Stackable Instructionally-embedded Portable Science (SIPS) Assessments Project

Grade 8 Science

Unit 4 Instructional Framework

Providing Solutions to Problems Using Simple Wave Properties

July 2023

The SIPS Grade 8 Science Unit 4 Instructional Framework: Providing Solutions to Problems using Simple Wave Properties was developed with funding from the U.S. Department of Education under the Competitive Grants for State Assessments Program, CFDA 84.368A. The contents of this paper do not represent the policy of the U.S. Department of Education, and no assumption of endorsement by the Federal government should be made.

Table of Contents

Science
Grade: 8 Unit: 4
43 days of instruction

Unit 4 Overview

Storyline Synopsis:

This unit consists of four segments, each engaging students in multiple science and engineering practices as students make sense of the key disciplinary ideas of properties and types of simple waves and provide design solutions to problems that involve these properties.

- **Instructional Segment 1:** By engaging in the practices of asking questions and defining problems, developing and using models, planning and carrying out investigations, constructing explanations and designing solutions, and using mathematical and computational thinking, students learn about the types and properties of simple waves. Students begin the unit by exploring an anchoring phenomenon that is based on how light and sound waves are experienced in different environments. Students' learning experiences will allow them to explore new driving questions in later segments. Possible driving questions include, "How do we use waves in everyday life?", "Have your eyes burned throughout the day?", "How do wave properties affect what we see?", etc. Students are also introduced to a design challenge based on the anchoring phenomenon and are asked to outline criteria and constraints as well as expected conditions and limitations as they refine the problem statements using their findings from exploring other local phenomena within the segment.
- **Instructional Segment 2:** By engaging in the practices of asking questions and defining problems, constructing explanations, planning and carrying out investigations, and developing and using models, students are able to build their understanding of why sound waves require a medium to travel as well as their ability to transfer energy without overall displacement. At the end of the segment, students add to their explanatory model based on their understanding of the mechanical and wavelike nature of sound that requires a medium to travel.
- **Instructional Segment 3:** By engaging in the practices of asking questions, planning and carrying out investigations, and developing and using models, students learn how properties of matter affect light behavior to understand how a one-sided mirror works. Students explore various properties of light such as reflection, refraction, diffraction, and additive properties. Students utilize this learning to add to their explanatory model based on their understanding of the properties and behavior of light to refine their design solution based on the anchoring phenomenon.
- **Instructional Segment 4:** By engaging in the practices of constructing explanations and designing solutions, defining problems, and developing and using models, students learn about completing a design specification by considering all criteria, constraints, and the different conditions for the performance of a device that uses waves to solve a problem. At the end of the segment, students compile their final design specification after revising their problem statements, prototypes, parameters of operation, and models of wave interaction as well as a comprehensive list of criteria and constraints.

Unit Storyline Phenomenon and/or Design Problem: Use waves to define problems and design solutions.

Science
Grade: 8 Unit: 4
43 days of instruction

Stage 1 – Desired Results

Overview of Student Learning Outcomes

The Grade 8 Unit 4 Topic Bundle, **"Providing Solutions to Problems Using Simple Wave Properties,"** organizes performance expectations with a focus on helping students deepen their knowledge about properties of mechanical and light waves and how they can be used to define and solve engineering problems. Students also learn how to determine success criteria and constraints needed to solve problems related to properties and behavior of simple waves. In this unit, there is significant overlap and synergy between the DCI and CCC dimensions, where patterns and structure of a wave will define its characteristics and properties. Similarly, the SEPs allow students to define problems, use mathematical and computational thinking, and consider other evidence to develop models and explanations around wave properties. By building familiarity with previous Unit 3 scientific practices and crosscutting concepts used to understand the history of the Earth and how fossil structures found within it are genetically related to present-day life forms, Unit 4 allows students to use and extend their ability to use these practices and crosscutting concepts to the properties of mechanical and light waves and how they can be used to define and delimit engineering problems.

Unit 4 Big Ideas:

PS4.A: Wave Properties + PS4.B: Electromagnetic Radiation	1. A simple wave has characteristic properties and a repeating pattern whose behavior can change with the introduction of a new medium. (MS-PS4-1, MS-PS4-2)
PS4.A: Wave Properties	2. Mechanical waves (e.g., sound or water) require a medium through which they are transmitted. (MS-PS4-2)
PS4.B: Electromagnetic Radiation	3. A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (MS-PS4-2)
ETS1.A: Defining and Delimiting Engineering Problems	4. Solutions to a design problem require precise determinations of the criteria for success and constraints using scientific principles and other relevant knowledge, including appropriate terminology. (MS-ETS1-1)

The SIPS Unit 4 Student Profile describes what students should know and be able to demonstrate prior to and at the culmination of three-dimensional science instruction in Unit 4 to prepare for new and increasingly sophisticated learning opportunities in Grade 9.

Next Generation Science Standards (NGSS) Performance Expectations & Foundation Boxes

MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.]

MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves.

Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Targeted Scientific Practices	Targeted Disciplinary Core Ideas	Targeted Cross-Cutting Concepts
[SEP-1] Asking Questions and Defining Problems Asking questions and defining problems in grades 6-8 builds on grades K-5 experiences and progresses to specifying relationships between variables and clarifying arguments and models. ● Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. **(MS-ETS1-1)** **[SEP-2] Developing and Using Models** Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. ● Develop and use a model to describe phenomena. **(MS-PS4-2)** **[SEP-5] Using Mathematics and Computational Thinking** Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. ● Use mathematical representations to describe and/or support scientific conclusions and design solutions. **(MS-PS4-1)**	**PS4.A: Wave Properties** ● A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. **(MS-PS4-1)** ● A sound wave needs a medium through which it is transmitted. **(MS-PS4-2)** **PS4.B: Electromagnetic Radiation** ● When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. **(MS-PS4-2)** ● The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. **(MS-PS4-2)** ● A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. **(MS-PS4-2)** ● However, because light can travel through space, it cannot be a matter wave, like sound or water waves. **(MS-PS4-2)** **ETS1.A: Defining and Delimiting Engineering Problems** ● The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific	**[CCC-1] Patterns** ● Graphs and charts can be used to identify patterns in data. **(MS-PS4.1)** **[CCC-6] Structure and Function** ● Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. **(MS-PS4-2)** **Influence of Science, Engineering, and Technology on Society and the Natural World** ● All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. **(MS-ETS1-1)** ● The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. **(MS-ETS1-1)**

	principles and other relevant knowledge that are likely to limit possible solutions. **(MS-ETS1-1)**	

Acquisition Goals

Students will know and be able to . . .

A1. Ask questions that arise from careful observation of wave phenomena or the occurrence of unexpected results related to the properties of waves.

A2. Carry out an investigation to determine that light and sound waves can be reflected, absorbed, transmitted, or refracted when they enter a new medium.

A3. Use models to describe how wavelength, frequency, and amplitude of a wave do not change and can be repeated in a given time.

A4. Develop and use a model to describe and identify the wavelength, frequency, and amplitude of a wave.

A5. Use mathematical and computational thinking to show that the wavelength and frequency of a wave are related to one another by the speed of travel of the wave.

A6. Apply their understanding to real-world phenomena about the ability of waves to transfer energy without overall displacement.

A7. Plan and carry out investigations to answer scientific questions about the longitudinal and/or transverse nature of waves.

A8. Develop and use models to show that sound waves are pressure waves and are longitudinal.

A9. Develop and use models to show that sound waves require a medium to move.

A10. Apply scientific ideas and principles to real-world phenomena to explain how sound waves require a medium to move.

A11. Examine how light is reflected and refracted when interacting with matter to develop questions about how properties of matter reflect or refract light waves.

A12. Use the ray model of light to explain how reflection and refractions of different wavelengths of light occur when interacting with a prism, lens, or other matter.

A13. Plan and carry out an investigation to explain how and why certain properties (wavelength, nature of materials) result in differences in the bending of light.

A14. Use information on the propagation of light to ask questions about how light waves and mechanical waves, such as sound, are related and different.

A15. Design and carry out an investigation to determine the way that light interacts with different materials, including the way different light frequencies are affected by a transition from one medium to another.

A16. Develop a model for the path of different frequencies of light through the interface of different media that uses the ray model of light.

A17. Describe a solution to a design problem in terms of criteria using appropriate terminology associated with waves and their motion.

A18. Refine a problem statement to include the expected conditions and limitations in which a solution will need to operate.

A19. Use a model of the behavior of waves to document the criteria and constraints that need to be considered, including precise indication of the nature of different parameters. **A20.** Complete a design specification in terms of all criteria, constraints, and the different conditions for the performance of a device that uses waves to solve a problem.
Cross-curricular Integration
Students deepen their knowledge about properties of mechanical and light waves and how they can be used to define and delimit engineering problems. They learn how to determine success criteria and constraints needed to solve problems related to properties and behavior of simple waves. Students develop these understandings by developing and interpreting models and using mathematical representations related to how waves transfer energy and information through various materials and utilize elements of structure and function of an object's material to determine and describe that light is reflected, absorbed, or transmitted through different materials. Students use reading and research skills to **acquire new information** and to **draw on** and **integrate information** from **multiple sources**. Students also use mathematical practices such as **reasoning and modeling** and mathematical concepts related to **measurement and data** to explain phenomena or create solutions to design problems.

