Coherence and Alignment Among Science Curriculum, Instruction, and Assessment (CASCIA)

Grade 8 Unit 4

End-of-Unit Assessment

Task Interpretation Guide

April 2024

The Grade 8 Unit 4 End-of-Unit Assessment Task Interpretation Guide 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 guide do not represent the policy of the U.S. Department of Education, and no assumption of endorsement by the Federal government should be made.

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Introduction

The use of formative assessment practices, with informative and immediate feedback that leads to adjustments to instructional next steps, has been shown to be effective in helping students learn (Black & Wiliam, 1998; Wylie & Lyon, 2009; Heritage, 2010). Interim or large-scale summative assessments, such as those required under the *Every Student Succeeds Act of 2015 (ESSA)*, cannot and are not meant to inform daily instruction because of how and when they are administered. These forms of assessment can bring value to an assessment system, but only if coordinated and meaningfully aligned within a comprehensive, coherent system.

The Coherence and Alignment Among Science Curriculum, Instruction, and Assessment (CASCIA) Project brings together three partner states—Nebraska, Alabama, and Alaska—with a team of researchers and experts to establish science assessment resources that are coordinated and aligned across all parts of the assessment system. With coherence as the guiding principle, these state-level educators and national science education and measurement experts have joined with hundreds of local educators to address states' need for quality, standards-aligned science assessments that generate meaningful, interpretable, and actionable results, and to design a scoring and score reporting framework that builds educators' capacity to track, interpret, and communicate students' learning in science and to offer effective instruction for all students.

Purpose

The purpose of the *Grade 8 Unit 4 End-of-Unit Assessment Task Interpretation Guide* is to support educators' understanding of the Grade 8 Unit 4 End-of-Unit assessment tasks and prompts, their features, and the evidence (i.e., knowledge and skills) they are designed to elicit about student learning, and how the assessment and the information it provides can be used to plan instruction and learning opportunities for students, whether it involves planning for instruction prior to teaching the instructional unit, reflecting on the quality and sufficiency of prior instruction and instructional materials or planning additional student learning opportunities or interventions in the subsequent unit.

The Grade 8 Unit 4 Science Assessment includes three science tasks, each including multiple scorable prompts. Task 1, *Now You See It*, includes three prompts and ten possible score points with Prompts 2 and 3 having a Part A and B; Task 2, *Color My World*, includes two prompts and 13 possible score points with Prompt 1 having a Part A, B, and C and Prompt 2 having a Part A and B; Task 3, *Sounds of Silence*, includes three prompts and 14 possible score points, with Prompts 2 and 3 having a Part A, B, and C.

Prompts from the three tasks that measure similar combinations of dimensions (i.e., Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts) from the Next Generation Science Standards (NGSS) are organized into three performance categories. The NGSS Performance Expectations (PEs) are addressed in one or more performance categories to provide multiple opportunities to demonstrate flexible thinking and competency in different situations and contexts.

Performance Category	NGSS PEs	Prompts in Performance Category	Points Possible
Analyze Data to Explain the Relationships Between Properties of Waves and Energy	MS-PS4-1, MS-PS4-2	Task 1, Prompt 2 Task 3, Prompt 2AB Task 1, Prompt 3 Task 3, Prompt 1 Task 3, Prompt 2C	14 points
Use Models to Describe Interactions Between Light Waves and Materials	MS-PS4-1, MS-PS4-2	Task 1, Prompt 1 Task 2, Prompt 1A Task 2, Prompt 1B Task 2, Prompt 1C Task 2, Prompt 2A Task 2, Prompt 2B	15 points
Design the Best Solution to a Problem Involving Properties of Sound Waves and Materials	MS-PS4-1, MS-PS4-2, MS-ETS1-1	Task 3, Prompt 3A Task 3, Prompt 3B Task 3, Prompt 3C	8 points

Contents

This document includes interpretive guidance to support educators' understanding of each prompt on the Grade 8 Unit 4 EOU Assessment, its features, and the evidence it is designed to elicit about students' learning, and offers important connections to the learning goals, formative assessment opportunities, and lesson descriptions within the SIPS Grade 8 Unit 4 Map / Instructional Framework as well as connections to future learning opportunities in the next unit.

