The Evolution of the T2L Science Curriculum

Over the last four years, the Teach to Learn program created 20 NGSS-aligned science units in grades K-5 during our summer sessions. True to our plan, we piloted the units in North Adams Public Schools, and asked and received feedback from our science fellows and our participating teachers. This feedback served as a starting point for our revisions of the units. During year 2 (Summer of 2015), we revised units from year 1 (Summer/Fall 2014) and created new units to pilot. In year 3, we revised units from years 1 and 2 and created new units of curricula, using the same model for year 4. Our understanding of how to create rich and robust science curriculum grew, so by the summer of 2018, our final summer of curriculum development, we had created five exemplar units and established an exemplar unit template which is available in the T2L Toolkit.

We made a concerted effort to upgrade all the existing units with exemplar components. We were able to do much, but not all. So, as you explore different units, you will notice that some contain all elements of our exemplar units, while others contain only some. The fully realized exemplar units are noted on the cover page. We did revise all 20 units and brought them to a baseline of "exemplar" by including the Lessons-At-A-Glance and Science Talk elements.

Grade 4 Waves

MCLA NAPS Williams

Teach To Learn

A collaboration between MCLA, Williams College, and North Adams Public Schools

Funded by NSF DUE-IUSE Award #1432591

T2L Curriculum Unit

Waves

Physical Science/Grade 4

Students will explore waves throughout this unit and will apply their knowledge to communication, sound, and vision. The students will use models of waves to describe patterns of movement in terms of amplitude and wavelength. Using models, the students will be able to describe that an object can be seen when light reflects off it and enters the eye. Students will be able to describe sound as the result of vibrations and will create models and explanations for various sounds. Throughout this unit, students will be expected to demonstrate grade-appropriate proficiency in asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information.

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Unit Creation and Revision History

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Unit Plan

Stage 1 Desired Results

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 Statement: 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]

[2006] 3-5.PS.11*. Recognize that sound is produced by vibrating objects and requires a medium through which to travel. Relate the rate of vibration to the pitch of the sound.*

4-PS4-2. Develop a model to describe that light must reflect off an object and enter the eye for the object to be seen. [State Assessment Boundary: Specific colors reflected and seen, the cellular mechanisms of vision, angles of incidence and reflection, or how the retina works are not expected in state assessment.]

Meaning

UNDERSTANDINGS **U**

Students will understand that…

- 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; it does not move in the direction of the wave except when the water meets the beach. (4-PS4-1)
- Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). (4-PS4-1)
- An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2)
- High-tech devices, such as computers or cell phones can receive and decode information and convert it from digitized form to voice—and vice versa. (4-PS4-3)

ESSENTIAL QUESTIONS **Q**

1. What is sound?
2. Why can't we see in the dark?

[2006] 3-5.PS.12 *Recognize that light travels in a straight line until it strikes an object or travels from one medium to another, and that light can be reflected, refracted, and absorbed.* **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.] **SL.4.3** Identify the reasons and evidence a speaker provides to support particular points. (4-PS3-1) **W.4.8** Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1) **R.4.1** Refer to details and examples in a text when explaining what the text says	***Students Targets*** ***Students will be able to…*** 1. Create examples of regular patterns of motion 2. Locate information in the text to answer questions 3. Identify and define key vocabulary terms 4. Draw conclusions based on information in the text 5. Identify cause and effect, main ideas, and draw conclusions 6. Define wavelength and amplitude 7. Argue from evidence that waves have a repeating pattern of motion 8. Sketch waves to illustrate variations in wavelength and amplitude 9. Explain through different mediums (writing/dialogue) how different wavelengths and amplitudes correspond to different sounds 10. Read text and take two column notes on information 11. Write a summary of an article 12. Define pitch and vibration 13. Observe the vibrations made by various objects that produce sound 14. Illustrate the relationship between vibration and pitch 15. Demonstrate the transfer of energy through the creation of a mechanical wave 16. Observe the vibrations made by various objects that produce sound 17. Summarize the relationship between force and volume 18. Define reflection, absorption, and refraction and identify the similarities and differences 19. Compare and contrast articles using evidence to support their statements 20. Use the information from both texts to write one paper that summarizes both articles 21. Draw an accurate diagram of the relationship between an object, the eye, and a light source to show light travels in a straight line and reflects off an object to enter the eye 22. Differentiate between reflection, refraction, and absorption of light and find examples

explicitly and when drawing inferences from the text. **4.R.4** Determine the meaning of general academic and domain-specific words or phrases in a text relevant to a grade 4 topic or subject area. **4.R.6** Compare and contrast a firsthand and secondhand account of the same event or topic; describe the differences in focus and the information provided. **4.R.9** Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. **4.W.9b** Apply grade 4 Reading standards to informational texts (e.g., "Explain how an author uses reasons and evidence to support particular points in a text"). **4.SL.4** Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.	23. Use the brightness of an object to judge how much light it absorbs 24. Create a message for others to decode using codes of their own design 25. Explain the importance of encoding and decoding messages 26. Explain how a telephone works using a basic model of plastic cups and string 27. Compare two different ways of encoding information and give an advantage and disadvantage for each

Stage 2 – Evidence	
Evaluative Criteria	**Assessment Evidence**
Pre-unit Assessment (if any)	Unit Assessment –CEPA
	OTHER EVIDENCE: **Show What You Know!** Many lessons contain MCAS style multiple choice and open response questions to assess the students understanding of the concepts presented in the lesson. The classroom teacher should administer the questions sometime after the completion of the lesson. The results can be used to plan additional lessons on concepts that students need help mastering. Students will be assessed on the following: ● Participation in class discussions, activities, and experiments ● Completion of worksheets and other resources ● Completion and comprehension of required readings ● Responses to prompts in science journals

Stage 3 – Learning Plan

Lesson Sequence

Lesson 1: What Are Waves? Students learn that *waves* are regular patterns of motion that carry energy through a *medium.* They will discover that the substance of the medium itself does not travel along with the wave (e.g., boats bob up and down and do not move forward with the wave), and that the energy of a wave is greater. Students will be introduced to the idea that mechanical waves are created by a *disturbance.*

Lesson 2: What Are Waves? Students will read an informational text, *Waves and Water,* and answer the questions that follow.

Lesson 3: Sketching Waves: Students learn vocabulary related to waves, (amplitude and wavelength) and what they represent. Students will sketch a wave, and label their diagrams to make connections between the size of the amplitude and wavelength and the impact on sound.

Lesson 4: Pitch: In this lesson, students will read an informational text, *Highs and Lows,* and write a summary of the information presented.

Lesson 5: Pitch Perfect: Mechanical Waves: Student will experiment with glass bottles and metal spoons by filling bottles with different levels of water, to help students make the connection between pitch and vibration and how the humans perceive sound. The students will record their findings after the experiment.

Lesson 6: Gongs, Bells, and Drums: Students will experiment with various percussion instruments to explore the idea that energy is being transferred from the mallet/hand to the gong. They should be making the connection between the force of the strike to the volume of the noise. They will be able to draw and explain the transfer of energy as related to waves.

Lesson 7: Let There Be Light: The students will read two articles, *Let There be Light*, and *Light Bounces!*, and will compare and contrast them.

Lesson 8: Introduction to Light and Reflection: This lesson introduces students to the connection between the eye, light, and an object. Students will develop a model to show how light is reflected to be seen by the eye.

Lesson 9: Refraction and Absorption: In this lesson, students will look at various materials and determine what impact light has when it comes into contact with them.

Lesson 10: Encoding and Decoding: A Secret Language? In this lesson, students will communicate using sound (like tapping with pencil) or light (using flashlight). The main goal of this lesson is to introduce students to encoding a message for communication purposes.

Lesson 11: Ways to Transfer Information Through Sound: Students will investigate the relationship between sound waves, encoding, and decoding a message and how it relates to a phone call. They should be able to diagram the path the waves take and discuss the reason they are encoded.

Tiered Vocabulary List

Tier 1	Tier 2	Tier 3
Waves	Repeating pattern	Disturbance
Volume	Skim	Amplitude
Instrument	Vibration	Wave length
Light	Diagram	Churn
Sound wave	Hypothesis	Buffeted
	Frequency	Absorption
	Pitch	Reflection
	Transfer	Refraction
	Source	
	Encode	
	Decode	
	Morse code	
	Binary	

Lessons-At-A-Glance

Lesson	Core Activities	Extensions	Tech Integration	Field Work
1	• Creating patterns • Marble in the water		YouTube	
2	• Guided reading			
3	• Predicting how sound waves look • Examples of sound waves • Sound worksheet		YouTube	
4	• Guided reading		YouTube	
5	• Pitch perfect experiment			
6	• The sound of instruments			
7	• Guided reading			
8	• What is light? • Do we need light to see? • How does light travel from source to eye? • Using reflection to direct the path of light			
9	• Refraction of light • Absorption of light • Absorption in action		YouTube	
10	• Morse code • Binary code • Make code	• Paired passages	YouTube	
11	• Revisiting code • Building a telephone			

Lesson 1: What Are Waves?