Common Core State Standards for Literacy	Common Core State Standards for Mathematics
Speaking and Listening **SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. **(MS-PS4-1) (MS-PS4-2)** ***Reading Science and Technical Subjects*** **RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. **(MS-ETS1-1)** ***Writing Science and Technical Subjects*** **WHST.6-8.8** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. **(MS-ETS1-1)**	***Mathematical Practice*** **MP.2** Reason abstractly and quantitatively. **(MS-PS4-1) (MS-ETS1-1)** **MP.4** Model with mathematics. **(MS-PS4-1)** ***Ratios and Proportional Relationships*** **6.RP.A.1** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. **(MS-PS4-1)** **6.RP.A.3** Use ratio and rate reasoning to solve real-world and mathematical problems. **(MS-PS4-1)** **7.RP.A.2** Recognize and represent proportional relationships between quantities. **(MS-PS4-1)** ***Functions*** **8.F.A.3** Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. **(MS-PS4-1)** ***Expressions and Equations*** **7.EE.3** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as

	appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. **(MS-ETS1-1)**
Enduring Understandings	***Essential Questions***
Students will understand that . . . **EU1.** Characteristics of mechanical (sound, water) and electromagnetic (light) waves such as repeating patterns, the scale of energy, and the speed of transfer can be used to explain observable phenomena. **EU2.** Models can be used to make sense of the properties and behaviors (i.e., reflection, absorption, or transmission) of waves interacting with different materials. **EU3.** Waves transmit differently through various mediums based on their properties, resulting in certain waves being better suited for particular functions. **EU4.** By understanding wave properties and the interactions of light waves with matter, scientists and engineers can develop technologies with certain properties that are well-suited for particular functions (e.g., lenses and mirrors, sound absorbers in concert halls, colored light filters, sound barriers next to highways). **EU5.** Scientists and engineers must use criteria and constraints to increase the likelihood of designing a successful solution. Criteria address how the product or system will function, its durability, and its cost, and constraints frame the conditions and limitations under which the problem must be solved.	**EQ1.** How can the characteristics of waves be used to explain phenomena? **EQ2.** How can we model the interactions between waves and materials? **EQ3.** Why are certain waves (e.g., light vs. mechanical waves) and the properties of materials well-suited for designing solutions for particular functions? **EQ4.** How can scientific principles about wave properties be used to influence advances in technology? **EQ5.** How can criteria and constraints be used to design successful solutions?

Vocabulary

• Waves	• Mechanical waves	• Refraction/Reflection
• Amplitude	• Electromagnetic waves	• Transmit
• Frequency	• Wavelength	• Transparent
• Absorb	• Transverse wave	• Criteria
• Medium	• Longitudinal wave	• Constraints

• Trough • Crest • Interface • Pitch	• Wave Speed • Visible light • Spectrum • Vacuum • Compression	• Parameters • Operating conditions • Design specification • Prototype • Rarefaction

Stage 2 – Assessment Evidence

Assessment Overview

For each of the acquisition goals listed in the Stage 1 – Desired Results, evidence statements were developed. These statements provide information on what we would want to see students do in order to determine the degree to which students have met the acquisition goals. These acquisition goals and evidence statements were then sequenced into instructional segments. Evidence statements and acquisition goals that were deemed critical were identified and assessment opportunities were developed. For this unit, four segments were identified. An overview of each segment is provided below.

Instructional Segment 1 focuses on Big Ideas 1 and 4. Students are informally assessed on their ability to ask questions, use mathematical and computational thinking, carry out investigations, and model waves as they apply their initial understanding to a design challenge. Students are formally assessed on their ability to carry out investigations about waves, use and develop models of waves, and use mathematical representations to describe that waves are repeating patterned disturbances that transfer energy and not matter.

Instructional Segment 2 focuses on Big Idea 2. Students are informally assessed on their ability to develop and use models of sound waves and carry out simple sound investigations. They are formally assessed on their ability to model particle motion in a sound wave, including modeling how oscillating particles and longitudinal waves interact with objects and the medium they move through. Students are also formally assessed on their ability to construct explanations as to why sound waves require a medium and how waves are impacted as they move through different materials. Additionally, students will be formally assessed on their ability to design and carry out an investigation that demonstrates how particles oscillate as energy is transferred in a longitudinal wave.

Instructional Segment 3 focuses on Big Idea 3. Students are informally assessed on differences between light and sound waves and their use of prisms, lenses, and/or media to answer questions and explain reflection and refraction. They are also informally assessed on planning and carrying out investigations about properties of light and how it interacts with different materials (including how light can travel in a vacuum). Students are formally assessed on their ability to ask questions, construct explanations, and develop models and carry out investigations to understand how light travels through a one-sided mirror based on observations they make on a one-sided mirror.

Instructional Segment 4 focuses on Big Ideas 1, 2, 3, and 4. Students are informally assessed on their ability to describe, through documentation and the use of models, the relevant criteria and constraints for design solutions. Students are formally assessed on their ability to describe, model, complete, and present a design specification (including criteria, constraints, and different performance conditions) for a device that uses waves to solve a problem as introduced in the anchoring phenomenon.

End-of-Unit Stackable, Instructionally-embedded, Portable Science (SIPS) Assessment:

For the end-of-unit SIPS assessment, students will engage in three scenario-based assessment tasks. The tasks focus on PEs MS-ETS1-1, MS-PS4-1 and MS-PS4-2.

Instructionally-embedded Assessments
For each instructional segment, descriptions of *informal* and *formal* instructionally-embedded assessments are included based on the acquisition goals and evidence statements deemed critical to assess along an instructional plan. Informal assessments defined as "in the moment" assessment opportunities identify student challenges and lack of knowledge or misconceptions and could include class check-ins such as discussion prompts, exit tickets, or graphic organizers. Formal assessments measure how well students perform when engaging with more complex tasks that require integration of the dimensions (SEPs, DCIs, CCCs) in the service of sense-making. They are administered at specific, intentional points in time along an instructional plan before or after a lesson or a series of lessons. Examples include performance tasks, concept maps, research projects, or hands-on tasks.

Instructionally-embedded Assessments for Use during Instructional Segment 1

Informal Assessment: All About Waves

Throughout Segment 1, informal assessments are used to provide information for further instructional needs. Informal assessments can be used frequently in this segment because students are introduced to a design challenge and practice asking questions about wave phenomena, carrying out investigations to answer their wave-related questions, and modeling waves. The teacher assesses students' understandings of waves and wave features, such as the source of waves, wave properties, and the factors that influence those properties and their ability to outline initial criteria and constraints of a design solution.

Assessment Purpose and Use

- These informal assessments are typically used for formative purposes. The goal is to gauge where students are in their learning, identify what challenges students are facing, and determine next steps for the class and/or individual students.
- The assessments provide information that can be used either at the class level or the individual student level to help determine what instructional activities will best support students.

Administration Time: 5-10 minutes

Scoring Time: 3 minutes

Assessment Type(s)

Informal - Classroom Check-In

Assessment Sub-Type(s)

Discussion prompts

Exit Tickets

In-the-moment Questions

Graphic Organizers

These assessments will assess students' ability to:

- Formulate a scientific question to investigate a phenomenon related to the properties of waves.
- Describe what evidence is needed to answer questions about a phenomenon related to the properties of waves, and how they help build toward an explanation of the phenomenon.
- Accurately describe how a simple mathematical wave model corresponds to the properties of a physical phenomenon.
- Accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations.
- Carry out an investigation to determine that light waves can be reflected, absorbed, transmitted, or refracted when they collide with new matter.

- Carry out an investigation to determine that sound waves can be reflected, absorbed, transmitted, or refracted when they collide with new matter.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):

- It's Too Bright, Too Loud, Too Much
- What is a Wave?
- Observing Mechanical Waves in Action
- Wave Properties Investigation
- Earthquakes: Waves of Danger
- Criteria and Constraints: Waves

NGSS PEs:	CCSS:	EUs/EQs:	AGs:
MS-PS4-1	MP.2	EU1/EQ1	A1
MS-PS4-2	MP.4	EU2/EQ2	A2
MS-ETS1-1	6.RP.A.1	EU5/EQ5	A4
	7.RP.A.2		
	SL.8.5		
	8.F.A.3		

Formal Assessment: What is a Wave?

In this performance task, students utilize evidence from their learning to develop an explanatory model to represent/communicate the properties of a wave, such as wavelength, frequency, wave speed, and amplitude. Students use their models to explain how a mathematical wave model can be used to describe the motion of a wave, how waves are repeated in a given time, how changing the frequency or wavelength will change the other, how wave speed is constant for a given medium, and how energy is transmitted while matter stays in place. Their model shows that the wave is a repeating pattern and relates the wave model to a given system or phenomenon (e.g., a wave made from dropping a pebble in a pool of water).

Assessment Purpose and Use

- Performance tasks provide opportunities for students to engage with the practices of the discipline along with the content. These tasks are used to measure how well students perform when provided with more complex tasks and are opportunities to engage in a meaningful way with the content in the curriculum.
- To assess students' ability related to communicate and represent the properties of a wave.

Administration Time: 30 minutes

Scoring Time: 5-10 minutes

Assessment Type(s)

Formal - Extended Performance Task

Assessment Sub-Type(s)

Scenario/Phenomena-based Assessment Task

These assessments will assess students' ability to:

- Accurately describe how a simple mathematical wave model corresponds to the properties of a physical phenomenon.
- Accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations.
- Accurately describe how a simple wave has a repeating pattern of specific wavelength, frequency, and amplitude.
- Accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how a wave is a repeating pattern of motion that transfers energy from place to place.

- Accurately identify the evidence that supports a claim about how waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter.
- Construct an accurate explanation that describes how waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• What is a Wave?	MS-PS4-1	SL.8.5	EU1/EQ1	A3
		MP.4	EU2/EQ2	A4
		8.F.A.3		A6

Formal Assessment: Representing Wave Properties Mathematically

In this assessment, students develop and use a mathematical representation to explain how different amplitudes or frequencies of mechanical waves have different amounts of energy when in the same medium. Students are provided with scenarios with simulated measurement data of a wave pattern, such as wave speed and several wavelengths, and asked to find other variables, such as frequency. Students show they understand how variables are related, which ones will change with each other, and that some properties do not change unless the medium changes.