For each prompt, the following information is provided:

- **Performance Category** – A classification of prompts within the EOU based on similarities in knowledge, skills, and abilities for which the prompts were designed to measure.
- **Acquisition Goals** – Specific goals that describe what students should understand, know, and be able to do at the end of a unit or course of instruction. The acquisition goals are derived from Stage 1 of the unit map / instructional framework that the prompt is intended to measure.
- **Prompt Knowledge and Skills for Measurement** – The evidence of student learning the prompt is designed to elicit.
- **Prompt and Exemplar Response** – The prompt consists of one to three sentences that raises an issue or asks a question to which students need to respond. An exemplar response represents a high-quality response that provides evidence that students have demonstrated the knowledge, skills, and abilities assessed by the prompt. Student exemplars are intended to assist in understanding the nature and expectations of the prompt. However, students may respond with other relevant scientifically accurate responses, evidence, observations, and ideas.

In general, a full-point exemplar response meets expectations and is:

- scientifically accurate
- complete
- coherent
- consistent with the type of student evidence expected as described in the rubric

For examples of student responses for each prompt representative of the full range of score points possible based on the scoring rubric, access the [Grade 8 Unit 4 EOU Assessment Scoring Guide.]

- **Prompt Complexity** – The sophistication of students' ability to demonstrate sense-making is characterized by their ability to (a) use disciplinary core ideas (DCIs), scientific and engineering practices (SEPs), and crosscutting concepts (CCCs) together in the service of sense-making about a phenomenon or problem, and (b) engage with and respond to items and tasks designed using variable features representing combinations of Low, Moderate, and High complexity designations. These combinations of features are based on the SIPS Complexity Framework.

  Adapted from the Cambridge Alignment Methodology (Forte, 2021) and informed by aspects of Achieve's Framework to Evaluate Cognitive Complexity in Science Assessments (Achieve, 2019), the SIPS Complexity Framework is grounded in sense-making and students' ability to flexibly apply knowledge through the integration of the same and new/different combinations of dimensions within the PEs from a unit bundle, in the context of a phenomenon or phenomenon-rooted design problem based on the focal DCIs.

- **Prompt Connections to the Unit Map / Instructional Framework** – A high-level overview of the evidence elicited by the prompt related to the acquisition goals, connections to the instructionally-embedded formative assessment opportunities within Stage 2 of the unit map, and connections to opportunities to learn based on the lesson descriptions within stage 3 of the unit map.

For each of the three tasks, the following information is provided:

- **Connections to Future Learning Opportunities** – The knowledge, skills, and abilities elicited by the prompt that can be leveraged and extended in future learning. Unit connections highlight where and how an educator can emphasize connections for students in the next unit.

SIPS Grade 8 Unit 4 EOU Assessment Task 1: Now You See It

Task 1 Prompt 1

Performance Category: Use Models to Describe Interactions Between Light Waves and Materials

Acquisition Goals

- **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.*
- **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.

Prompt 1 measures the students' ability to:

- Develop or use models to support descriptions of the pathway of light as it travels in air using the law of reflection.

Student Worksheet

This task is about the repeating patterns of simple waves with specific wavelengths, frequencies, and amplitudes.

Task

About 541 million years ago, the appearance of primitive eyes, called eyespots, allowed organisms to move in response to light. Organisms living today depend on their sense of sight for survival. Most people rely on their sense of sight more than their other senses. However, that doesn't mean humans can see everything. In fact, some animals are able to see things that we cannot!