BACKGROUND

Overview of the Lesson

In this lesson, we will learn that *waves* are regular patterns of motion that carry energy through a *medium.* We will discover that the substance of the medium itself does not travel with the wave (e.g. boats bob up and down but do not move forward with the wave), and that the energy of a wave is greater. We will also learn about the *amplitude* and *wavelength* of waves. We will also be introduced to the idea that mechanical waves are created by a *disturbance.*

Focus Standard

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 Statement: 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.]

Learning Target

I can create and discuss examples of regular patterns of motion.

Assessment

Students will reflect on the following in their science journals**:**

- Discuss or diagram something that has a regular pattern of motion and is found in nature

Targeted Academic Language/ Key Vocabulary

Tier 1: waves
Tier 2: repeating pattern
Tier 3: disturbance

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per class	Projector	Classroom Teacher
1 per student	Science Journal	Classroom Teacher
1 per class	Computer	Classroom Teacher
1 per group	**Medium-sized bucket**	**Bin**
1 per group	**Marble**	**Bin**
1 per class	**Piece of rope**	**Bin**
1 per group	Materials checklist	Binder
1 per group	**Small toy boat**	**Bin**
1 per group	Yardstick	Classroom Teacher
1 per class	**Laminated Speedboat Image**	**Bin**
	Ocean Waves Video: https://youtu.be/uEpy_oY4V9Q	CMC website

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/Activator

Introduce the idea of repeating patterns by drawing the example of "square-circle-triangle-square-circle-triangle," etc., on the whiteboard. Ask the students to observe the pattern and write down everything they notice about it (whether it repeats, what it does repeat, etc.…). After the discussion the pattern will be identified as a "repeating pattern" and we will define a "repeating pattern" based on the example.

During the Lesson

1. **Creating Patterns:** Divide the students into small groups of **no more than 4 students**, have each group create their own repeating patterns using letters, numbers, shapes, or anything else that is applicable and appropriate in their science journals. The groups will then present their pattern to the class using the image projector and the class will identify if it is in fact a repeating pattern. If the pattern is not repeating, the students will identify the irregularities and will work with the group to correct the irregularities as necessary (the number of group presentations can be based on time constraints). **(SP8-Obtaining, Evaluating, and Communicating Information)**

2. Brainstorm and ask students: What do you think of when I say waves? Now show the video of ocean waves and ask students to list what they notice. This video is over an hour long, so it can be played continuously for as much or as little time as necessary. Ask students the following questions: Is the sound regular? Is it different? Do the waves all look the same? Ask students to talk with a partner about what they think would happen to the pattern if a speed boat went by. If necessary, explain what a speedboat is and show the provided image.

3. **Marble in the Water: Small Group Activity (4 students per group)**
   a. Write the following statement on the board, *this activity introduces the idea of creating a mechanical wave through the dropping of a pebble into water.*

   b. Pass out the materials and materials checklist and have the groups check to see if they have all of the required materials (certain materials can be omitted at the discretion of the science fellow and teacher), this will allow the students to practice preparation for experiments, which will be important in later grades.

   c. Groups will write three predictions (in their science journals) of what they think will happen when a marble is dropped in water.

   d. The groups will share their predictions with the class, they can be written down on the whiteboard in order to compare/contrast the different predictions.

   e. The groups will begin dropping the marble into the bucket, beginning at a height of 6 inches and moving up in increments of 6 inches until they reach 24 inches (2 feet). If necessary, the science fellow and/or teacher can highlight where 6 inches is on a yardstick and can provide assistance identifying where the 12, 18, and 24 inch marks are located on the yardstick.

   f. After each marble drop we will record what we observed in our science journals. Make sure the students indicate what height the marble was dropped from in their observations.

g. After the marble has been dropped from each height the groups will be asked to identify any trends or observations (higher drop heights equals bigger waves.) **(SP3-Planning and Carrying Out Investigations)**

h. Illustrate (on the whiteboard) the waves that formed when the marble was dropped into the water, ask students to predict what a toy boat would do if it were in the bucket.

i. Now place the small toy boat in the bucket and drop the marble from any height, ask the students to share what they observed. The students should recognize that the wave caused the boat to move up and down. It is important to note that the boat does not move away from the center or in the direction of the wave.

4. We will now come together in an open space in the classroom (bring the provided piece of rope). A few students will take turns using the rope to create waves, the students not directly participating in this activity will be required to write down their observations and to decide whether or not they are witnessing a pattern of motion, and if they are, what that pattern resembles (the waves from the previous activity). This will allow the students the opportunity to engage in the creation of patterns of motion and will increase their overall comprehension with regards to waves and regular patterns of motion. This step can be lengthened or shortened as necessary due to any possible time constraints.

Lesson Closing

Ask the students if they can think of any repeating patterns (other than waves) that are found in nature (these can include the rising and setting of the sun and moon, changing of the seasons, or any other applicable pattern). This will begin to connect the idea of waves and sound as a precursor for the next science lesson.

Assessment

Students will reflect on the following in their science journals**:**

- Discuss or diagram something that has a regular pattern of motion and is found in nature

Lesson 2: What are Waves (Literacy Lesson)

Taught by Classroom Teacher

BACKGROUND

Overview of the Lesson

In this lesson, students will read the informational text *Waves and Water* and answer the questions that follow.

Focus Standard(s)

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 Statement: 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.]

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1)

R.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.

Learning Targets

I can locate information in the text to answer questions.
I can identify and define key vocabulary terms.
I can draw a conclusions based on information in the text.
I can identify the cause and effect, main idea, and draw conclusions based on information provided..
I can define wavelength and amplitude.

Assessment

- Students will be assessed on their answers to the multiple choice and open response questions provided.
- Students will draw a diagram of what they think a wave looks like in their science journal (labeling wavelength and amplitude).

WIDA Language Objectives

(Dependent on the needs of your ELL students)

Targeted Academic Language/ Key Vocabulary

Tier 1: waves
Tier 2: skim
Tier 3: amplitude, wavelength, churn, buffeted

RESOURCES AND MATERIALS

Quantity	Item	Source
1	"Waves and Water" Reading Passage and Questions	Binder (Classroom Teacher to make copies)

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

In partners, students will share their patterns from their lesson one journal entry by turning and talking to each other. Each student will give one reason why his or her partner's pattern is a repeating pattern. Ask students to discuss the following with their partner: *"What do you notice about your partner's drawing? Is it like yours or different? Discuss some similarities and differences. Give one reason why your partner's drawing is a repeating pattern" (Give students about five minutes to complete this)."*

During the Lesson:

1. **Guided Reading:**
   a. The teacher will pass out the text and questions, ask the students:" *What type of text do you think this is? Is it fiction or non- fiction?* What *is the purpose of this text? Why do we read informational texts?"*

   b. The teacher can share the following: **"***Informational texts are non-fiction. What does that mean? (A non-fiction text is not made up; it is about facts). We read informational text in order to get information about something we don't know about or something we want to learn more about."*

c. The teacher can model reading through question one, *"What is a wave, as defined in the passage?" This tells me the main idea of the passage is going to be about waves. When I am looking for the main idea I will gather information from the text and will be thinking about the question: What is a wave?"*

d. Say: **"***Now, I would read through the questions to see if any of them are related. In this case, I notice that a, b, c, and d all have the word "pattern" in them. I would then think about what I learned in Lesson one about patterns. This gives me a way to connect what I have previously learned and know to what to look for while gathering information from the text."*

e. Teacher will then post the two key vocabulary words on the board: **amplitude** and **wavelength**, ask students to skim the text with their partner and highlight/ circle (based on what teacher normally does) any time they see **amplitude** or **wavelength**. Give students a few minutes to skim and compare with each other where they located the words.

f. The teacher can pass out a Frayer Square for wavelength and amplitude and then display the Frayer Square using their ELMO or overhead projector. Fill in the word: wavelength. Ask the students, "*What do you think a wavelength is?*" Through guided discussion the teacher and class will come up with a class definition of wavelength. Students should talk with students sitting nearby about what they think a wavelength is, have a student from each group share what was discussed. After each group has shared, the class will agree on a definition of wavelength: *wavelength is the distance between two peaks in a wave.* As the students read the informational text they will learn more about wavelength. Repeat steps for teaching vocabulary for the word ***amplitude. (The height of the wave****.)*

g. Ask students to read through the passage with their partner, they can alternate reading three sentences at a time. **(The teacher can take a group of students who are unable to read at grade level and do a guided reading with them).**

h. Teacher says: *"while we are reading we are looking for our new vocabulary words. Take note of how they are used in the sentence and what they are describing."* **(Teacher will do this activity with the group of low-level readers to scaffold.)** After the students have finished reading ask them to answer the questions at the end of the text. The teacher will circulate and assist any students who need help.

i. The teacher can model the procedure for answering questions and locating and labeling the evidence in the text.

j. *"Question one says: 'What is a wave as defined in the passage?' Where in the passage did we read the definition for a wave? Oh, it's right at the beginning in paragraph two. Everyone find the sentence in paragraph two where the word wave is defined and put your finger on it so we can see that you're in the right spot. Now, I'm going to re-read that sentence. 'A wave is a pattern of motion', now underline it. Now we will put a small #1 next to that sentence so we can remember that is where we found the answer to question #1. Now we can look back at the question and re-read the choices. Which of those choices is the correct answer? Show me by putting your heads down and holding up one finger if you think its A, 2 fingers if you think its B, 3 fingers if you think its C and 4 fingers if you think its D."*

Lesson Closing

Students should finish filling in the final three boxes of the Frayer Squares on **amplitude** and **wavelength** in small groups. Besides wavelength and amplitude, the most important ideas from the article are:

- Waves are caused by a disturbance
- Waves are regular patterns of motion
- The medium in which the wave is traveling does not move (think "the wave" at a baseball stadium)

The teacher should reread the passage below and draw a diagram to illustrate the waves that the different cruise ships would make. Tell students that in their next lesson they will be doing more work with drawing and modeling waves.