Assessment Purpose and Use

- Assessment tasks are typically used to provide a measure of how well students are able to engage with the concepts taught in the curriculum. Questions are generally tied closely to the concepts as they are taught in the curriculum. While they can provide formative information, they are generally not designed to provide in-depth information for each of the concepts and instead provide an overview of student performance across a range of concepts.
- To assess students' ability related to communicate and represent properties of a wave.

Administration Time: 20-30 minutes

Scoring Time: 5 minutes

Assessment Type(s)

Formal - Quiz

Assessment Sub-Type(s)

Scenario/Phenomena-based Assessment Task

Other

Sample Instructionally-embedded Assessment Task: "Representing Wave Properties Mathematically"

These assessments will assess students' ability to:

- Accurately describe how a simple wave has a repeating pattern of specific wavelength, frequency, and amplitude.
- Accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how a wave is a repeating pattern of motion that transfers energy from place to place.
- Accurately describe how a simple mathematical wave model corresponds to the properties of a physical phenomenon.
- Accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations.

- Generate mathematical representations of the relationship between properties of waves to show that the wavelength and frequency of a wave are related to one another by the speed of travel of the wave.
- Accurately identify the evidence that supports a claim about how waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter.
- Describe how mathematical representations support conclusions about differences in one property of a wave that will result in differences in the amount of energy present or transmitted.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Wave Properties Investigation	MS-PS4-1	MP.2	EU1/EQ1	A4
		MP.4	EU2/EQ2	A5
		8.F.A.3		A6
		6.RP.A.1		
		7.RP.A.2		

Formal Assessment: Observing Waves in Action

In this assessment, students conduct an investigation to see what happens to waves when they enter a new medium (e.g., wave on a string connected to a thicker string) or interact with new matter (e.g., a wall). Students make hypotheses for different new matter and then test out these hypotheses. Students record observations and quantitative data as part of their measurements, analyze their data, and then draw conclusions based on their investigations.

Assessment Purpose and Use

- Performance tasks provide opportunities for students to engage with the practices of the discipline along with the content. These tasks are used to measure how well students perform when provided with more complex tasks and are opportunities to engage in a meaningful way with the content in the curriculum.
- Assess students' current level of knowledge in relation to carrying out investigations about the behavior of waves when they enter a new medium.

Administration Time: 40-50 minutes

Scoring Time: 10 minutes

Assessment Type(s)

Formal - Short Performance Task

Assessment Sub-Type(s)

Lab/Experiment

These assessments will assess students' ability to:

- Carry out an investigation to determine that light waves can be reflected, absorbed, transmitted, or refracted when they collide with new matter.
- Carry out an investigation to determine that sound waves can be reflected, absorbed, transmitted, or refracted when they collide with new matter.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Observing Mechanical Waves in Action	MS-PS4-2	MP.2	EU2/EQ2	A2

Instructionally-embedded Assessments for Use during Instructional Segment 2

Informal Assessment: Modeling Sound

Students gather information and create annotated drawings as they explore resources in order to develop a model that explains a phenomenon where particles oscillate when energy is transferred through sound waves. Students investigate simple sound demonstrations (e.g., knocking on a door, plucking a string or rubber band, or viewing a speaker), observe a high-speed video of sound waves, utilize simulations, and read and view informational text and media. Students may be in groups, but they each create their own model which will be expanded upon. The teacher examines these initial models, asking probing questions to help guide students to develop their model to illustrate that particles will move back and forth to transfer the energy.

Assessment Purpose and Use

- These informal assessments are typically used for formative purposes. The goal is to gauge where students are in their learning, identify what challenges students are facing, and determine next steps for the class and/or individual students.
- The assessments provide information that can be used either at the class level or the individual student level to help determine what instructional activities will best support students.

Administration Time: Will vary

Scoring Time: 1 minute per question

Assessment Type(s)

Informal - Classroom Check-In

Assessment Sub-Type(s)

Discussion prompts

Exit Tickets

In-the-moment Questions

These assessments will assess students' ability to:

- Accurately model how sound waves transfer energy through a medium through oscillation of the particles.
- Accurately describe how sound waves are pressure waves and can be either transverse or longitudinal.
- Accurately apply a wave model to a physical system or phenomenon to identify how sound waves are pressure waves and can be either transverse or longitudinal.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):

- Chladni Plates
- Experiencing Sound
- How Does Sound Move?
- How do Chladni Plates Work?

NGSS PEs:	CCSS:	EUs/EQs:	AGs:
MS-PS4-2	MP.2	EU1/EQ1	A6
	SL.8.5	EU2/EQ2	A7
			A8
			A9
			A10

Formal Assessment: Modeling Sound in Action

Students revise their initial sound wave model (described in the informal assessment for this segment) to explain how sound transfers energy and causes a phenomenon, such as sand moving on Chladni plates. The phenomena are up to the teacher's discretion. Additional ideas include examples such as echoes, how sound moves from a source to ears, why helium changes a voice, how speakers create sound, or how musical instruments create sound. Students present their models to the class in a multimodal presentation in a way that makes sense for them.

Assessment Purpose and Use

- Performance tasks provide opportunities for students to engage with the practices of the discipline along with the content. These tasks are used to measure how well students perform when provided with more complex tasks and are opportunities to engage in a meaningful way with the content in the curriculum.

Administration Time: 15 minutes

Scoring Time: 5 minutes

Assessment Type(s)

Formal - Short Performance Task

Assessment Sub-Type(s)

Scenario/Phenomena-based Assessment Task

These assessments will assess students' ability to:

- Accurately identify the evidence that supports a claim about how waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter.
- Accurately describe how sound waves require a medium.
- Construct an accurate explanation that describes how waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter.
- Accurately model how sound waves transfer energy through a medium through oscillation of the particles.
- Accurately apply a wave model to a physical system or phenomenon to identify how sound waves are pressure waves that interact with objects and the medium they move through.
- Identify information that explains how sound waves require the presence of a medium to travel.
- Explain how similarities and differences between types of media that sound passes through affect the sound.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• How Do Chladni Plates Work?	MS-PS4-2	SL.8.5	EU1/EQ1	A6
		RST.6.8.1	EU2/EQ2	A8
				A9
				A10

Formal Assessment: How Does Sound Move?

Students are challenged to explain how sound travels from the source, such as a speaker, to the observer, such as an ear. Students record their initial thinking and then explore resources to observe sound waves (longitudinal/compression waves) in unique contexts. Students gather qualitative data, review their data, and then check their initial understanding of sound. Students use their new data and data from prior learning experiences to write a scientific explanation of how sound waves travel as longitudinal/compression waves through a medium from a vibrating source to an observer.

Assessment Purpose and Use

Administration Time: 90 minutes

- Performance tasks provide opportunities for students to engage with the practices of the discipline along with the content. These tasks are used to measure how well students perform when provided with more complex tasks and are opportunities to engage in a meaningful way with the content in the curriculum.

Scoring Time: 10 minutes

Assessment Type(s)

Formal - Short Performance Task

Assessment Sub-Type(s)

Hands-on Task

Scenario/Phenomena-based Assessment Task

These assessments will assess students' ability to:

- Gather observations to answer scientific questions about the longitudinal nature of sound waves.
- Make observations and/or measurements to produce data to answer scientific questions about the longitudinal nature of sound waves.
- Use observations and/or data to generate a conclusion about the longitudinal nature of sound waves.
- Identify information that explains how sound waves require the presence of a medium to travel.
- Explain how similarities and differences between types of media that sound passes through affect the sound.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• How Does Sound Move?	MS-PS4-2	SL.8.5	EU1/EQ1	A6
		RST.6-8.1	EU2/EQ2	A7
		WHST.6.8.8	EU3/EQ3	A8*
				A9*
				A10

Instructionally-embedded Assessments for Use during Instructional Segment 3

Informal Assessment: Light Waves

Students are presented with a phenomenon involving light waves, such as a one-way mirror. The teacher checks for understanding as students generate questions about the phenomenon. Then students experience several learning experiences which allow them to gather information about the properties of light waves, propagation of light waves, and differences between light and sound/mechanical waves. Students engage in small group and whole group discussions about the experiences, making connections back to the light phenomenon. Students record information about their learning experiences as annotated drawings, graphic organizers, notes in scientific notebooks, or other ways that make sense for students.

Assessment Purpose and Use

- These informal assessments are typically used for formative purposes. The goal is to gauge where students are in their learning, identify what challenges students are facing, and

Administration Time: 5-10 minutes

Scoring Time: 3 minutes

Assessment Type(s)

Informal - Classroom Check-In

determine next steps for the class and/or individual students.

- The assessments provide information that can be used either at the class level or the individual student level to help determine what instructional activities will best support students.
- These informal assessments should be given throughout the instruction to help inform future instruction and the need for remediation.

Assessment Sub-Type(s)

Exit Tickets

Discussion prompts

In-the-moment Questions

Graphic Organizers

Lab/Experiment

These assessments will assess students' ability to:

- Ask questions about how light waves are reflected and refracted based on the properties of the matter the light waves interact within for a given phenomenon.
- Use the ray model of light to provide evidence of the process of selective reflection and refraction as different wavelengths through their interaction with a prism, lens, or other matter.
- Design an investigation, documenting the relevant properties (wavelength, nature of materials), to answer scientific questions about the movement of light and its interaction (refraction) with various transparent media.
- Make observations and/or measurements to produce data to answer scientific questions about the movement of light and its interaction with various transparent media as straight lines which bend at material transitions.
- Use observations and/or data to generate a conclusion about frequency-dependent bending of light at a surface between media.
- Identify information found in scientific text(s) to develop questions about how light can travel in a vacuum and how to study the interaction of light with different materials.
- Describe the structure of materials and why materials with certain properties (e.g., change of speed of the wave when passing from one medium to another can cause the wave to change direction or refract) are well-suited for particular functions based on information found in scientific text(s).
- Use the ray model of light to provide evidence that the path of different frequencies of the visible light spectrum can be predicted as the light passes from one medium to another.
- Identify information found in scientific text(s) that provide evidence that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- Describe what evidence is needed to answer questions about a phenomenon related to the properties of light waves, lenses, and prisms, and how they help build toward an explanation of the phenomenon.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):

- A Mirror and A Window?
- Light vs. Sound
- What do we See?