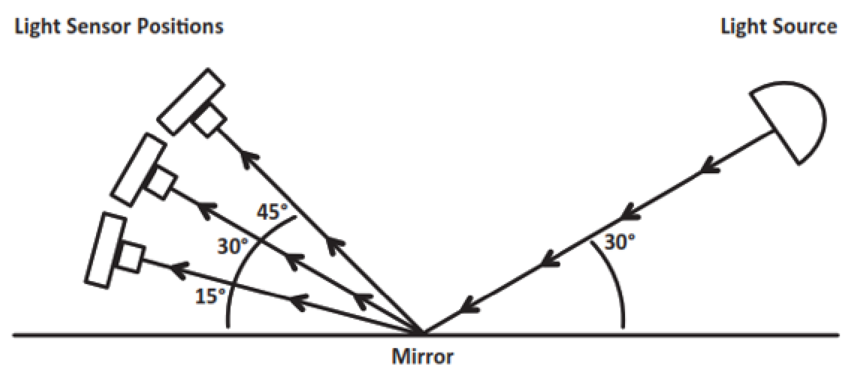
Prompt 1

Just like human eyes, animals' eyes work by detecting light. To survive in the arctic tundra, polar bears hunt for their food in intense sunlight. Polar bears have a protective covering over their eyeballs that protects their eyes from the bright sunlight that reflects off the snow.

A light sensor, like an eye, can detect the intensity or brightness of light. A light sensor displays a number that shows how much light is detected by the sensor.

Figure 1 shows a model of an investigation in which a light source was directed toward a mirror at a 30° angle. A light sensor recorded the brightness of the reflected light at 15°, 30°, and 45° angles.

Figure 1. Light Source and Light Sensor



Prompt 1

Explain which position of the light sensor in **Figure 1** recorded the highest brightness, and how it relates to the law of reflection using your knowledge of light and energy.

The law of reflection is that the angle of incidence equals the angle of reflection. If an incoming light beam makes a 30° angle with a mirror, the light beam leaving the mirror will also make a 30° angle. So, the highest reading on the light sensor will occur when the light enters it at the same angle as the light hits the mirror.

Task 1 Prompt 1 Complexity		
Degree and Nature of Sensemaking	**Low**	**This task…** • Requires one or two dimensions • One dimension may have a greater degree of emphasis than another
Complexity of the Presentation	**Moderate**	• The amount and type of information provided in the scenario supports multiple evident connections among ideas or concepts. • Provides graphics/data/models
Cognitive Demand of Response Development	**Low**	• Requires well-defined set of actions or procedures • Requires a connection or retrieval of factual information
Cognitive Demand of Response Production	**Moderate**	• Responses include one or more sentences or a paragraph, a moderately complex graphic, or multiple steps in a simple or moderately complex process

Task 1 Prompt 1 Connections to the Instructional Framework	
Integration of Knowledge and Skills for Response Development	
• Students read the provided background information and Figure 1, which presents an analogy of how a human eye receives light and processes light like a light sensor. • Students describe the law of reflection using a model and mathematical thinking to demonstrate an understanding of wave properties. • Students indicate the highest reading at 30° and explain how the law of reflection supports their answer.	
Formative Assessments	**Opportunities to Learn**
Segment 3, pp. 15-16 *Informal Assessment: Light Waves (A11*, A12)* • Students 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. • Students 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 that bend at material transitions.	**Segment 3, p. 33** *What do we See? (A11*, A12)* • Students experiment with the full box model to explore factors involved in the reflection of light, finding that the mirror reflects the room with brighter light, that light travels in straight lines (rays), and that to see something, light must travel from the source to the object to our eyes.

Task 1 Prompt 1 Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 3, pp. 17-18 *Formal Assessment: Plan and Carry Out an Investigation on the Bending of Light Waves (A11*, A12)* • 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. • Students 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.	**Segment 3, pp. 33-34** *Bending and Bouncing Light Rays (A11*, A12)* • Students observe and experience reflection, refraction, absorption, transmission, dispersion, and addition of light at a series of stations. 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. • 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.

Task 1 Prompt 2 – Parts A and B

Performance Category: Analyze Data to Explain the Relationships Between Properties of Waves and Energy

Acquisition Goals

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

Prompt 2 – Parts A and B measure the students' ability to:

- Analyze and interpret models, data, and graphs to support conclusions about the mathematical relationship between the amplitude of light and sound waves and energy.