> Waves generated in the same way can have great differences in amplitude and wavelength. For example, think back to the cruise ship. While each ship creates waves caused by the movement of the boat, the properties of each of the waves may be very different. For example, a larger cruise ship, with powerful engines, may create a wave that has high amplitude and a short wavelength. However, if the ship's engines slow down, they may then start creating less powerful waves at a slower rate. This would cause the waves' amplitude to decrease, but its wavelength to increase.

Assessment

- Students will be assessed on their answers to the multiple choice and open response questions provided.
- Students will draw a diagram of what they think a wave looks like in their science journal (labeling wavelength and amplitude).

Lesson 3: Sketching Waves

Taught by Science Fellow in collaboration with the Classroom Teacher

BACKGROUND

Overview of the Lesson

In this lesson students will review the vocabulary (amplitude and wavelength), what they represent, and how they look in a sketch of a wave. They will be able to label their diagrams and make connections between the size of the amplitude and wavelength and their impact on sound. The students will be watching an educational video as well. **Both the science fellow and Classroom Teacher should pre-watch the video in order to prepare for the lesson.**

Focus Standard

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 Statement: 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.]

Learning Targets

I argue from evidence that waves have a repeating pattern of motion.
I can sketch waves to illustrate variations in wavelength and amplitude
I can explain how different wavelengths and amplitudes correspond to different sounds

Assessment

The students will be assessed based on participation in classroom activities, discussions, completion of the provided worksheet, and by responding to the following prompts in their science journals:

- Using information from the previous lessons, explain how you know that waves have repeating patterns of motion.
- How does the size of amplitude and wavelength impact the sound that is made? What happens to the sound when the wavelength and amplitude are large versus when they are small?

Targeted Academic Language/ Key Vocabulary

Tier 1: volume
Tier 2: vibration, diagram**,** hypothesis
Tier 3: pitch

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per student	Science Journal	Classroom Teacher
1 per student	Sketching Waves Worksheet	Binder
2 per student	Graph Paper	Classroom Teacher
1 per class	Computer and Projector	Classroom Teacher
	Sound Waves video (https://youtu.be/XM2FSTd9wDM)	Thumb Drive

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

This lesson will begin with students pairing up and writing down everything that they have learned or already know about waves (lasting no more than 3-5 minutes), this will activate prior learning and will allow students to more effectively engage with the upcoming material.

During the Lesson

1. Predicting How Sound waves Look: We will now work in small groups (no more than 4 students in a group) to hypothesize what the sound waves of an airplane (something that is loud) and whispering to a friend (something quiet) will look like when sketched out. The groups will have five minutes to sketch what they think the sounds waves will look like, we will then share our pictures.

2. The groups will then watch the Sound Waves video and use the information presented during the video to either support or refute their initial hypothesis/sketch. This video (or sections of the video) can be replayed as many times as necessary in order to ensure student comprehension. Note**:** *This video refers to "frequency" (a concept not explicitly discussed during this unit) and so the science fellow or teacher should relate this concept to "wavelength" in order to avoid confusion.*

3. After the completion of the video the students will regroup and discuss whether their initial hypotheses/sketches were correct or incorrect and why.

4. We will then reconvene as a whole, and the science fellow and or teacher will construct a model of a wave by drawing a picture on the board, labeling "wavelength" and "amplitude" with the help of the class. This can be repeated up to three

times to make models of quiet, loud, high pitched, or low pitched sounds in order to emphasize the differences in amplitude and wavelength. **Note*: Examples of how to appropriately draw waves can be found in the video.***

5. **Examples of Sound Waves:** Now the students will be given examples of sounds (someone whispering, a train whistle, etc.) and then will be asked to describe the resulting sound wave. Guide the students in the right direction by reminding them about what they learned in the previous activity and video. Draw the sound wave that the students describe on the board and discuss the concepts once more with them before they move on to work independently.

6. **Sound Worksheet:** Each student will be given a worksheet containing four different sound sources, (an airplane, an 18-wheeler, a normal car, and a bicycle) after reviewing the directions of the worksheet students should sketch (on provided graph paper) what they believe the wavelengths of the sound generated by these objects would look like. The objects that create loud sounds should have large wavelengths and amplitudes, while the objects that create little noise should have smaller wavelengths and amplitudes. **[SP2-Developing and Using Models]**

Lesson Closing

The students will then have the opportunity to share their sketches and will validate their assertions using evidence from this lesson and previous learning. The other students in the class can ask questions of their peers about their sketches, the science fellow and teacher can guide/lead this discussion/sharing time. [**SP7-Engaging in Argument from Evidence]**

Assessment

The students will be assessed based on participation in classroom activities, discussions, completion of the provided worksheet, and by responding to the following prompts in their science journals:

- Using information from the previous lessons, explain how you know that waves have repeating patterns of motion.
- How does the size of amplitude and wavelength impact the sound that is made? What happens to the sound when the wavelength and amplitude are large versus when they are small?

Lesson 4: Pitch (Literacy Lesson)

Taught by Classroom Teacher

BACKGROUND

Overview of the Lesson

This lesson can be divided over two days. This lesson presents important background information about sound and vibration. *Prior to teaching lessons 4 and 5 the science fellow and teacher should read the background information on teaching children about sound.*

Focus Standard(s)

[2006] 3-5.PS.11*. Recognize that sound is produced by vibrating objects and requires a medium through which to travel. Relate the rate of vibration to the pitch of the sound.*

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1)

C.RI.4.4 Determine the meaning of general academic and domain-specific words or phrases in a text relevant to a *grade 4 topic or subject area*.

R.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.

Learning Targets

I can read a text and take notes on information

I can write a summary based on the reading

I can define pitch and vibration

Assessment

- Students will be assessed on classroom discussion and participation.
- Students will write a summary that includes the key vocabulary.

WIDA Language Objectives

(Dependent on the needs of your ELL students)

Targeted Academic Language/ Key Vocabulary

Tier 1: instrument

Tier 3: vibration, frequency, pitch

RESOURCES AND MATERIALS

Quantity	Item	Source
20	**Foss Science Stories: Physics of Sound: P. 8-10 and 11-13**	**Bin**
1 per student	Keys to Literacy, Activity 3 Summary Template	Binder
1 (optional)	Foss Science Stories- Teachers Guide p. 6-9	Binder
	Orchestra Video: first 3 minutes: https://youtu.be/hxjRF6MEDqQ	Thumb Drive
	Marching Band Video: https://youtu.be/lAPY4NE1zH0	Thumb Drive
1	Computer	Classroom Teacher
1 set	Speakers compatible with computer	Classroom Teacher
1	Poster size chart paper	Classroom Teacher

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

Prior to starting the video, the teacher will ask the students to listen for different sounds and what the sounds make them think of, play the Orchestra video for the first three minutes. When you are finished listening brainstorm what instruments they think were used.

During the Lesson

Guided Reading

1. Follow the procedure in Foss Manual on pages 6-7. Let students know that the information they are learning about today and tomorrow will help them with their next lesson.

2. The teacher will hand out the Foss Science Stories book, *Physics of Sound*, and have students turn to page 11. Teacher will say: "*Today we are going to read an informational text about the highs and lows of music. What do you think the purpose of this text is?"* Teacher will then take answers from the class and say, *"This is an informational text. We are reading this article to learn about sound waves. What do we know about sound waves?"*

3. Teacher says, *"During our reading, we will be looking for some key vocabulary and main points of the article. Can someone tell me some of the strategies we have learned for pulling out the main idea of an informational text?"* Teacher will then list some of the strategies students say they use (ie; look for bolded or italicized words, looking at the picture, looking for repetitive words, looking for context clues around key vocabulary).