NGSS PEs:	CCSS:	EUs/EQs:	AGs:
MS-PS4-2	SL.8.5	EU2/EQ2	A11
	RST.6-8.1	EU3/EQ3	A12
	WHST.6-8.8	EU4/EQ4	A13

- Bending and Bouncing Light Rays
- Light Waves and Their Properties
- I Can See You, but You Can't See Me!

A14
A16

Formal Assessment: Plan and Carry Out an Investigation on the Bending of Light Waves

To better understand how light interacts with materials in order to explain a phenomenon, students plan and carry out an investigation to identify properties important to the bending of light waves and gather evidence to support their thinking. For example, students could use lasers/ray boxes to investigate how light bends/changes when passing through different materials—water, glass, air, clear gelatin, etc.

Assessment Purpose and Use

- Students are provided with (or pick out) a specific research topic and asked to explore this topic. The purpose is to provide an opportunity for students to apply their knowledge to a particular question, or to demonstrate their ability to research a specific topic. It allows them to demonstrate how they would apply concepts over an extended period of time.
- The teacher uses this assessment to determine if there are topics, they would like to revisit in follow-up lessons.

Administration Time: 180 minutes

Scoring Time: 20 minutes

Assessment Type(s)

Formal - Research Project

Assessment Sub-Type(s)

Lab/Experiment

These assessments will assess students' ability to:

- Design an investigation, documenting relevant properties (wavelength, nature of materials) to answer scientific questions about the movement of light and its interaction (refraction) with various transparent media.
- Describe how to conduct an investigation to answer scientific questions about the way that light interacts with different materials, including the way different light frequencies are affected by a transition from one medium to another.
- Use observations and/or data to generate a conclusion about the way that light interacts with different materials, including the way different light frequencies are affected by a transition from one medium to another.
- Make observations to produce qualitative data to answer scientific questions about the movement of light and its interaction (refraction) with various transparent media.
- Identify information found in scientific text(s) that provide evidence that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- Describe what evidence is needed to answer questions about a phenomenon related to the properties of light waves, lenses, and prisms, and how they help build toward an explanation of the phenomenon.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Bending and Bouncing Light Rays • Light Waves and Their Properties	MS-PS4-1 MS-PS4-2	SL.8.5 RST.6.8.1 WHST.6.8.8	EU3/EQ3 EU4/EQ4	A11 A12* A13 A15

Formal Assessment: I Can See You, but You Can't See Me!

Students develop an explanatory model using the ray model of light to explain a phenomenon involving light, including how light moves between different mediums, interacts with different surfaces and matter, and why any changes in the light occur. This qualitative assessment does not require students to measure angles. Students can pick (or be assigned) a specific phenomenon to model, for example, a one-way mirror, shining a laser pointer through different lenses or glass/acrylic geometric figures, the bending of light when entering and exiting a prism, or the difference in the apparent position of a fish from where it actually is when looking at from above the water.

Assessment Purpose and Use

- Performance tasks provide opportunities for students to engage with the practices of the discipline along with the content. These tasks are used to measure how well students perform when provided with more complex tasks and are opportunities to engage in a meaningful way with the content in the curriculum.

Administration Time: 20 minutes

Scoring Time: 3-5 minutes

Assessment Type(s)

Formal - Short Performance Task

Assessment Sub-Type(s)

Scenario/Phenomena-based Assessment Task

Design Project

Sample Instructionally-embedded Assessment Task: "I Can See You, but You Can't See Me!"

These assessments will assess students' ability to:

- Develop a model to show how the path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• I Can See You, but You Can't See Me!	MS-PS4-2	SL.8.5 MP.2	EU2/EQ2 EU3/EQ3	A16

Instructionally-embedded Assessments for Use during Instructional Segment 4

Informal Assessment: Criteria and Constraints of a Design Solution

Students are presented with an engineering challenge from a "client" as well as additional information about the problem. Using this initial information, students develop criteria/constraints for use in their solutions that specifically address wave interactions. Throughout the first three segments of the unit, students revisit their initial criteria and constraints and make revisions based on new learning about waves, sound waves, and light waves.

Assessment Purpose and Use

- These informal assessments are typically used for formative purposes. The goal is to gauge where students are in their learning, identify what challenges students are facing, and determine next steps for the class and/or individual students. The assessments provide information that can be used either at the class level or the individual student level to help determine what instructional activities will best support students.
- This should be an important moment to give feedback to students about whether they have achieved these goals, as they build on these statements over the next lessons.
- The assessment is used to determine if there is any reteaching that needs to occur before students can move on to the next lesson.

Administration Time: 1-5 minutes

Scoring Time: 10 minutes

Assessment Type(s)

Informal - Classroom Check-In

Assessment Sub-Type(s)

Exit Tickets

These assessments will assess students' ability to:

- Provide sound reasoning for why the revised problem statement is better with regard to the expected conditions for operation of the solution.
- Identify the major components, including their relationships within the system, and the system boundaries in order to clarify the definition of the problem.
- Describe the criteria and constraints that need to be considered, including a precise indication of the nature of the different parameters, to develop a model of the behavior of waves.
- Accurately apply a wave model to a phenomenon related to the behavior of waves by addressing the criteria and constraints that need to be considered, including precise indication of the nature of the different parameters.
- Identify information related to how to complete a design specification in terms of all criteria, constraints, and the different conditions for its performance.
- Explain how to complete a design specification in terms of all criteria, constraints, and the different conditions for its performance.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):

- It's Too Bright, Too Loud, Too Much
- Criteria and Constraints: Waves
- Criteria and Constraints: Sound
- I Can See You, but You Can't See Me!

NGSS PEs:	CCSS:	EUs/EQs:	AGs:
MS-PS4-1	WHST.6-8.8	EU4/EQ4	A17
MS-PS4-2	MP.2	EU5/EQ5	A18
MS-ETS1-1			A19
			A20

- Using Waves to Help People
- Waves in Action

Informal Assessment: Waves in Action

Students use criteria/constraints pertaining to their design problems to develop solutions that utilize waves to solve/help with a problem. As students are working, the teacher, administrators, local experts, and peers provide feedback on their devices. Feedback should include encouraging students to consider the criteria and constraints in their design, strengths of the design, areas for improvement, unseen limitations, and other considerations.

Assessment Purpose and Use

- These informal assessments are typically used for formative purposes. The goal is to gauge where students are in their learning, identify what challenges students are facing, and determine next steps for the class and/or individual students.
- The assessments provide information that can be used either at the class level or the individual student level to help determine what instructional activities will best support students.
- The teacher uses this assessment as an opportunity to identify and address any lingering misconceptions about the nature of waves and their interactions with objects, as well as to ensure students understand the definition of a parameter, and how to develop parameters for operation of devices.

Administration Time: 1-5 minutes

Scoring Time: 10 minutes

Assessment Type(s)

Informal - Classroom Check-In

Assessment Sub-Type(s)

Exit Tickets

These assessments will assess students' ability to:

- Describe the criteria and constraints that need to be considered, including a precise indication of the nature of the different parameters, to develop a model of the behavior of waves.
- Accurately apply a wave model to a phenomenon related to the behavior of waves by addressing the criteria and constraints that need to be considered, including precise indication of the nature of different parameters.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Waves In Action	MS-PS4-1	SL.8.5	EU4/EQ4	A19
	MS-PS4-2	RST.6-8.1	EU5/EQ5	
	MS-ETS1-1	MP.2		

Formal Assessment: Final Design Specification

The purpose of this assessment is to determine whether students can develop a design specification, including all criteria, constraints, and conditions for the performance of a device that uses waves. Students are given a problem or asked to pick a problem. They define the problem, describe how a solution can address the problem, generate a model of the solution, and complete design specifications for the solution to the problem.

Final design specifications should include the following:

- Revised problem statement
- Complete Bill of Materials
- Revised diagram of the prototype (with labeled components and descriptions of component interactions)
- Comprehensive list of criteria/constraints (including those not pertaining to waves)
- Revised list of parameters for operation
- Revised model of wave interactions

Assessment Purpose and Use

- Students are provided with (or pick out) a specific research topic and asked to explore this topic. The purpose is to provide an opportunity for students to apply their knowledge to a particular question, or to demonstrate their ability to research a specific topic. It allows them to demonstrate how they would apply concepts over an extended period of time.
- This assessment can be used to identify gaps in students' knowledge about design solutions.

