder partner on their right, and describe what they observed today in the wave simulations. They also ask each other what other things might create waves.

Lesson Number and Name: https://betterlesson.com/lesson/639089/what-is-a-wave

Overview of the Lesson
Students will learn key vocabulary terms, identify the different types of waves, create models to show each type of wave.

Standard(s)/Unit Goal(s) to be addressed in this lesson:

- Define the parts and characteristics of waves (REM)
- Give examples of waves; determine how each type starts (UND)
- Illustrate that a wave is a regular pattern of motion caused by a disturbance that travels outward from the source (UND)

- Identify whether pictures of waves are transverse or longitudinal (UND)

Essential Question(s) addressed in this lesson:

● What are waves and what can they do?
● How does a wave begin moving?
● What happens to the energy in a wave when the wave stops moving?

Targeted Academic Language Key Vocabulary:

- Transverse waves (ocean waves, light waves)
- Longitudinal waves (sound waves)
- Frequency: The number of times something happens in a given time.
- Amplitude: The maximum movement from a position of rest.
- Wave: repeated oscillation around a point. (This means that waves move from a point of rest to a maximum point and then back again.)

Procedure:

Lesson Opening

Have students sit back-to-back. One member of the pair sits facing the screen, the other facing away. I play a YouTube video of the Queen waving, https://www.youtube.com/watch?v=yJQRTQJL7jQ silently. The student watching the screen must describe to his/her partner what is going on and the partner must try to mimic it. I wander between pairs and tell students when they have it correct. I tell students that there are two kinds of waves. We are going to make these different waves using a slinky. I have students sit in pairs facing each other. They each take an end of the slinky and stretch it out on the floor (this works best on floor and not carpet).

Lesson 2: Let's Make Waves

Science Activity

Background

Many children hold misconceptions about the nature of water waves. One common misconception is that waves are generated from within the water. Although that may appear to be true, most waves -- and certainly the waves most children see -- are actually generated by wind. As wind travels across the water's surface, it pushes against the water and energy in the wind is absorbed by the water.

Another common misconception is that as a wave moves the water itself moves with the wave. In fact, a wave is the movement of energy through water. The water moves up and down, but not sideways in the direction of the wave's motion. The energy from wind moves in the direction of the wind. The energy moves from water molecule to water molecule, making each molecule move in a small circle. When one molecule bangs into its neighboring molecule, energy transfers to that neighboring molecule.

The most effective way to help children replace a misconception is to give them an experience that directly challenges it. In this simple set of activities children use wind to create waves and use marbles to model energy moving through water.

WHAT YOU'LL NEED

- 1 large, flat pan, about 4 or 5 inches deep, for each group (dishpans or larger)
- 1 straw for each person
- buckets or jugs for filling the pans with water
- food dye (optional)
- 5 large marbles or ball bearings for each group

WHAT TO DO

1. Ask the class what causes waves. Discuss their ideas.
2. Put the pans on tables and fill each pan with 2-3 inches of water.
3. Divide students into as many groups as you have pans and put each group around a pan.
4. Ask students to predict what will happen when the straw is used to blow across the water's surface. After students have made predictions, model a small wind with a straw.

5. Have students report the results. Were there waves? Did the water bunch up at the far end of the pan? Did the water slosh out of the pan? Then use a medium wind and have students report again. Last model a strong wind and discuss.
6. Let students take turns creating waves at different speeds. Have each student record the results of the experiment.
7. Discuss with the class the connection between the wind and the waves. Ask students to guess why the water didn't bunch up at the far end of each pan.
8. Give each group a set of 5 marbles. Have students place 4 of the marbles on a table, lined up in a row with each marble touching its neighbors. Ask students to predict what will happen if the fifth marble is gently rolled at the marble at one end of the row. After students have made predictions, have one student in each group roll the fifth marble. The marble at the far end of the row will roll away and the others will not move. Have students repeat the experiment several times.
9. Discuss the idea that the energy in the rolling marble went into the marble it hit, and from that marble to the next, until the energy reached the last marble. The energy made that marble roll away. Wave energy moves through water the same way.
10. Bring the students together for a wrap-up discussion. Ask them what causes waves. Discuss their answers, relating the answers to the wave experiment. Ask them if water moves sideways inside a wave, or if the water stays in one place while the wave moves through it. Discuss the answers, relating the answers to the wave experiment and to the marble experiment.

Lesson Closing

To further illustrate the movement of an ocean wave, show the video: https://www.youtube.com/watch?v=NShUBfJQEHk Discuss where the energy goes.

Lesson 3: Do Waves Move Boats?

*If possible, this experiment would be best done outdoors ☺

Materials:

1 for each group: cork, large under the bed storage container, water to fill container half way, large beach towel, piece of wood (2X4) to fit in short side of container, pepper, blue food coloring, recording sheet

Procedure:

Ask children to predict what will happen to a cork placed in the center of the container when waves are started from the side. Ask them to predict the movement of the cork. Students will record their answers on sheet.