4. Teacher then writes the words: **pitch, frequency,** and **vibration** on the board. Teacher says, "*Our key vocabulary for this lesson are pitch, vibration, and frequency. As we read through this article, please be looking for the vocab words."*

5. The class will read the first article together, the teacher may begin the story and then call on volunteers to read a paragraph. While reading, the teacher will pause and model the process of finding a key vocabulary word. The teacher will say, *"In paragraph one, we just read the word **pitch.** That is an important word. While we keep reading we need to listen for clues that are in and around our key word that may help to figure out what this word means."*

6. After reading the text, the teacher will ask the students to brainstorm new information and vocabulary they came across and record it on chart paper at the front of the class in two column notes. Teacher says, *"We will now think about what we have read and keep notes so we will be able to write a summary of the article. Can anyone tell me one new thing they learned?*

7. The teacher will explain that the notes they took will be used to answer some questions," *We take notes to help us remember the key points of the article. Now we need to work with our partners and use our notes to come up with a summary of the information we read. A summary tells about all the main parts of the article in our own words."*

8. Depending on the level and previous experience of the class, the teacher may want to model summary writing using *The Key Comprehension Routine* (Sedita, 2010). The summary template and additional information on summarizing has been included at the end of this lesson.

9. The teacher will have students re-read the article in small groups. Write the following questions on the board for students to answer in their science journal: **You are sitting on the side of the road watching the parade when a band marches by, using the information from the text, what are some of the sounds that you hear? What kind of instruments do you see and hear? Which instruments produce a high pitch? Which instruments produce a low pitch.** While students are writing their answer the teacher may play the marching band video for students who have never heard a marching band.

10. The Foss Teachers guide for the story *Highs and Lows* has been provided in case the teacher would like to use it to plan additional activities for this story.

Assessment

- Students will be assessed on classroom discussion and participation.
- Students will write a summary that includes the key vocabulary.

Lesson 5: Pitch Perfect: Mechanical Waves

BACKGROUND

Overview of the Lesson

In this lesson, students will experiment with glass bottles and metal spoons by filling bottles with different levels of water. The students will record their findings in their science journals. **Science Fellows and Classroom Teachers should pre-read the materials list and directions before the start of the lesson to become familiar with the information being presented.**

Focus Standard(s)

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 Statement: 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.]

[2006] 3-5.PS.11*. Recognize that sound is produced by vibrating objects and requires a medium through which to travel. Relate the rate of vibration to the pitch of the sound.*

Learning Targets

I can observe the vibrations made by various objects that produce sound.
I can illustrate the relationship between vibration and pitch.

Assessment

Students should answer the following prompts in their science journals:

- What happened to the pitch of the sound when more water was added to the bottles? What happened when water was taken out of the bottle?
- What do you think would happen if a larger bottle (with water) was used? What would happen if a smaller bottle was used?
- Based on what you've learned so far, is there a relationship between vibration and pitch? How do you know this?

Targeted Academic Language/ Key Vocabulary

Tier 3: pitch

RESOURCES AND MATERIALS

Quantity	Item	Source
4 per group	**Glass bottles (one marked empty, and the others marked at ¼, ½, and ¾ full respectively)**	**Bin**
1 per group	**Metal spoon**	**Bin**
1 per student	Science Journal	Classroom Teacher
1 per student	Experiment materials list/procedure	Binder

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

This lesson will begin with students pairing off and completing a "think-pair-share" activity related to waves, pitch, and the subject matter taught in the previous literacy lesson. They will have three minutes to list the key points from the previous reading before sharing their ideas with the class, make sure to emphasize key points in this unit (such as wavelength and amplitude) in order to reinforce student learning.

During the Lesson

Pitch Perfect Experiment

1. Students should be put in groups of 3-4. Each student will then receive a copy of the experiment worksheet. The class will review what is expected from them as a whole before the materials are handed out. The groups will then work to hypothesize what they think the sounds from each of the bottles (with different amounts of water in them) will be and how the pitch will change, have the students talk about their predictions with their group.

2. The science fellow or teacher will then demonstrate how to correctly hit the glass bottles with the spoon (a short strike in order to produce sound) in order to avoid any possible confusion. We will then complete the activity (hitting the spoon on bottles with the four different levels of water in each bottle) and record any differences on the experiment worksheet. [SP3**-Planning and Carrying Out Investigations**.]

3. The groups will then determine whether or not their observations supported or refuted their initial hypotheses, and will then conclude what they feel is the connection between vibration and pitch (faster vibrations lead to higher pitches and vice versa). Each group will have the opportunity to present their hypothesis, observations, and conclusions to the class. [**SP8-Obtaining, Evaluating, and Communicating Information**.]

Lesson Closing

We will then reconvene as a whole and list important concepts in this unit thus far. This list will be recorded by the science fellow and can be expanded throughout the remainder of the unit in order to allow students the opportunity to reflect on what they've learned so far. **Note:** ***If time constraints are an issue, this discussion can be shortened or lengthened as deemed necessary.***

Assessment

Students should answer the following prompts in their science journals:

- What happened to the pitch of the sound when more water was added to the bottles? What happened when water was taken out of the bottle?
- What do you think would happen if a larger bottle (with water) was used? What would happen if a smaller bottle was used?
- Based on what you've learned so far, is there a relationship between vibration and pitch? How do you know this?

Lesson 6: Gongs, Bells, and Drums

BACKGROUND

Overview of the Lesson

In this lesson students will use various percussion instruments to demonstrate transfer of energy from mallet/hand to the respective instrument. They will relate the force of the strike to the volume of the noise that is created, then they will draw and explain the transfer of energy as it relates to waves. **Note:** ***Prior to this lesson, consult with the school music teacher to coordinate borrowing instruments for the lesson.***

Focus Standard(s)

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 Statement: 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.]

[2006] 3-5.PS.11*. Recognize that sound is produced by vibrating objects and requires a medium through which to travel. Relate the rate of vibration to the pitch of the sound.*

Learning Targets

I can demonstrate the transfer of energy through the creation of a mechanical wave
I can observe the vibrations made by various objects that produce sound
I can summarize the relationship between force and volume

Assessment

Students will be assessed based on their answers to the following prompts in their science journals:

- Why do the instruments make a sound when you strike them with your hand or a mallet? How does this show the transfer of energy?
- Why do larger drums and bells make lower sounds?
- Is there any relationship between the size of an instrument and the speed of the vibrations that it creates?

WIDA Language Objectives

(Dependent on the needs of your ELL students)

Key Vocabulary

Tier 1: instrument
Tier 3: transfer

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per group	Drum	Contact Music Teacher
1 per group	Musical gong/Triangle	Contact Music Teacher
1 per group	**Bell**	**Bin**
1 per student	Science Journal	Classroom Teacher
1 per class	Small drum	Contact Music Teacher
1 per class	Large drum	Contact Music Teacher

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

This lesson will begin with the science fellow or teacher hitting two percussion instruments of the same type (i.e drums) but of different sizes. The larger instrument will create a lower sound while the smaller instrument will create a higher sound. The students will then break into pairs and discuss why the similar instruments created different sounds.

During the Lesson

The Sound of Instruments:

1. Divide the students into groups of four, handing out assorted percussion instruments to each group **while explaining how to properly use and handle each instrument.** Then explain that we will be creating sounds with each instrument and will be recording observations. The science fellow can list some possible observations such as volume, pitch, duration, or any other notable factors on the whiteboard for the students to reference throughout the lesson.

2. The groups will then predict what pitch each sound will be before striking the various instruments and recording their observations. The groups will be reminded to feel the instruments when they strike them in order to ascertain the speed and force of the vibrations that are being created. **Each student will have the opportunity to use each instrument at least once.** After the groups have completed their initial interactions with the instruments, they will decide whether their observations supported or refuted their initial hypotheses and why they were either correct or incorrect. [**SP8-Obtaining, Evaluating, and Communicating Information]**

3. The groups will now predict what will happen when they strike each instrument with more or less force. The groups will share their predictions with the class before proceeding with the hands-on portion.

4. The groups will then decide if their observations support or refute their predictions, and the science fellow will ask each group if the amount of energy transferred to each instrument impacts the volume of the sound that is created by that instrument. Have each group share an observation they made. **[SP7-Engaging in Argument from Evidence**]

Lesson Closing

The students should summarize the relationship between force and volume and create sketches to show how more or less force changes the volume (or amplitude) of the sound wave. The students will be given the opportunity to share their conclusions about force and volume with the class utilizing the image projector as necessary to show any illustrations, this should last 5-10 minutes.

Assessment

Students will be assessed based on their answers to the following prompts in their science journals:

- Why do the instruments make a sound when you strike them with your hand or a mallet? How does this show the transfer of energy?

- Why do larger drums and bells make lower sounds?
- Is there any relationship between the size of an instrument and the speed of the vibrations that it creates?

Lesson 7: Let There Be Light (Literacy Lesson)

Taught by Classroom Teacher

BACKGROUND

Overview of the Lesson

In this lesson students will be introduced to vocabulary for upcoming lessons. The students will read two articles, *Let There be Light* by Erin Horner and *Light Bounces* from ReadWorks.org, and compare and contrast the information from the two articles.