Administration Time: 45-90 minutes

Scoring Time: 60 minutes

Assessment Type(s)

Formal - Research Project

Assessment Sub-Type(s)

Design Project

These assessments will assess students' ability to:

- Identify information related to how to complete a design specification in terms of all criteria, constraints, and the different conditions for its performance.
- Provide sound reasoning for why the revised problem statement is better with regard to the expected conditions for operation of the solution.
- Identify the major components, including their relationships within the system, and the system boundaries in order to clarify the definition of the problem.
- Describe the criteria and constraints that need to be considered, including a precise indication of the nature of the different parameters, to develop a model of the behavior of waves.
- Accurately apply a wave model to a phenomenon related to the behavior of waves by addressing the criteria and constraints that need to be considered, including precise indication of the nature of the different parameters.
- Explain how to complete a design specification in terms of all criteria, constraints, and the different conditions for its performance.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):

- Using Waves to Help People
- Waves In Action
- Into The Shark Tank

NGSS PEs:	CCSS:	EUs/EQs:	AGs:
MS-PS4-1	RST.6-8.1	EU4/EQ4	A17
MS-PS4-2	WHST.6-8.8	EU5/EQ5	A18
MS-ETS1-1	MP.2		A19
	7.EE.3		A20

Guidance for Equitable Assessments for Diverse Learners
How do we optimize accessibility for diverse learners and why is this important? Designing Equitable Assessments for Diverse Learners provides steps to planning and developing equitable assessments that incorporate the principles of Universal Design for Learning (UDL) and the elements of Universally Designed Assessments (UDA). Both UDL and UDA are designed to provide access to instruction and/or assessment to the widest range of students. This includes, but is not limited to, students with varying abilities, cultures, primary languages, background knowledge, and interests. For more information about equitable assessment design and use, and why it is important, view *Chapter 4: Fairness and Accessibility* of the Strengthening Claims-based Interpretations and Uses of Local and Large-scale Science Assessment Scores (SCILLSS) Digital Workbook on Educational Assessment Design and Evaluation: Creating and Evaluating Effective Educational Assessments.
Assessment Resources
Stage 2 Instructionally-embedded Classroom Assessment Resources: **Segment 4** ● Identify Criteria and Constraints | Engineering for Good | PBS LearningMedia [https://www.pbslearningmedia.org/resource/criteria-constraints/identify-criteria-and-constraints-engineering-for-good/ia] ● Engineering for Good - Student Notebook - Google Docs [https://docs.google.com/document/d/1_jIJNSE561xAtFMeLAyvhaG5bbDN9NK04sApnASJqVc/edit]

Stage 3 – Learning Plan

Learning Plan Rationale

The learning plan is based on an articulation of learning goals (i.e., NGSS PEs, CCSS, EUs/EQs, and acquisition goals (defined in Stage 1) distributed over four instructional segments. These learning goals are used in Stage 2 to identify and describe the assessments that will be used to assess (to collect evidence of) students' learning throughout the course of the unit and instruction. The lessons in instructional segments one through four are designed to ensure students have opportunities to acquire and apply the learning goals in Stage 1. The instructional segments in both Stage 2 and Stage 3 are similar in terms of the learning goals they represent. Assessments listed in Stage 2 for a segment might use (assess) fewer learning goals than are present in the respective Stage 3 but will not use additional learning goals (unless they were taught in a prior segment).

Unit Entrance

The unit opening will focus on students experiencing and discussing a phenomenon that sparks their interest and curiosity. To do so, the class will engage with an "anchor phenomenon" and generate questions based on that phenomenon, posting their questions to the "driving question board." Some of the questions added to the driving question board can be used by the teacher to transition into Instructional Segment 1, by framing the lessons (and segment) as a means by which to investigate and answer some of the questions that students generate based on the anchor phenomenon.

Throughout the unit, (e.g., at the conclusion of each instructional segment) the teacher returns to the driving question board and students reflect on their recent learning, and which questions they can now answer based on their learning in the prior segment. Following this reflection, the teacher uses the driving question board again, this time identifying remaining unanswered (or partially answered) questions that can motivate the activities and investigations that will be the focus of the next instructional segment.

Anchor Phenomenon

In this unit, the anchor phenomenon is about light and sound in different environments. The teacher presents students with an engineering design challenge: *Design a piece of equipment that a child your age could use to help cope with sensitivities to light, sound, or particular colors.*

The teacher can customize the anchor phenomenon, rather than using the design challenge example. Additional suggestions for the anchoring phenomenon include designing a piece of safety equipment that could be used by NASA in space or on the surface of the moon or Mars to protect individuals from sudden bright lights and loud sounds and allows them to quickly turn them on or off, or some other design challenge that challenges youth to use information about waves, light, and sound together.

The teacher may also want to consider local industry and the community for the anchoring phenomenon. For the lesson, *Into the Shark Tank,* students are asked to present their idea as if making a pitch to investors. Potential investors could include local industry experts who could also provide guidance and feedback to students. The teacher may want to contact representatives from a local engineering group or regional industry to bring in local experts who may have additional ideas for a potential problem area.

Unit Framing

Framing for SIPS Instructional Framework

After using an anchoring phenomenon to present students with a design challenge that requires knowledge about light, sound, and waves, the teacher solicits students' questions about waves and features/observations of the anchoring phenomenon (and related phenomena).

The teacher informs the class that over the course of the unit they will build up to design a solution to the problem, and that the solution and/or problem will involve waves and/or properties of waves. In order to design an effective solution, students learn about waves and engineering methods (i.e., defining problems and designing solutions that are informed by scientific knowledge and methods). As students work through the unit, they develop their understanding of waves and the ability to use properties, features of waves, and wave behaviors to make sense of phenomena.

Starting in Instructional Segment 1, students begin working on defining engineering problems and constraints to their solution. As students progress through the segments, they will revisit their initial work to revise their solutions and support their decisions using evidence about waves, light, and sound.

Example Driving Questions

Potential/example driving questions that students might generate based on the anchoring phenomenon:

- How do we experience waves in everyday life?
- How do wave properties affect what we see or hear?
- How can we change some wave properties and not others?

Problematization/Investigative Strategy for the Unit

If we want to understand properties of mechanical and light waves well enough to be able to design and develop effective solutions, we need to understand and compare waves' properties, including how those properties manifest in different environments. We need to understand what leads to these differences and the effect of a medium on wave behavior. What is it about the environment that causes changes to how we see and hear waves? How does the presence or absence of a medium affect wave behavior? We also need to compare frequency, amplitude, and wavelengths of different wave types. How does structure of various waves define their properties? Students engage in a variety of investigations, use mathematics, and build models as they answer these questions and develop their understanding of waves and wave behavior. Knowledge and abilities developed through Instructional Segments 1-3 are aimed at preparing students to apply them to solve problems/challenges in Segment 4.

Science

Grade: 8 Unit: 4

43 days of instruction

Instructional Segment 1

Learning Investigations and Sample Lessons

Alignment Coding

NGSS PEs:

- **MS-PS4-1**
- **MS-PS4-2**
- **MS-ETS1-1**

CCSS:

- **MP.2**
- **MP.4**
- **6.RP.A.1**
- **7.RP.A.2**
- **SL.8.5**
- **8.F.A.3**

EUs/EQs:

- **EU1/EQ1**
- **EU2/EQ2**
- **EU5/EQ5**

AGs:

- **A1**
- **A2**
- **A3**
- **A4**
- **A5**
- **A6**
- **A17**
- **A18**
- **A19**
- **A20***

Estimated Classroom Time: 675 minutes

It's Too Bright, Too Loud, Too Much

- 5Es: Engage
- Estimated Time: 100 minutes
- AGs: A1, A17*, A18*, A19*, A20*

To introduce the theme of the unit, the teacher presents students with a client who has a problem. The teacher informs students that they will be working at an engineering think tank for this unit and that they have to figure out what exactly the client needs to define the problem, learn more about the science behind their problem, revise their criteria and constraints for the problem after understanding the science, and then design a solution that meets the client's needs. Then, the teacher shares with students that at the end of the unit, they present their design to a group of "investors" who evaluate their design for the client.

In this unit, we use the example of a child in 8th grade who needs help with sensory overload to light, sounds, or particular colors. The teacher is encouraged to consider other clients that may better meet the local context.

The teacher presents students with an example student. It could be a real person who has agreed to participate, it could be a local social worker/teacher who is acting as a representative for the client/s, or it could be a made-up person represented by a stock photo or drawing. The teacher explains to students that this person has issues with sensory overload, *specifically changes in sound, brightness, and feeling overwhelmed when there are too many colors,* and encourages students to share what they already know about the topic. *Some students may feel comfortable sharing their own experiences, students should not be called out if they are not comfortable sharing and personal student information should not be shared. Also, there are many types of sensory overload, many of which would not apply to the learning in this unit. It is important that the "client" needs support related to light waves and sound waves.*

To add to students' understanding, the teacher directs them to Sensory Issues. Students read the article using a reading strategy such as paired reading to learn more about the challenges faced by individuals with sensory issues. As students are reading, the teacher encourages them to highlight important information about sensory issues.

After introducing the design challenge, the teacher shows the class videos to demonstrate how people use waves to solve similar problems on Earth.

Example videos:

- Make Fire from Ice: GIANT ICE LENS Start from 2:45 (can stop after about 4:45, but there is some interesting information at the end) [https://youtu.be/Nt3c8hjDnKk]

	● [Shorts: Daniel Kish's echolocation in action](https://youtu.be/xATIyq3uZM4) [https://youtu.be/xATIyq3uZM4] Next, introduce the concepts of criteria and constraints using the following or similar resources: ● [Identify Criteria and Constraints | Engineering for Good | PBS LearningMedia](https://www.pbslearningmedia.org/resource/criteria-constraints/identify-criteria-and-constraints-engineering-for-good/) [https://www.pbslearningmedia.org/resource/criteria-constraints/identify-criteria-and-constraints-engineering-for-good/] ● [Engineering for Good - Student Notebook - Google Docs](https://docs.google.com/document/d/1_jIJNSE561xAtFMeLAyvhaG5bbDN9NK04sApnASJqVc/edit) [https://docs.google.com/document/d/1_jIJNSE561xAtFMeLAyvhaG5bbDN9NK04sApnASJqVc/edit] ● [Technological Design Constraints (Read) | Chemistry | CK-12 Foundation (ck12.org)](https://www.ck12.org/chemistry/technological-design-constraints/lesson/Technological-Design-Constraints-MS-PS/?referrer=concept_details) [https://www.ck12.org/chemistry/technological-design-constraints/lesson/Technological-Design-Constraints-MS-PS/?referrer=concept_details] The teacher shares the request from the client with students; the client needs a device to help with their sensory issues. Based on students' levels, the teacher may want to share more or less information about the topic. Students who are above grade level may be provided with less information about potential criteria and constraints. Students who need additional support may need guidance such as categories to consider or sentence stems to help them start. Pairs of students brainstorm a list of requirements that the client may need for a device. Some examples include (a) the ability to make things less bright, brighter, quieter, or louder to filter out certain colors that could be overwhelming, (2) a cost under a certain amount of dollars, or (3) look stylish/cool. *The class revisits this list throughout the unit to refine their criteria and constraints before starting work on their design in Segment 4.* Next, a driving question board should be developed. The teacher asks students, "What might we need to know more about light and sound to help with this problem?" Questions should be developed with respect to the properties of light and sound such as the kind of wave and the media through which the wave travels. Questions could also include wave properties and properties of media. The teacher shares with students the structure of the unit; they start with learning about waves in general, then learn more about sound waves and light waves, refining criteria and constraints before starting to work on developing a solution to the problem. To close the lesson, students write an initial design problem of their own based on the class-developed lists and discussion. **What is a Wave?** ● 5Es: Engage, Explore ● Estimated Time: 200 minutes ● AGs: A3, A4, A7*

In this lesson, students are introduced to the concepts of waves beginning with vibrations, pulses, and then standing waves as generated on a string or using a slinky.