Each group will set up their station so that they have the towel underneath the container to absorb any water that goes over the side, if an indoor space is being used. Students will add enough pepper into the water so that they can see the particles throughout. Students will place cork in the middle of the container. The water needs to be resting before waves are started. One student will lower and raise block of wood 2 times. Students will discuss observations and record. Prompt children to make observations on the side of the container as well as above. After water comes to rest again, students will make 3 waves, discuss observations and record. Finally, students will make the last waves after water has come to rest again. This time 4 waves will be made, children will discuss observations and record.

Students will then discuss the conclusions together and record.

Lesson Closing

Children will gather with recording sheets and separate so that they are sitting next to someone that was not in their group. Children will turn and talk about their findings, noting what was the same, and what was different. Teacher will call on children to share with the entire group.

Lesson 4: Can You See Sound?

Materials:

Each group will need: Large Bowl, Large paper plate, Plastic Wrap, 1 teaspoon round ice cream nonpareils, ruler, Recording Sheet

Procedure:

Ask children if it is possible for them to see sound? Discuss.

Explain the set up to the children: Wrap bowl tightly with plastic wrap. Place bowl onto plate. Place a teaspoon of nonpareils on top of plastic wrap. The children will hum at three different distances to the bowl. (1 foot away, 6 inches away, 1 inch away) The children will discuss and record their findings on the recording sheets.

Have children go into their groups and set up the experiment. Encourage each of the children to experiment with the three distances. Discuss the conclusions and record.

Lesson Closing

Children will gather with recording sheets and separate so that they are sitting next to someone that was not in their group. Children will turn and talk about their findings, noting what was the same, and what was different. Teacher will call on children to share with the entire group.

Lesson 5: Investigate – Hello, Hello

Materials For each group:

3 different types of disposable cups (different types of plastic, paper, foam) – 2 of each
3 different types of string (cotton, nylon, thread, yarn, fishing line, florist wire) – 5 foot lengths of each
6 large paper clips
Tape
Reading packet and recording sheets

Procedure:

Ask children if sound can travel through anything besides the air. Ask them what types of solids they think might work best and why. Explain to the children that they will be constructing a "phone" out of the materials shown. Explain the basic design of each phone. (Puncture a small hole in the bottom of the cup. Tie the "string" to a paperclip. Tape the paperclip to the inside of the cup. Repeat with the second cup.) Have them predict which combination they think will work the best.

Let students go to their stations to construct and test their theories. They will design and construct three different telephones. They will need to discuss their results with their group and record their findings.

Lesson Closing

Children will gather with recording sheets and their most effective telephone. Children will turn and talk about their findings, noting what was the same, and what was different. Teacher will call on children to share with the entire group.

Lesson 6: Musical Stations -Pitch

Materials: 3 mason jars (4 oz. 8 oz. 12oz.) water, recording sheet, 3 drums (cylinders covered with clear packing on one end – hollow on the other) *Try to find 3 empty canisters that differ in only one variable, height or width, small piece of wood with 6 nails pounded in. (nails will be hammered in groups of 2: 2 inches apart, 4 inches apart and 8 inches apart) rubber bands *preferably the same width, ruler, recording sheet, Straw, Scissors, Someone who can blow really hard, recording sheet, 3 empty bottles (same size), water, recording sheet

Procedure:

Gather children to think of a single sound like a note played on a guitar. How can you change the sound? Why does the sound change? What is it called when we change the sound? What happens to the sound wave as we do this?

After children have discussed this, show them the video: https://www.youtube.com/watch?v=ZjvuiOSo3ow

Tell them that today they will be doing some exploration of pitch. They will travel to each station and discover what changes the pitch for each sound created.

Teacher will group students; Students will go to each group. Children will carousel around each station discussing and recording findings as they go.

Mason Jar Music
Drum Circle
Rubber Band Band
Straw flutes
Bottle horns

Station 1: Mason Jar Music

Materials: 3 mason jars (4 oz. 8 oz. 12oz.) water, recording sheet

Procedure: Students will fill jars (smallest to largest) with 75 ml, 150 ml, and 300 ml. Discuss what the outcomes may be. Record on sheet. Students will take turns "playing" the jars. Discuss why the tones sounded the way they did, and record.

Station 2: Drum Circle

Materials: 3 drums (cylinders covered with clear packing on one end – hollow on the other) *Try to find 3 empty canisters that differ in only one variable, height or width.

Procedure: Students will look and feel the drums. Discuss the possible results when they are played. Students will take turns "playing" the drums. Discuss why the tones sounded the way they did, and record.

Station 3: Rubber Band Band

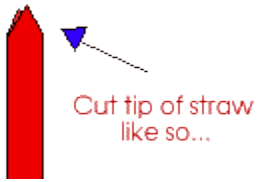
Materials: small piece of wood with 6 nails pounded in. (nails will be hammered in groups of 2: 2 inches apart, 4 inches apart and 8 inches apart) rubber bands *preferably the same width, ruler, recording sheet

Procedure: Students will discuss the possible results when the "instrument" is played. They may measure the distances between the nails. Record results. Students will take turns "playing" the rubber band instrument. Discuss why the tones sounded the way they did, and record.