Focus Standard(s)

[2006] 3-5.PS.12 *Recognize that light travels in a straight line until it strikes an object or travels from one medium to another, and that light can be reflected, refracted, and absorbed.*
4.R.4*—Determine the meaning of general academic and domain-specific words or phrases in a text relevant to a grade 4 topic or subject area.*
4.R.6*—Compare and contrast a firsthand and secondhand account of the same event or topic; describe the differences in focus and the information provided.*
4.R.9*—Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.*
4.W.9b*—Apply grade 4 Reading standards to informational texts (e.g., "Explain how an author uses reasons and evidence to support particular points in a text").*
4.SL.4*—Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.*

Learning Objectives

I can define reflection, absorption, and refraction and identify the similarities and differences.
I can compare and contrast the two articles using evidence from the text to support their statements.
I can use the information from both texts to write a paper that summarizes both articles.

Assessment

Student essays will be assessed, teachers should look for key vocabulary words and understanding of content.

WIDA Language Objectives

(Dependent on the needs of your ELL students)

Targeted Academic Language/ Key Vocabulary

Tier 3: Reflection, refraction, absorption

RESOURCES AND MATERIALS

Quantity	Item	Source
1	"Let There Be Light" Reading and Questions	Binder (Classroom Teacher to make copies)
1	"Light Bounces" Reading and Questions	Binder (Classroom Teacher to make copies)
	Chart paper	Classroom Teacher

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

The classroom teacher will ask the following: *"How do we see what we see? What happens when we close our eyes? What happens when we turn the lights off?"* Note the responses on chart paper and guide the discussion. Say, "*We are going to read two articles about light, the articles will have some information that is the same and some information that is not the same. What should we do with the information? (Organize it) How can this information help us learn more about light? When we are finished reading and discussing both articles, your task will be to write a compare/contrast essay."*

During the Lesson

Guided Reading:

1. The teacher will hand out the first article, *Let There Be Light.* Ask the class to think about the title and predict what type of text it is (informational). The teacher will ask each student to write down one reason why they think it's an informational text in their science journals. The teacher will then ask the students to skim the article and write down any unfamiliar words on post it notes (One word per note).

2. The teacher will put a K-W-L chart up on the board and ask students to come up and put their post it notes under the correct column.

3. The students should get into groups of three and take turns reading the article aloud. The teacher should take into consideration the reading level of the students and pair students accordingly.

4. Once the reading has been completed, students will be asked to identify the main idea and three supporting details from the article and write them in their journals.

5. Repeat steps 2-5 for the second article.

6. Once the groups have completed this task, the teacher will put a Venn diagram up on chart paper and ask the students what they purpose of the Venn diagram is (to organize information based on similarities and differences. Say, "*What is this? What do we use it for? How do you think we can use this Venn diagram to help us with our compare/contrast essay? How should we label each circle? With your group members, fill in the template so that I understand how you are going to organize your writing".*

7. Once the diagram and templates are complete and have been discussed, the students will use the information collected to write a compare and contrast essay on the two articles. The teacher will remind students what the expectations are. (FCA's—depending on where the teacher is in writing instruction but must be explicitly stated prior to writing.)

Lesson Closing

Teacher will ask for volunteers to share their essays with the class.

Assessment

Student essays will be assessed, teachers should look for key vocabulary words and understanding of content.

Lesson 8: Introduction to Light and Reflection

BACKGROUND

Overview of the Lesson

This lesson introduces students to how our eyes are able to light, they will develop a model to show how light is reflected to be seen by the eye. The experiment with the reflection of a flashlight on a mirror is adapted from *Who Turned Out the Lights* by Mary Ellen Kanthack. http://betterlesson.com/lesson/617379/who-turned-out-the-lights

Focus Standard(s)

4-PS4-2. Develop a model to describe that light must reflect off an object and enter the eye for the object to be seen. [State Assessment Boundary: Specific colors reflected and seen, the cellular mechanisms of vision, angles of incidence and reflection, or how the retina works are not expected in state assessment.]

[2006] 3-5.PS.12 *Recognize that light travels in a straight line until it strikes an object or travels from one medium to another, and that light can be reflected, refracted, and absorbed.*

Learning Target

I can draw an accurate diagram of the relationship between an object, the eye, and a light source to show that light travels in a straight line and reflects off an object to enter the eye.

Assessment

- Have students respond to the following prompt in their science journals: Why can't we see in the dark? Include a diagram of how objects are seen as evidence for your answer.
- Show What You Know worksheet.

WIDA Language Objectives

Dependent on the needs of your ELL students

Targeted Academic Language/ Key Vocabulary

Tier 1: light
Tier 2: source
Tier 3: reflection

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per student	Science Journal	Classroom Teacher
1 per group	**Flashlight**	**Bin**
1 per group	**Mirror**	**Bin**
1 per student	Show What You Know Worksheet (2 pages)	Binder
1	**Container of Aluminum Foil**	**Bin**
1	**Container of Plastic Wrap**	**Bin**
1 per group	Sheet of paper	Classroom Teacher
	Light Waves video: https://youtu.be/EkvxdR7_2hQ	Thumb Drive

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

Give the students five minutes to think about how we see objects with our eyes, they should draw a diagram or describe the process in words in their science journals. This activity will reveal what baseline knowledge the students have about how vision works. After the students have had time to think on their own, invite a few students to share their ideas.

During the Lesson

1. **What Is Light?**
   a. Ask the students what they know about light. What is light? Where does it come from? What objects in the classroom are sources of light?

   b. Show the Light Waves video, this will introduce the concept of shadows, providing a review from first grade. The sections on color and the electromagnetic spectrum can be glossed over because they are not required for fourth grade. However, you can invite students to do more research on light at home if they are interested and explain that the curriculum will go into greater detail in sixth grade.

2. **Do We Need Light to See?**
   a. Close the blinds and shut off all the lights in the classroom to make it as dark as possible. Ask students what they can see, if anything.

   b. Discuss what has changed when the room went from light to dark. Did the individual objects in the room change? Did our eyes change? Lead students to the conclusion that light is necessary for us to see.

c. Finally, draw a diagram on the board of how objects are seen (see sample diagram at the end of this lesson for reference). Once they come up with a light source, an eye, and an object, move on with the next activity. Leave the diagram on the board because we will return to it later in the lesson. **[SP2 - Developing and Using Models]**

3. **How Does Light Travel from The Source to Our Eye?**
   a. Ask the students what they know about how light travels. At this point the most relevant characteristic of light is that it travels in a straight line; this is part of the first grade curriculum, though it's not guaranteed every student will remember this fact.

   b. To show that light travels in a straight line, turn off the lights and shut the blinds in the classroom again. Have two people stand in the center of the dark classroom, one with a flashlight and one with a mirror. Have the students make predictions about what will happen when the light is shined at the mirror.

   c. Turn on the flashlight and shine beam on the center of the mirror. Then, rotate the mirror.

   d. Invite three more student volunteers to trace the path of the light with string. One student holds the string at the light source, the second holds the string at the spot where the light hits the mirror, and the third student holds the string where the light beam is visible on the wall, the string should make a V shape. Ask students what they noticed about the angle of the light (visually traced out by the string) before and after it hits the mirror? The angle of the light coming in (the angle of incidence) is the same as the angle of the light coming out (the angle of reflection).

   e. Turn the lights back on and ask students to share their observations about the light and the mirror. How did the light travel around the room? Did the light suddenly bend in the presence of the mirror?

f. Students may answer that the light "hit," "collided," or "bounced" off of the mirror. These observations are correct, the proper word to describe this occurrence is **reflection.** Add arrows to the vision diagram to show how light comes from a light source, reflects off of an object, and travels to the eyes. **[SP6 - Constructing explanations]**

4. **Using Reflection to Direct the Path of Light**
   a. Break students into small groups (3-4 students) to experiment with light reflection using flashlights and reflective surfaces. Each group will receive one flashlight, one mirror, a sheet of aluminum foil, a sheet of plastic wrap, and a sheet of paper. Remind students that flashlights and reflections of flashlights should not be pointed at anyone's eyes.

   b. The teacher or science fellow will explain that the goal of this activity is to use reflection to aim the flashlight beam at a target on the wall. The first task each group must accomplish is to decide what is the best reflective material to use, give the students about five minutes to examine each of their reflective objects and write down any observations in their science journals.

   c. The teacher or science fellow will place a target on the wall in the front of the classroom (a mark of tape or a piece of paper). Then, mark a spot in the center of the classroom where each group must shine their light from. Remind the students that their goal is to shine the flashlight beam at the target.

   d. Give the students time to plan out the placement of their flashlight and reflective object of choice (either paper, mirror, plastic wrap, or foil) to accomplish the task. Then, turn out the lights in the classroom and have each group take turns trying to hit the target. If groups are having trouble, the teacher or science fellow can suggest ways to improve such as adjusting the angle of the light or using a different reflective material.