The teacher introduces key vocabulary relevant to the lesson to students in a way that makes sense to them. The teacher may want to follow the example of A Wave With Words for this activity.

Next, the teacher provides pairs or small groups of students with Slinkies to create longitudinal and transverse waves and observations which they record in their science notebooks. Example: Slinky Lab (Note: the lab refers to velocity but uses the equation for speed. Students may need a reminder on how to calculate speed from Unit 1.)

Finally, to support retention and check for understanding, the class reviews and discusses some of the key takeaways related to wave properties, particularly the differences between longitudinal and transverse waves. The teacher may want to follow the example of Modeling Mechanical Waves for this activity.

Sample Lesson: "What is a Wave?"

Observing Mechanical Waves in Action

- 5Es: Explore
- Estimated Time: 100 minutes
- AGs: A2

Students observe mechanical waves in a wave tank to observe wave propagation, reflection, refraction, and diffraction. Students utilize a simulator to make observations of waves on their own and then look at images from Google Earth to observe wave properties in real life. The teacher may want to follow the example lesson of Ripple Tank for this activity.

Wave Properties Investigation

- 5Es: Explore, Explain
- Estimated Time: 200 minutes
- AGs: A5

In *What is a Wave?,* students collected observational data about waves using Slinkies. If the teacher followed the example activity, students qualitatively explored the relationships between wave properties. For this activity, students design and conduct an experiment to find the relationship between the speed, frequency, and wavelength of the wave by collecting numerical data. Students could either do this with a wave tank, a wave generator, by hand, or using a simulation such as Wave On A String.

After collecting their data, students analyze the data to find the linear relationship between frequency and wavelength, $f = v\lambda$, where f is frequency, lambda is the wavelength, and v is both the slope of the line and the speed of the waves.

Teacher note: Students may need additional support to understand that the speed of different waves (both mechanical and electromagnetic) is the same in the same medium. Students can change the frequency of vibrations and see the change in wavelength, but nothing they do can change the speed of the wave in the medium, other than changing the

	medium. The speed of a wave depends on the properties of the medium, not the frequency or the wavelength. If students are stuck on this misconception, one strategy can be to change the properties of the medium, such as trading out for a string or changing the tension, allowing students to see how the slope of the line changes, resulting in different wavelengths. The equation in this form, $f = v\lambda$, or $\lambda = vf$ accurately shows how the speed of the wave is a constant and not a dependent or independent variable. Following their experiment and analysis, students write a conclusion based on their data. Then, students verify their results with the field. Students read or research the wave properties of frequency, speed, and wavelength using core curricular resources or other scientific texts such as CK-12: Wave Speed. Students return to their conclusions and data analyses and compare their results to the field and make revisions. In their final conclusion, students support their findings using both data and their research from the field. **Earthquakes: Waves of Danger** ● 5Es: Elaborate ● Estimated Time: 50 minutes ● AGs: A6, A17, A18 To understand how waves transfer energy but not matter, the class explores information on recent deadly earthquakes, how buildings withstand earthquakes, and tsunami formation and discuss why earthquakes are dangerous even when the epicenter is far away. The teacher may want to follow the example lesson of Waves of Danger for this activity. The class is presented with a challenge at the end of Waves of Danger where they are asked to brainstorm projects to reduce the impact of earthquakes. Instead of brainstorming solutions, the teacher uses this scenario to provide students with an opportunity to practice defining criteria and constraints. The teacher introduces the scenario to students and then provides them with time to consider what an effective solution must do and what limitations are necessary. **Criteria and Constraints: Waves** ● 5Es: Evaluate ● Estimated Time: 25 minutes ● AGs: A1, A17*, A18, A19, A20* Students revisit their initial criteria and constraints as well as the initial problem based on the anchoring phenomenon to determine what changes and revisions need to be made. Students write a new set of criteria and constraints, keeping the old one so they can refer back if needed. Revisions to the criteria and constraints may be limited at this time, as students have only been exposed to the basics of waves. After revising their criteria, the class returns to the driving question board to identify questions that they can now answer and to add new questions based on their learning about mechanical waves and wave properties.

<table>
<tr><th colspan="2">Instructional Segment 2</th></tr>
<tr><th colspan="2">Learning Investigations and Sample Lessons</th></tr>
<tr><td>Alignment Coding
NGSS PEs:
MS-PS4-2
CCSS:
MP.2
SL.8.5
RST.6-8.1
WHST.6-8.8
EUs/EQs:
EU1/EQ1
EU2/EQ2
EU3/EQ3
EU5/EQ5
AGs:
A1
A6
A7
A8
A9
A10
A17*
A18
A19
A20*</td>
<td>Estimated Classroom Time: 375 minutes
Chladni Plates
● 5Es: Engage
● Estimated Time: 50 minutes
● AGs: A1, A6, A9*
Students make observations as they watch a video of a Chladni plate in action (Info for the teacher about Chladni plates). After the video, the teacher encourages students to share questions that they have about the video: “What caused the sand to move?”, “Why did the sand form patterns?”, “Why did changing the pitch of the sound change the sand pattern?”, “Why did increasing the loudness move more sand?” (The teacher can do this as a demonstration as well.)
For this segment, the teacher develops a second driving question board and students share their questions about Chladni plates. Then, the class comes up with a class question about the phenomenon that students can work to gather information about. Students brainstorm additional sub questions to investigate that help them answer the class question, including concepts from Segment 1.
Finally, the teacher asks students to draw an annotated drawing of what they think is occurring with the plate and their own ear. For students who need additional prompting, the teacher may want to ask the following questions: “How do you think sound was involved?”, “How did changing the sound properties change the plate?”, “How did the sound get from the “plate” to your ear?”, and “What do you think is happening inside your ear?”
Experiencing Sound
● 5Es: Explore
● Estimated Time: 100 minutes
● AGs: A6, A7, A8, A9
Students explore a variety of sound demonstrations/activities using a stations model. Stations are set up around the classroom and students are provided enough time to visit each station and make and record observations in their scientific notebooks or using handouts from the teacher. The teacher may want to follow the example lesson Sound Stations for this activity.
After the investigations, students generate a series of annotated drawings for the stations, making note of how the sound was created, how the sound travels, and how the sound was changed (if it was). Before beginning the drawings, the class discusses what needs to be represented in each drawing related to sound. The teacher uses questioning strategies to support students in including the vibrating source of the waves, the medium the waves</td></tr>
</table>

	are moving through, why the sound would change, and any signs of kinetic energy or energy transfer. The teacher reminds students to include labels and arrows and, with the class, determines how to show energy moving, sound moving, and matter moving. **How Does Sound Move?** ● 5Es: Explore, Explain ● Estimated Time: 100 minutes ● AGs: A6, A7, A8, A9, A10 *Teacher note: It is a common misunderstanding/misconception that sound is the result of air traveling from the vibrating source, such as your mouth, all the way to the ears. This activity is focused on challenging that misconception in different ways to support students in refining their understandings of sound waves without directly telling students, instead providing a series of discrepant events to challenge that misconception.* The teacher opens class by asking students, “What does sound look like?” The teacher encourages students to share responses and build on each other, to refer to their annotated diagrams for ideas and observations from *Experiencing Sound.* The class watches the video What Does Sound Look Like? While watching the video, the teacher pauses the video and poses discussion questions to students that allow students to reflect on the video, make observations about the images, and consider how sound gets from the source to our ears. In the video, the speaker discusses how the images are captured, but the focus of this activity should be on how the sound waves appear and move. One way to support students with this focus is to watch the video without sound and for the teacher to provide some simple narration. Students develop an annotated drawing for one of the sound scenes in the video. In their drawings, they indicate changes in density (high/low areas), how the sound waves and energy are moving, and that the air particles are staying near the same place, that it is the density change that is moving. Next, students get into their small groups and the teacher provides each group with a Slinky and an internet-connected device. The teacher directs students to Visualizing Sound in a Medium. Students experiment with the different settings on the simulation to see the impacts. Then, students revisit the different settings, but this time they duplicate what they see on the screen with the Slinky. As they increase the pitch, what do they have to do to the slinky to match the change in the movement of the particles? What about when they increase the loudness? Next, if possible, the teacher sets up a demonstration with a speaker or other device that makes sound in a bell/vacuum jar. If the teacher does not have the required equipment for the demonstration, the teacher can use Bell in a Bell Jar instead. The teacher asks the students, “We have an alarm bell which is inside of this glass bell jar. What do you think will happen if we turn on the air pump and remove the air from the jar?” Students pause and consider the question for a moment, then turn and share with a nearby peer. Then, the teacher demonstrates to the students the alarm bell ringing before turning on the

pump so they can hear the bell ringing. The teacher turns on the pump (or plays the video) and students observe how the sound disappears when the air is removed. The teacher pauses the video at this point and asks the students, "What happened and why?" Students share their thinking about what has occurred and they use evidence to support their thinking, from both the demonstration and the earlier learning in the lesson. After the class discussion, the teacher asks them to predict what they think will happen when we (or the video) open the jar and allow air back into the jar. Students write down their predictions. Then, the teacher either demonstrates for students that the bell is still ringing or watches the remainder of the video showing the bell still ringing. Students create an annotated drawing of this phenomenon and record it in their notebooks. The teacher reminds students to use labels and arrows to make things clear and to use the same representations as in earlier drawings for sound, energy, particles, movement, etc. in order to keep things consistent and easier to understand.