Station 4: Straw Flutes

Materials: Straw, Scissors, Someone who can blow really hard, recording sheet

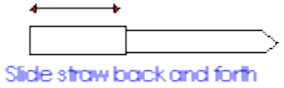
Procedure: Student will take the straw and the scissors, and cut off the tip of the straw to a point, like so. (Try to get both sides to be the same!)



- Now, *gently* chew on the straw to soften the tip, and to get the edges to be smooshed together. You would like the two tips to be *almost* touching each other.
- Students will discuss the possible results when the "instrument" is played. Record hypothesis.
- Now, take the person who can blow really hard, and have them put the pointy end in their mouth, and *blow really hard*. If they do it right (it might take some practice), they will get a very loud sound from the flute!
- Discuss why the tones sounded the way they did, and record.

Now, try some of these things:

- Cut the non-pointy end of the straw off. What does this do to the tone?
- Can you cut holes in the straw so that you can play it like a real flute?
- Maybe you can take a second straw, and slide it over the first. This would make sort of a straw trombone!



Station 5: Water Bottle Horns

Materials: 3 empty bottles (same size), water, recording sheet

Procedure: Students will measure and pour 50 ml, 100 ml, 200 ml into each bottle respectively. Students will discuss what they think the results will be. Students will blow across the top of the bottle and compare the sounds. Students will discuss the results and record.

Curriculum Embedded Performance Assessment (CEPA)
Teacher Instructions

Did You Hear That?

At the close of the unit on waves, the teacher will introduce the concept of using waves to transmit information. Although binary code is not listed as a resource here, teachers may choose to use that if their classroom of students is ready. The teacher will ask children to brainstorm a list of ways we communicate now. She will then go back in time and discuss the problems faced by communicating over long distances, or the problems faced when enemies could understand the communication. The teacher will show the videos on Morse Code and the Navajo Code and discuss why these tools were used and what benefits they had.

After learning about these problems, the students will create a coded message using waves to send and receive information. Each group will need to create a code to be sent and received. This code will be transmitted using waves. The students will be provided the tools used to create waves during the course of the waves unit, but may choose to use other tools with teacher approval. Students will need to create an alphabet or key so that the other students can crack their coded message. Students will record their code on their choice of format. They may do a poster, Google Slide, or Infographic. Each group will be presenting their code to their classmates as well as doing a demonstration that will send a message that will be received by the class to decode.

Resources: video *Morse Code and the Information Age* https://www.youtube.com/watch?v=xcjgm6ctzAw
Navajo Code Talkers, Our Heroes https://www.youtube.com/watch?v=5rSvm3m8ZUA
Navajo Code (graphic) https://www.archives.gov/files/education/lessons/code-talkers/images/figure-1.jpg

CEPA Student Instructions

Your job will be to create a coded message to be sent and received by waves. You may base your code on the codes you learned about or create a new code. You will need to create a key or alphabet that will show your code. You may use a poster, Google Slide or Infographic to display your code. Your group will be doing a presentation that will explain the code and actually send a message using the code. Your audience will be asked to decode your message.

Materials: 3 mason jars (4 oz. 8 oz. 12oz.) water, 3 drums (cylinders covered with clear packing on one end – hollow on the other) *Try to find 3 empty canisters that differ in only one variable, height or width, small piece of wood with 6 nails pounded in. (nails will be hammered in groups of 2: 2 inches apart, 4 inches apart and 8 inches apart) rubber bands *preferably the same width, ruler, recording sheet, Straw, Scissors, Someone who can blow really hard, 3 empty bottles (same size), water

1. Your first step will be to discuss what type of code you would like to use or create. After your group establishes a type to use, you will need to record it.

2. Your group will then need to discuss how you will be transmitting your code. All of the materials used during the waves unit will be available. If your or your group has something else in mind, you may ask the teacher to use it. Teacher will determine if it can be used.

3. You must practice sending and receiving messages so that you can work out any problems.

4. Create your graphic for your code. You may use poster board or a trifold, Google Slides, or create an Infographic.

5. Plan your presentation. Create cards for your speech and practice speaking.

6. Check the scoring rubric against your work. Make any changes necessary.

7. Present your coding project.

CEPA Rubric
Curriculum Embedded Performance Assessment (CEPA)

Criteria	E Exceeds Expectation	M Meets Expectation	P Progressing Towards Expectation	N Not Yet
Sends and Receives Coded Information	More than one messages is sent and receive using code	One messages is sent and receive using code	Message is either correctly sent or received	Message did not correctly get sent or received
Code Graphic	Graphic is exceptionally neat, clearly presented and is easy to understand	Graphic is neat, clearly presented and is easy to understand	Graphic is done or nearly done	Graphic needs some more work in order to be complete
Oral Presentation	PVLEGS: all was exceptional	PVLEGS: Most was great	PVLEGS: Some work is needed	PVLEGS: oral presentation is not yet up to standard