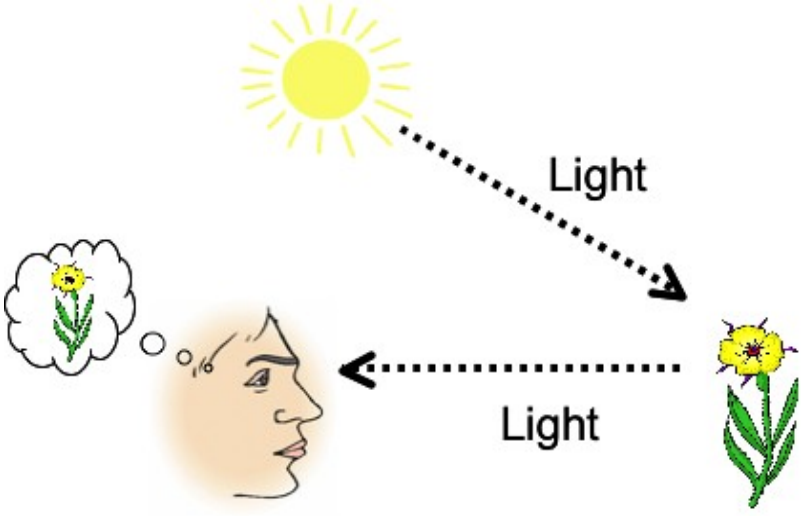
Lesson Closing

Discuss why reflection is important, first and foremost, reflection of light allows us to see objects, perfectly smooth surfaces like mirrors allow us to see an image reflected on the surface. Mirrors are important safety tools in cars and other vehicles.. Mirrored coatings on sunglasses also reflect sunlight and protect our eyes.

Assessment

- Have students respond to the following prompt in their science journals: Why can't we see in the dark? Include a diagram of how objects are seen as evidence for your answer.
- Show What You Know worksheet.

A sample diagram of vision



Lesson 9: Refraction and Absorption

BACKGROUND

Overview of the Lesson

Students will study refraction and absorption of light in small group experiments. Refraction is studied by looking at the image of a pencil in a glass of water. Absorption is studied by comparing the melting of an ice cube on white versus black paper. The model of how we see objects is reinforced, and an extension to the lesson might explain how rainbows are the result of refracted light and colors are the result of reflection and absorption of light. The pencil/water experiment is adapted from http://betterlesson.com/lesson/630470/refraction-and-rainbows. The paper/ice cube experiment is adapted from http://www.sciencekids.co.nz/experiments/lightcolorheat.html.

Focus Standard(s)

4-PS4-2. Develop a model to describe that light must reflect off an object and enter the eye for the object to be seen. [State Assessment Boundary: Specific colors reflected and seen, the cellular mechanisms of vision, angles of incidence and reflection, or how the retina works are not expected in state assessment.]

[2006] 3-5.PS.12 *Recognize that light travels in a straight line until it strikes an object or travels from one medium to another, and that light can be reflected, refracted, and absorbed.*

Learning Targets

I can differentiate between reflection, refraction, and absorption of light.
I can identify examples of objects that reflect, refract, or absorb light.
I can use the brightness of an object to judge how much light it absorbs

Assessment

Have students respond to the following prompt in their science journals:

- Your friend has confused the words **reflection** and **refraction**, explain the difference between these two terms?
- If the weather is sunny and 85˚ today, would you be more comfortable in a black t-shirt or a white t-shirt? Support your answer using what you know about **absorption** of light
- Answer Show What You Know questions (in binder)

Targeted Academic Language/ Key Vocabulary

Tier 2: reflection

Tier 3: refraction, absorption

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per student	Science Journal	Classroom Teacher
2 per group	**Beaker**	**Bin**
2 per group	Pencil	Classroom Teacher
1 cup per group	Water	Classroom Teacher
1	Large black item (such as an article of clothing)	Classroom Teacher
1 per group	Black paper	Classroom Teacher
1 per group	White paper	Classroom Teacher
2 per group	Ice cubes	Classroom Teacher
2	**Ice Cube Tray**	**Bin**

1 per group	**Flashlight**	**Bin**
1 sheet per group	Aluminum Foil	Bin
1 sheet per group	Plastic wrap	Bin
1 per group	**Mirror**	**Bin**
1 per student	Show What You Know Worksheet (2 pages)	Binder
	Reflection and Refraction video (https://youtu.be/O5zSsxW9Pzc)	CMC website
	Bill Nye Refraction Video (https://youtu.be/NO5YcHJEARI)	CMC website
	Disappearing Money Video (https://youtu.be/cyPgEutqZyY)	CMC website

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/Activator

Divide the class into small groups (3-4 students). Each group will have a few minutes to brainstorm as many examples as they can of objects that refract light. Then, have each group share their examples and make a master class list. The teacher or science fellow should give feedback to the students as they share and add to the list if any important items are left off. Some examples of common objects that refract light are: water, raindrops, magnifying glasses, eyeglasses, contact lenses, and prisms.

During the Lesson

1. **Refraction of Light**
   a. Show the Reflection and Refraction video. It provides a review of reflection (Lesson 5) and introduces the students to refraction and absorption. Pause the video frequently and consider watching it multiple times to ensure that the students understand the content of the video. The concept of light **refracting** (bending) when it travels from one

medium to another is difficult, and the picture of the rope in water in the video provides a good visual example. Again, knowledge of colors is not required for fourth grade.

b. Show the video of the disappearing money trick. Discuss how this trick worked. It may help to remind students what they learned about how objects are seen from the last lesson. If we can't see the coin then light reflecting off of the coin is not making it to our eyes. Thus, the light must have changed direction when it entered the water filled cup. The word used to describe how light changes direction when it passes from one medium to another is called **refraction**.

c. To allow the students to further explore the concept of refraction, split the class into small groups (3-4 students). Give each group two beakers and two pencils. One beaker should be empty and one should be filled with water (½ or ¾ full).

d. Place one pencil in the empty cup and record observations in the science journal using pictures and words.

e. Make a prediction (using words and pictures) of what a pencil will look like when it is placed in the beaker of water. Place the second pencil in the beaker of water and record observations in the science journal. Give the students 5-10 minutes to view the pencil from different angles in the water and observe how the image of the pencil changes.

f. Come back together as a class and have students share out their observations. Discuss what happened to the pencils using evidence from the experiment. **[SP7 - Engaging in arguments from evidence]**

g. To end the section on refraction, show the Bill Nye the Science Guy refraction video. This video explains how magnifying glasses refract light to make objects look bigger. The same principle applies to eyeglasses, contacts, and telescopes as well

2. Absorption of Light

a. As in the demonstration at the beginning of Lesson 5, close the shades and turn off the lights in the classroom. Ask students what they see in the dark room. Lead students to make the connection that darkness or blackness is the absence of light.

b. Then, hold up a large black object such as an article of clothing. Remind the students that blackness is the absence of light. Since we see objects because of the light that reflects off of them, black objects are black because they do not reflect light. If the light is not reflected, what happened to it?

c. When light energy is transferred to an object, the process is called **absorption**. When an object absorbs light, the light cannot be seen anymore. Most commonly light energy is transferred into heat energy during absorption. Objects that absorb lots of light get hotter, this is why it's uncomfortable to wear all black on a hot summer day! Discuss other examples of objects that absorb light. Why does the blacktop get unbearably hot on a sunny day, but the grass doesn't?

3.Absorption in Action (this portion of the activity needs to be done outside)

a. Have students get back into their group, give each group a piece of white paper, a piece of black paper, and two ice cubes. In their science journal, ask students to make a prediction about what will happen to the ice cubes after they are exposed to direct sunlight for 10 minutes.

b. Place one ice cube on each sheet of paper and place both sheets in direct sunlight. If the weather is not favorable, consider using another light source such as a desk lamp or a flashlight.

c. Observe the ice cubes, and after 10 minutes describe or draw the ice cubes in the science journal. Make conclusions about the impact of white paper vs. black paper on how the ice cube melts.

Lesson Closing

Discuss why the ice cube on the black paper melted faster? The light was absorbed by the black paper and transferred into heat energy, this heat energy was then transferred to the ice cube, so it melted faster. The white paper reflects most of the light, and therefore absorbs very little thus less heat energy is transferred from the white paper to the ice cube, so it melts more slowly. **[SP6 - Constructing explanations]**

Assessment

Have students respond to the following prompt in their science journals:

- Your friend has confused the words **reflection** and **refraction**, explain the difference between these two terms?
- If the weather is sunny and 85˚ today, would you be more comfortable in a black t-shirt or a white t-shirt? Support your answer using what you know about **absorption** of light
- Answer Show What You Know questions (in binder)

Lesson 10: Encoding and Decoding: A Secret Language

BACKGROUND

Overview of the Lesson

In this lesson, students should be able to communicate a message using sound (like tapping with pencil) or light (using flashlight). The main goal of this lesson is to introduce students to encoding and decoding a message for the purpose of communication, Morse Code will also be introduced in this lesson as a means of encoding and decoding messages. **Prior to teaching the lesson, the Science Fellow and Classroom Teacher should review the definition and uses of Morse Code found in the handout.**

Focus Standard(s)

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.]