To close the lesson, students respond to the prompt, "How does sound move?" as a scientific explanation. The teacher should remind students that they should make a clear statement that answers the question and then support that statement using evidence and reasoning from the unit.

How Do Chladni Plates Work?

- 5Es: Evaluate, Elaborate
- Estimated Time: 100 minutes
- AGs: A6, A8, A9, A10

The teacher returns to the opening video for Segment 2 from *Chladni Plates.* The teacher has students rewatch the video to remind them about the phenomenon and the driving question board. Students explore resources, such as those listed at the end of the unit map, to answer unanswered questions from the driving question board if necessary.

Students work either individually or in small groups to create an explanatory model for the segment phenomenon. The teacher encourages students to incorporate information from their annotated drawings, notes, or additional online research into the properties of sound and waves. Students should create a multimodal explanation that they can present in a way that makes sense for them.

Criteria and Constraints: Sound

5Es: Evaluate

Estimated Time: 25 minutes

AGs: A1, A17*, A18, A19, A20*

Students revisit their initial criteria and constraints as well as the initial problem to determine what changes and revisions need to be made. Students should write a new set of criteria and constraints, keeping the old versions so they can refer back if needed. The teacher encourages students to consider how sound waves are part of sensory challenges and what an individual might need to help with sound sensitivities.

	After revising their criteria, the class should return to the unit driving question board to identify questions that they can now answer and to add new questions based on their learning about sound waves and sound properties.
Instructional Segment 3	
Learning Investigations and Sample Lessons	
Alignment Coding **NGSS PEs:** **MS-PS4-2** **CCSS:** **SL.8.5** **RST.6-8.1** **WHST.6-8.8** **EUs/EQs:** **EU2/EQ2** **EU3/EQ3** **EU4/EQ4** **AGs:** **A1** **A11** **A12** **A13** **A14** **A15** **A16**	**Estimated Classroom Time: 800 minutes** **A Mirror and A Window?** ● 5Es: Engage ● Estimated Time: 100 minutes ● AGs: A1, A11, A16* Students observe the phenomenon of a one-way mirror and begin to generate questions about the phenomenon. Students utilize a box functions-like model[1] to explore the phenomenon on a small scale in the classroom. Students create an initial, multimodal explanatory model using annotated drawings for the phenomenon. Using this phenomenon as a segment phenomenon, students generate a driving question board focused on light and the properties of light. The teacher may want to refer to and utilize resources from lesson 1 of OpenScieEd: Light and Matter (free account setup required). **Light vs. Sound** ● 5Es: Explore ● Estimated Time: 50 minutes ● AGs: A1, A11, A14 To connect Segment 2 and 3, students compare and contrast different types of waves and how electromagnetic waves do not require a medium. First, students generate a series of observations of light and sound about a familiar phenomenon such as a lightning strike. Next, students generate questions they have about the differences between light and sound and questions they have about the phenomenon of a lightning strike. As students engage with the materials from the lesson, the teacher encourages them to try and answer their questions. Next, the class reviews the different kinds of waves and is introduced to the term electromagnetic waves. Then, students will revisit the sound activity "Very Old School Telephone" from the lesson, *Experiencing Sound*. Students consider how this phone is alike and different from phones today, with phones using both mechanical/sound and electromagnetic/radio waves to function. Next, they build on this idea of mixed waves and how electromagnetic waves do not require a medium as they read over several different scenarios which use sound waves, light waves, or both. To close the lesson, students complete an exit ticket where they share how mechanical and electromagnetic waves are

[1] A functions-like model is something that doesn't look the same as the real world but acts similarly.

	involved in their daily lives. The teacher may want to refer to the example lesson, Waves Without A Medium, for portions of this activity. **What do we See?** ● 5Es: Explore ● Estimated Time: 150 minutes ● AGs: A11, A12, A14* Students return to the one-way mirror to investigate the phenomenon and develop a deeper understanding of what is occurring. Students remove the mirror from the box model and explore the mirror's properties to find that the mirror both reflects light and allows light to pass through. Then, students experiment with the full box model to explore factors involved in the reflection of light, finding that the room with brighter light is reflected by the mirror, that light travels in straight lines (rays), and that in order to see something light must travel from the source to the object to our eyes. Students revise their multimodal explanatory model of the phenomenon based on what they have learned. The teacher may want to refer to and utilize resources from lesson 2 of OpenScieEd: Light and Matter (free account setup required). **Bending and Bouncing Light Rays** ● 5Es: Explore, Explain ● Estimated Time: 300 minutes ● AGs: A11, A12, A13, A15, A16 *Days one and two:* Students observe and experience reflection, refraction, absorption, transmission, dispersion, and addition of light at a series of stations. The stations each have instructions and provide students with context on individual properties of light and familiarity with optics equipment that they may not otherwise be familiar with. While engaging in each of the activities, students create an annotated drawing for each activity that provides a beginning explanation about the particular property of light and create a list of questions that they have about the individual station. Students decide which station they are interested in experimenting with and then work in their group to develop an investigable question to help them better understand how/why one-way mirrors are able to allow some light to pass and reflect other light. *Days three through five:* Next, students utilize a one-way mirror, glass, a regular mirror, a prism, and other objects to conduct their experiment to understand how one-way light interacts with an object and is impacted by different materials. Using ray boxes, students shine beams of light onto objects in different brightness and at different angles to explore how light changes when it interacts with matter and collect qualitative data. Students who are performing above grade level may also collect quantitative data. Students write a conclusion based on their data and share their findings with their peers. *Day six:*

<table>
<tr><td></td><td>Students build on their multimodal explanatory model of the phenomenon after finding that the one-way mirror reflects some light and transmits some light, the regular mirror reflects most of the light, and the glass reflects a small amount of light and transmits most of the light. Using the prism, they will find that not all light is transmitted in the same way.
Sample Lesson: “Bending and Bouncing Light Rays”
Light Waves and Their Properties
Explore, Evaluate
Estimated Time: 100 minutes
AGs: A16
Students revisit the driving question board for the segment and consider what they still need to know to explain the phenomenon using an explanatory model. Students review core curricular materials, teacher-curated resources, or other resources they find to answer the remaining questions about light, light’s properties, and the segment phenomenon. The teacher supports students by providing reteaching opportunities if needed and encourages students to improve their explanation of the one-way mirror by utilizing questioning strategies that challenge their thinking. Depending on student level, the teacher may have specific grouped resources for topics, questions, and sub-questions. The teacher may use a more open inquiry approach where students explore with minimal guidance.
I Can See You, but You Can’t See Me!
5Es: Evaluate, Elaborate
Estimated Time: 100 minutes
AGs: A16
Students finalize their multimodal explanatory model on how a one-way mirror works. Students develop a scientific explanation to explain why only one side can see through a one-way mirror, provide feedback to each other, and then submit their final explanation.
Students then revisit the anchoring phenomenon to consider what additional criteria and constraints should be considered with the problem statement based on their learning related to light.</td></tr>
<tr><th colspan="2">Instructional Segment 4</th></tr>
<tr><th colspan="2">Learning Investigations and Sample Lessons</th></tr>
<tr><td>Alignment Coding
NGSS PEs:
MS-PS4-1
MS-PS4-2
MS-ETS1-1
CCSS:
MP.2</td><td>Estimated Classroom Time: 400 minutes
Using Waves to Help People
5Es: Engage, Explore
Estimated Time: 100 minutes
AGs: A17, A18, A19, A20
Students finalize the design specification for a device that addresses a problem introduced through the anchoring phenomenon, in this case, helping someone with sensory issues. Students begin individually by coming up with their own ideas before sharing them with</td></tr>
</table>

RST.6-8.1 WHST.6-8.8 SL.8.5 7.EE.3 EUs/EQs: EU4/EQ4 EU5/EQ5 AGs: A17 A18 A19 A20	their group. The lesson and materials lead students through the design specification process: ● **Develop the problem statement:** Companies will use properties of _______________ (sound/light) waves to design a device that… ● **Using the science of waves as a foundation:** a. Three ideas about __________ waves that will be important to this design are… b. Three ideas I had while watching the video that will be important to my design are… ● **Bill of Materials:** To build this device, companies will need… ● **Sketch:** Draw an initial design, labeling the major components (or important parts) ● **Review:** Use the sketch to double-check the Bill of Materials and add any major components that were left out. Students develop an initial design on their own and then get into groups. With their group, each student shares their initial design specifications and then the group comes to consensus on a list of the three to four most important specifications for their group. As a group, they then develop a single sketch of their prototype. *Teacher note: At the conclusion of this instructional segment, students submit the completed design specification, which will include many sections requiring hand-written artifacts. Therefore, it will be useful for student groups and teachers to have a binder or folder with dividers to keep track of and organize the work.* Resources: ● Design Specification | Teaching Resources (tes.com) [https://www.tes.com/en-us/teaching-resource/design-specification-12357968] ● ibo.org [https://ibpublishing.ibo.org/server2/rest/app/tsm.xql?doc=m_8_techn_tsm_1406_1_e&part=3&chapter=5] ● VistaThink.com - CritA-PaperWaterTank - Define and Research Problem [https://www.vistathink.com/wp-content/uploads/2022/04/CritA-PaperWaterTank-DefinitionAndResearchOfAProblem-VistaThink2.pdf] ● CritB-PaperWaterTank-DevelopIdeas-VistaThink.pdf [https://www.vistathink.com/wp-content/uploads/2020/03/CritB-PaperWaterTank-DevelopIdeas-VistaThink.pdf] **Waves in Action** ● 5Es: Explore, Explain ● Estimated Time: 100 minutes ● AGs: A17*, A19 Students review their prototypes to identify wave interactions with their devices and develop a set of parameters (operating conditions) for proper functioning of the devices. The devices should be drawn with sufficient detail to show how it interacts with waves.