Learning Targets

I can create a message for their classmates to decode using codes of their own design.
I can explain the importance of encoding and decoding messages using evidence from this lesson to validate their claims.

Assessment

Students will be assessed on their participation in class discussions and activities, as well as on their responses to the following prompts in their science journals:

- Why is it important to encode and decode messages?
- Was your group successful at encoding and decoding messages? If so, why do you believe you were? If not, what would you change in order to successfully encode and decode messages?

WIDA Language Objectives

(Dependent on the needs of your ELL students)

Targeted Academic Language/ Key Vocabulary

Tier 1: sound wave
Tier 3: encode, decode, Morse Code**,** binary

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per student	Science Journal	Classroom Teacher
1 per group	Dictionary	Classroom Teacher
1 per student	Pencil	Classroom Teacher
2 per group	**Flashlight**	**Bin**
1 per group	**Morse Code kit**	**Bin**
1 per student	Communication Experiment Materials List and Procedure (2 pages)	Binder
1 per student	Morse Code Information Handout (2 pages)	Binder
1 per student	Binary worksheet	Binder
1 per student	Binary worksheet key	
1 per student	Creating a Code worksheet	Binder
	Morse Code Music video (https://youtu.be/NFv3QLHEjuk)	CMC website
1 per student	"Sounds of a Wookie" Reading	Binder
1 per student	"Thump, Thump, Thump" Reading	Binder
1 per student	Paired Text Questions	Binder

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

This lesson will begin with a "think-pair-share" activity based on what has already been taught throughout this unit. Students will have five minutes to work with a partner in order to create a list of important concepts and ideas that have been taught. After the previous activity has been completed, the pairs will work together to create a list of ways that we use communication and should think about why these methods of communication are so important. The pairs will then share their lists with the class. The pairs will also share why they think communication is such a necessary component of daily life, this discussion can be guided by the science fellow or teacher to emphasize prior learning and to keep the discussion focused and relevant.

During the Lesson

1. Divide the students into small groups and ask them to develop possible definitions for the following vocabulary: "encode" and "decode". They can use information from previous literacy lessons or can access classroom dictionaries in order to formulate these. The groups will then have the opportunity to share their working definitions, and with the help of the science fellow, will create a classroom definition for these vocabulary words.

2. Then ask the groups to create lists of devices that are used for encoding or decoding messages (these can include cell phones, televisions, radios, Morse Code, the light on a lighthouse, etc.). They will then share their lists with the rest of the class. The science fellow will then introduce the term "Morse Code" (unless students have already come up with this method of communication) and will ask the groups what they think Morse Code is and how it is used. After the students have presented their ideas related to Morse Code, the science fellow will introduce what Morse Code really is and how it is used. You can distribute the Morse Code handout for students to review

3. **Morse Code**
   a. Remind students that we can communicate with light and sound, explain that today we will encode and decode messages in two different ways. The first way we will decode information is using Morse Code, the fellow or teacher

should come up with a secret message (written in Morse Code) for the students to decode. Tell students they will decode the message by the end of the class.

b. Show students the Morse Code Music video to demonstrate how letters are represented as sounds.

4. **Binary Code**
   a. It is not necessary for students to memorize the explanations; however, students will need to use keys to decode messages. Tell students that computers encode and decode information, but they don't do it with words they use a special code called binary code. Explain that we are going to learn how to understand the language of a computer! Computers translate information by encoding it into a series of digits.

   b. Access the website Covert Binary, http://www.convertbinary.com/, and type in a sample message to show students how the letters are represented in a serious of zeros and ones. Enter some additional text into the encoder. The computer will convert those letters into numbers, and then it will convert those numbers into binary.

   c. Give students the binary key and have them work to decode the message on their worksheet.

5. **Make Code**
   Pass out the **make a code** worksheet and have students pair up. Once student can make a message for the partner to decode. It will be helpful for the classroom teacher to set up parameters for this activity such as what is an appropriate message to send. Students may use flashlights, pencil tapping, or pictures to make their code. Students will need to make a key so when they trade their massages their partner can decode the message

Assessment

Students will be assessed on their participation in class discussions and activities, as well as on their responses to the following prompts in their science journals:

- Why is it important to encode and decode messages?
- Was your group successful at encoding and decoding messages? If so, why do you believe you were? If not, what would you change in order to successfully encode and decode messages?

Optional Extension

Note: this may be completed at another point in time, such as when the science fellows are not present:

- Have students complete the paired passages activities. In these activities, students will read two passages and answer questions. Students will read the "Sounds of a Wookie" and "Thump, Thump, Thump" readings.

Lesson 11: Ways to Transfer Information Through Sound

BACKGROUND

Overview of the Lesson

In this lesson, students will investigate the relationship between sound waves, encoding, and decoding a message, and how it relates to a phone call. They will build a model telephone using plastic cups and string. They should also be able to diagram the path the waves take and discuss how a telephone encodes sound and carries it across long distances.

Focus Standard(s)

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.]

[2006] 3-5.PS.11*. Recognize that sound is produced by vibrating objects and requires a medium through which to travel. Relate the rate of vibration to the pitch of the sound.*

Learning Targets

I can explain how a telephone works using a basic model of plastic cups and string.
I can compare two different ways of encoding information and give an advantage and disadvantage for each model.

Assessment

Students will respond to the following questions in their science journals:

- Imagine you are lost in the woods and need help. Would you rather use a telephone or Morse Code to send out a message? What is the advantage of using this form of communication?
- Imagine you are in your backyard and want to send a message to your best friend, who lives next door. Would you rather use a telephone or Morse Code to send out a message? What is the advantage of using this form of communication?

WIDA Language Objectives

(Dependent on the needs of your ELL students)

Targeted Academic Language/ Key Vocabulary

Tier 1: sound wave

Tier 2: encode, decode

RESOURCES AND MATERIALS

Quantity	Item	Source
2 per group	Plastic cups	Bin
2 per group	Paper clips	Classroom Teacher
1 per group	Length of string (about 6 feet long)	Bin
1 per group	Thumb tack	Bin

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

This lesson will begin with a "think-pair-share" activity to review what the students learned about sound earlier in the unit. Students will have five minutes to work with a partner in order to create a list of important concepts and ideas from the unit.

During the Lesson

1. Review the activity from the previous lesson; in particular, discuss the ways in which the activity was challenging. How well could your classmates decode your message? How far could your message travel? Would it be possible to translate a complete language using your code?

2. **Revisiting Code:** Break the students back up into their groups from the previous lesson and have them revisit the code they used to send messages via sound. This time, have one student tap out a message on the desk/table while another listens with his/her ear **directly on the table**. How quietly can the first student tap and still have the message be heard by the second student? Now repeat the message **at the same volume** with the second student listening normally, away from the table. Can the message be heard as well as before?

3. **Discussion Point:** Improvements in sound communication technology have relied on the fact that many materials are better than air at transmitting sound. The first phonograph, a device used to record and play sounds (like music), operated much like a pencil tapping on a table. The only difference is that a needle tapping a metal cone made the sound.

4. Come up with a list (as a class) of modern devices that are used to communicate sound. The most important items on such a list are the radio and the telephone.

5. **Building a Telephone**
   a. Divide the class into small groups (3-4) students. Give each group two plastic cups, two paper clips, a thumbtack, and a length of string.

   b. Using the thumbtack, make a small hole in the bottom of each cup. Then, thread each end of the string through the hole in each cup, students may need assistance. Tie each end of the string around a paper clip. This prevents the string from sliding out of the hole.

   c. To use the phone, have two students stand far enough apart so that the string is taught. Have one student puts one cup up to his/her mouth and speak while the other student listens to the message through the other cup. The speaker does not need to talk loudly but must be clear because the cup muffles the sound a bit. **[SP2 - Developing and Using Models]**

   d. Give the students five minutes to experiment with the phone and to take turns using it., at some point during the lesson have students place a hand on the cup and the string to feel the vibrations traveling through the phone.

   e. Have the students make a diagram showing how sound travels through their model of a telephone. Label each part of the diagram (air, cup, string, etc.) with a note about how the material carries the sound and in which direction the sound is moving.

Lesson Closing

1. Come back together as a class and discuss the telephone activity. The main question to be answered is: how do telephones transmit sound? In the model telephone that the students built, the sound from our voice (vibrating air) vibrates the cup, which in turn vibrates the string, the string then vibrates the cup on the other end of the line, which vibrates the air inside the cup and allows the original sound to be heard. The original message was encoded from vibrations in the air to vibrations in the cup and string. On the other end, that message is decoded back into vibrations in the air.