	Students should use evidence from their research about light, sound, and waves, as well as the criteria and constraints they developed in the previous lesson to ensure that they are creating a solution that helps with sound and light. Rather than addressing all criteria and constraints from the brainstorm, groups specifically target only those (at least 3) that pertain to waves at this time. Students annotate the prototype drawings specifically where/how they have addressed the selected criteria/constraints. Students also annotate the models with any parameters of operation that pertain to waves (e.g., a particular reflective surface on the solar oven must directly face the sun, etc.). [Note: other criteria/constraints are certainly important and should be kept for future use in the design specification, but this lesson is focused on student understanding of waves and how they interact with the device.] Students revise the diagram of their prototypes (sketch with labels for major components), and bill of materials (list of all major components in the design) based on their review. Students write a description of the design that discusses any interactions between major components and system boundaries. Prompts that might help get students started are: ● Does anything need to be able to move/be adjusted? ● What is the acceptable range of motion/adjustment? ● Will the device need to interact with other objects to function? ● What are the system boundaries? ● Does the device need to open/close? ● Does the device need the ability to emit/pick up waves? To promote deeper thinking, students may be asked to compare the new design and wave interactions to models from previous segments in this unit, remarking on differences in operation of their device. **Into The Shark Tank** ● 5Es: Elaborate, Evaluate ● Estimated Time: 200 minutes ● AGs: A17*, A18*, A19*, A20* First, students work in their groups to finalize their project with the goal of presenting their idea to a panel of expert "investors". After finalizing their project design ideas, students present their final design plan to a panel of experts for feedback. This board could be made up of school administrators, teachers, local experts, or other interested parties. The students present their ideas in a rapid "Shark Tank" (Shark Tank clip) format in a short time. The board evaluates the design plan and the presentation based on the expectations of the initial client, creativity, and the use of scientific learning from the unit.

Accessibility and Differentiation for Diverse Learners
"Universal Design for Learning (UDL) is a framework to improve and optimize teaching and learning for all people based on scientific insights into how humans learn" (CAST, 2022). Taking time to reflect on prior instruction when planning for accessible, differentiated, and culturally responsive instruction for diverse learners and culturally diverse classrooms serves to identify ways to improve future instructional practices. The UDL Guidelines provide a framework for this reflection. The guidelines include three principles, Multiple Means of Engagement, Multiple Means of Representation, and Multiple Means of Action & Expression as ways to focus on variety and flexibility in instructional practices. By examining instruction and instructional materials through the lens of each of these principles, we can identify and thus reduce or remove barriers to diverse learners. Providing Multiple Means of Engagement (e.g., allowing choices, authentic scenarios, varying demands, and clear goals), broadens the opportunities for gaining and sustaining students' interest and cognitive engagement in learning the content. Providing Multiple Means of Representation (e.g., variety of presentation modes, clarifying vocabulary, activating background knowledge) allows students to receive and comprehend the content. Providing Multiple Means of Action & Expression (e.g., a variety of methods to respond to instruction, and a variety of ways to interact with the instructional materials) helps students to use their strengths and abilities to access the instructional materials and express what they understand. Accommodations typically reserved for students receiving special education, students who have a 504 plan, and English Learners can be made available to all students using the UDL principles, thus allowing all students to benefit from the accommodations. The SIPS Grade 8 Unit 4 Instructional Framework Differentiation Strategies and Resources support educators' intentional planning of accessible, differentiated, and culturally responsive instruction for all students aligned to the specific performance expectations in focus for this unit.
Core Text Connections
• The Physics Classroom [https://www.physicsclassroom.com/class/waves] • CK12 Flexbook, Middle School Physical Science [https://flexbooks.ck12.org/cbook/ck-12-middle-school-physical-science-flexbook-2.0/?_gl=1*1kg503i*_ga*ODUwMzExOTg4LjE2ODYwNjE5NDA.*_ga_7PBE4L0PZZ*MTY4NjA2MTk0MC4xLjAuMTY4NjA2MTk0MC4wLjAuMA] • CK-12 Flexbook, Wave Speed [https://flexbooks.ck12.org/cbook/ck-12-physics-flexbook-2.0/section/11.4/primary/lesson/wave-speed-ms-ps/] • Concord Consortium: Making Waves [https://learn.concord.org/eresources/654.run_resource_html] • Cognito: Wave Properties [https://youtu.be/aCu4VRKMstA]

- CK-12 Flexbook, Sound Wave
  [https://flexbooks.ck12.org/cbook/ck-12-middle-school-physical-science-flexbook-2.0/section/17.1/primary/lesson/sound-waves-ms-ps/]
- Infinity Learn: Propagation of Sound
  [https://www.youtube.com/watch?v=WqnF-VPfGPw]
- CrashCourse Physics: Traveling Waves
  [https://youtu.be/TfYCnOvNnFU]
- Physics Classroom: Sound as a Longitudinal Wave
  [https://www.physicsclassroom.com/class/sound/Lesson-1/Sound-as-a-Longitudinal-Wave]
- Physics Classroom: Sound is a Pressure Wave
  [https://www.physicsclassroom.com/class/sound/Lesson-1/Sound-is-a-Pressure-Wave]
- Speed of Sound
  [https://www.youtube.com/watch?v=BlENwMSTUy4]
- Sound Waves in Action
  [https://www.youtube.com/watch?v=TgJKf3G6LuE]
- Concord Consortium: How Loud, How High?
  [https://learn.concord.org/eresources/649.run_resource_html]
- CK-12 Flexbook: Visible Light
  [https://flexbooks.ck12.org/cbook/ck-12-middle-school-physical-science-flexbook-2.0/section/19.1/primary/lesson/sources-of-visible-light-ms-ps/]
- Kahn Academy: Middle School Science | Waves
  [https://www.khanacademy.org/science/ms-physics/x1baed5db7c1bb50b:waves]
- Let's Talk Science: Light and Its Properties
  [https://letstalkscience.ca/educational-resources/backgrounders/light-and-its-properties]
- Encyclopedia Britannica: Light
  [https://www.britannica.com/summary/light]
- YouTube: Criteria and Constraints
  [https://youtu.be/CWTNawFx8FM]

Instructional Resources

- Legends of Learning: Waves and Their Properties Science Games
  [https://www.legendsoflearning.com/learning-objectives/waves-and-their-properties/?utm_source=nsta_site&utm_medium=external&utm_campaign=nsta_waves]
- The Physics Classroom: Describing Waves Complete Toolkit
  [https://www.physicsclassroom.com/Teacher-Toolkits/Describing-Waves/Describing-Waves-Complete ToolKit]
- PBS Physical Science: Wave Properties Resources

[https://aptv.pbslearningmedia.org/subjects/science/physical-science/waves-and-light/properties-of-waves/]

- Virtual Simulation: PhET Waves Intro
  [https://phet.colorado.edu/en/simulations/waves-intro]
- Teach Engineering: Wave and Wave Properties
  [https://www.teachengineering.org/lessons/view/clem_waves_lesson02]
- SciGen Teacher Dashboard: Making Waves
  [https://serpmedia.org/scigen/e4.3.html]
- A Wave With Words
  [https://serpmedia.org/scigen/e4.2.html]
- Making Waves
  [https://serpmedia.org/scigen/e4.3.html]
- OpenScieEd: Sound Waves
  [https://www.openscied.org/instructional-materials/8-2-sound-waves/]
- BetterLesson: Sound Waves and Ocean Waves
  [https://teaching.betterlesson.com/lesson/645430/sound-waves-and-ocean-waves]
- Shine Music School: Sound Experiments for Kids
  [https://shinemusicschoolonline.com/2020/05/sound-experiments-for-kids/]
- The Smithsonian: Chladni Plates
  [https://americanhistory.si.edu/science/chladni.htm]
- OpenSciEd: Light & Matter
  [https://www.openscied.org/instructional-materials/6-1-light-matter/]
- PhET: Bending Light Lab
  [https://phet.colorado.edu/en/contributions/view/4316]
- Science Buddies: Teach About Visible Light with Hands-on Lessons
  [https://www.sciencebuddies.org/blog/teach-visible-light-science#middle]
- Ducksters: Science Experiments – Visible Light
  [https://www.ducksters.com/science/experiment_light_spectrum.php]
- Study.com: Light for Kids – Activities and Experiments
  [https://study.com/academy/popular/light-for-kids-activities-experiments.html]
- Science Learning Hub: Refraction of Light
  [https://www.sciencelearn.org.nz/resources/49-refraction-of-light]
- Teach Engineering: Sound and Light
  [https://www.teachengineering.org/curricularunits/view/cub_soundandlight_curricularunit]
- PBS LearningMedia: Identify Criteria and Constraints | Engineering for Good
  [https://dptv.pbslearningmedia.org/resource/criteria-constraints/identify-criteria-and-constraints-engineering-for-good/]

- NASA: Identifying Criteria and Constraints
  [https://www.nasa.gov/pdf/473907main_Packing_Lesson1_DBE.pdf]
- NASA JPL: Engineering in the Classroom
  [https://www.jpl.nasa.gov/edu/teach/resources/engineering-in-the-classroom.php#ms]