2. Ask the students to reflect on the quality of their telephones. Was it easy or hard to hear? What other limits does this design have? End the lesson by explaining that real telephones operate on the exact same principle of encoding vibrations in the air caused by our voices to other media. Instead of encoding messages into string, telephones encode messages into electrical currents and radio waves. Telephones allow us to have conversations with great clarity across long distances. The downside is that we need special technology to make a telephone. All communication technology that we use today, including cell phones, TV, and Internet all send signals using either electricity or radio waves. To make a communication device, scientists and engineers follow a similar process to what we did in the past two lessons.

Assessment

Students will respond to the following questions in their science journals:

- Imagine you are lost in the woods and need help. Would you rather use a telephone or Morse Code to send out a message? What is the advantage of using this form of communication?
- Imagine you are in your backyard and want to send a message to your best friend, who lives next door. Would you rather use a telephone or Morse Code to send out a message? What is the advantage of using this form of communication?

Science Talk and Oracy in T2L Units

Science talk is much more than talking about science. In line with the science and engineering practices, students are expected to make a claim that can be supported by scientific evidence. The MA STE Standards (and the NGSS) value the importance of engaging in an argument from evidence. NGSS defines how this practice takes form in the real world: *"In science, reasoning and argument are essential for identifying the strengths and weaknesses of a line of reasoning and for finding the best explanation for a natural phenomenon. Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated."*

Students are asked to participate in articulate and sensible conversations in which they are able to communicate their ideas effectively, listen to others to understand, clarify and elaborate ideas, and reflect upon their understanding. These forms of talk can be developed using scaffolds such as the A/B Talk protocol (below) and strategies for class discussions (from the Talk Science Primer, link below). Oracy is developed in the physical, linguistic, cognitive, and social-emotional realms; each of these realms can be expanded upon over time in order to develop a thoughtful speaker. Being able to display appropriate body language, use proper tone and grammar, be thoughtful and considerate thinkers, and allow space for others thoughts and opinions are all important facets of oracy to work on and through with students. Incorporating the appropriate scaffolding is an important aspect of fostering these skills. Techniques for teaching effective science talk often include modeling, discussion guidelines, sentence-starters, and generating roles, while gradually putting more responsibility on students to own their thinking and learning.

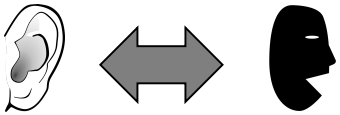
Part of creating a safe school environment for students is allowing them a space that is comfortable enough for them to express ideas and ask questions, while being validated for their thoughts and questions; students should be feel comfortable and confident when speaking and listening for understanding. Effective talk is an important part of being an active, intelligent member of a community and society. Successful development in oracy is important for future employability and general well-being of adults.

The following resources should be helpful examples of how to employ effective use of progressive oracy and science talk in your classrooms.

- Oracy in the Classroom: https://www.edutopia.org/practice/oracy-classroom-strategies-effective-talk
- Science Talk Primer: https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf

A/B Talk Protocol

Adapted from https://ambitiousscienceteaching.org/ab-partner-talk-protocol/

1. Share your ideas **Partner A**  • I think _____ happened because… • Evidence that supports my idea is… • The activity we did with _____ helps me know more about _____ because… • One thing I'm wondering about is…	**2. Listen to Understand** **Partner B**  • I heard you say _____. What makes you think that? • I heard you say _____. What if _____? • Can you explain the part about _____ again? • What do you mean when you say _____?
3. Clarify and elaborate **Partner A**  Answer partner's questions or ask for clarification in order to understand a question.	**4. Repeat steps 2 & 3 until all questions are answered**  
5. Switch roles and repeat steps 1-4 	**6. Reflect on your understanding in writing** • My idea about _____ changed when my partner said _____. • I will add _____ to my idea about _____ because… • I still have questions about… • I may be able to answer my question(s) if I could investigate _____.

List of Unit Resources

Lesson 1

Quantity	Item	Source
1 per class	Projector	Classroom Teacher
1 per student	Science Journal	Classroom Teacher
1 per class	Computer	Classroom Teacher
1 per group	**Medium-sized bucket**	**Bin**
1 per group	**Marble**	**Bin**
1 per class	**Piece of rope**	**Bin**
1 per group	Materials checklist	Binder
1 per group	**Small toy boat**	**Bin**
1 per group	Yardstick	Classroom Teacher
1 per class	**Laminated Speedboat Image**	**Bin**
	Ocean Waves Video: https://youtu.be/uEpy_oY4V9Q	Thumb Drive

Lesson 2

Quantity	Item	Source
1	"Waves and Water" Reading Passage and Questions	Binder (Classroom Teacher to make copies)

Lesson 3

Quantity	Item	Source
1 per student	Science Journal	Classroom Teacher
1 per student	Sketching Waves worksheet	Binder
2 per student	Graph Paper	Classroom Teacher
1 per class	Computer and Projector	Classroom Teacher
	Sound Waves video (https://youtu.be/XM2FSTd9wDM)	Thumb Drive

Lesson 4

Quantity	Item	Source
20	**Foss Science Stories: Physics of Sound: P. 8-10 and 11-13**	**Bin**
1 per student	Keys to Literacy, Activity 3 Summary Template	Binder
1 (optional)	Foss Science Stories- Teachers Guide p. 6-9	Binder
	Orchestra Video: first 3 minutes: https://youtu.be/hxjRF6MEDqQ	CMC Website
	Marching Band Video: https://youtu.be/lAPY4NE1zH0	CMC Website
1	Computer	Classroom Teacher
1 set	Speakers compatible with computer	Classroom Teacher
1	Poster size chart paper	Classroom Teacher

Lesson 5

Quantity	Item	Source
4 per group	**Glass bottles (one marked empty, and the others marked at ¼, ½, and ¾ full respectively)**	**Bin**
1 per group	**Metal spoon**	**Bin**
1 per student	Science Journal	Classroom Teacher
1 per student	Experiment materials list/procedure	Binder

Lesson 6

Quantity	Item	Source
1 per group	Drum	Contact Music Teacher
1 per group	Musical gong/Triangle	Contact Music Teacher
1 per group	**Bell**	**Bin**
1 per student	Science Journal	Classroom Teacher
1 per class	Small drum	Contact Music Teacher
1 per class	Large drum	Contact Music Teacher

Lesson 7

Quantity	Item	Source
1	"Let There Be Light" Reading and Questions	Binder (Classroom Teacher to make copies)
1	"Light Bounces" Reading and Questions	Binder (Classroom Teacher to make copies)
	Chart paper	Classroom Teacher

Lesson 8

Quantity	Item	Source
1 per student	Science Journal	Classroom Teacher
1 per group	**Flashlight**	**Bin**
1 per group	**Mirror**	**Bin**
1 per student	Show What You Know Worksheet (2 pages)	Binder
1	**Container of Aluminum Foil**	**Bin**
1	**Container of Plastic Wrap**	**Bin**
1 per group	Sheet of paper	Classroom Teacher
	Light Waves video: https://youtu.be/EkvxdR7_2hQ	CMC Website

Lesson 9

Quantity	Item	Source
1 per student	Science Journal	Classroom Teacher
2 per group	**Beaker**	**Bin**

2 per group	Pencil	Classroom Teacher
1 cup per group	Water	Classroom Teacher
1	Large black item (such as an article of clothing)	Classroom Teacher
1 per group	Black paper	Classroom Teacher
1 per group	White paper	Classroom Teacher
2 per group	Ice cubes	Classroom Teacher
2	**Ice Cube Tray**	**Bin**
1 per group	**Flashlight**	**Bin**
1 sheet per group	Aluminum Foil	Bin
1 sheet per group	Plastic wrap	Bin
1 per group	**Mirror**	**Bin**
1 per student	Show What You Know Worksheet (2 pages)	Binder
	Reflection and Refraction video (https://youtu.be/O5zSsxW9Pzc)	Thumb Drive
	Bill Nye Refraction Video (https://youtu.be/NO5YcHJEARI)	Thumb Drive
	Disappearing Money Video (https://youtu.be/cyPgEutqZyY)	Thumb Drive

Lesson 10

Quantity	Item	Source
1 per student	Science Journal	Classroom Teacher
1 per group	Dictionary	Classroom Teacher

1 per student	Pencil	Classroom Teacher
2 per group	**Flashlight**	**Bin**
1 per group	**Morse Code kit**	**Bin**
1 per student	Communication Experiment Materials List and Procedure (2 pages)	Binder
1 per student	Morse Code Information Handout (2 pages)	Binder
1 per student	Binary worksheet	Binder
1 per student	Binary worksheet key	
1 per student	Creating a Code worksheet	Binder
	Morse Code Music video (https://youtu.be/NFv3QLHEjuk)	CMC Website
1 per student	"Sounds of a Wookie" Reading	Binder
1 per student	"Thump, Thump, Thump" Reading	Binder
1 per student	Paired Text Questions	Binder

Lesson 11

Quantity	Item	Source
2 per group	Plastic cups	Bin
2 per group	Paper clips	Classroom Teacher
1 per group	Length of string (about 6 feet long)	Bin
1 per group	Thumb tack	Bin