Prompt 2

Part A.

The energy of a light wave or its brightness depends on its amplitude. Table 1 shows the relationship between energy and amplitude. The energy transported by a wave is directly proportional to the square of the amplitude of the wave.

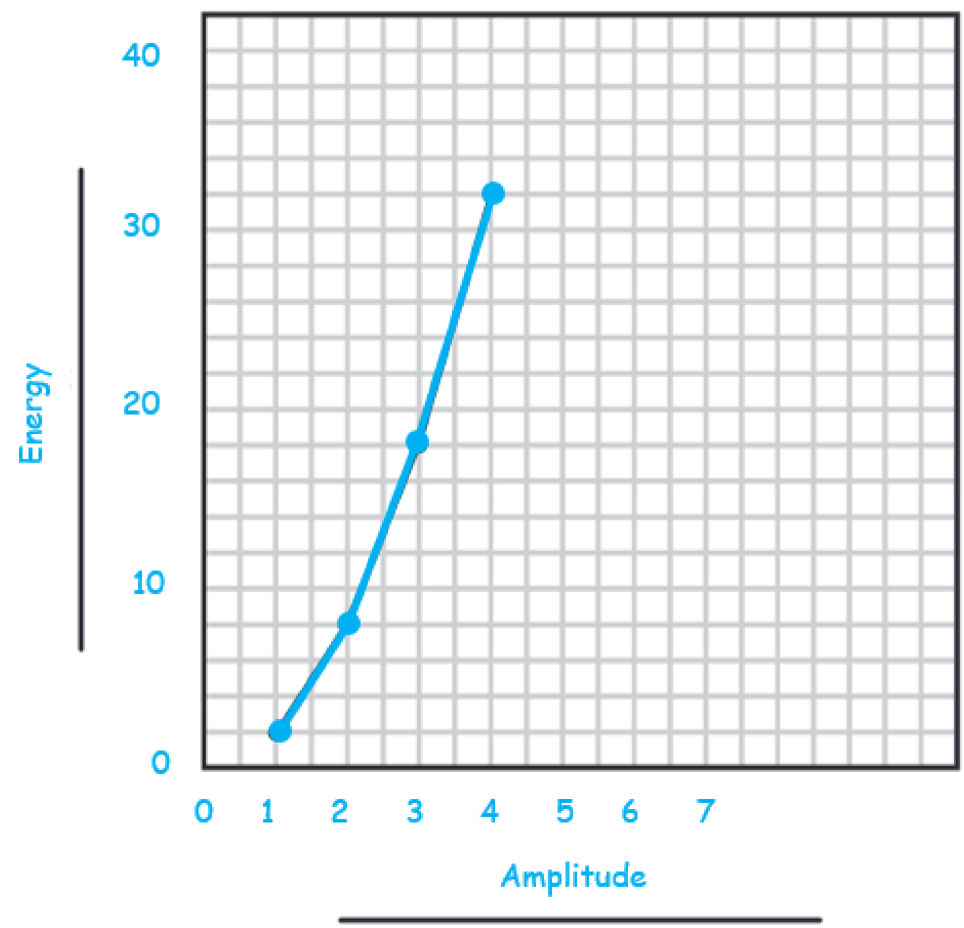
Table 1. Energy-Amplitude Relationship

Amplitude Units	1	2	3	4
Energy Units	2	8	18	32

Use the data in **Table 1** to graph the change in the energy-amplitude relationship. The *x*-axis represents amplitude, and the *y*-axis represents energy. Your graph must include:

- A label for the variable represented by the *x*-axis
- A label for the variable represented by the *y*-axis
- A scale for each axis
- Data points connected with a line

Graph 1. Energy-Amplitude Relationship



Part B.

Complete the sentences describing the relationship between the energy and amplitude of a wave. Use the **Word Bank** and **Graph 1** to support your response.

Word Bank

halved	**doubled**	**quadrupled**	**the same**

The amount of energy transported by a wave is quadrupled in strength when the amplitude is doubled. I know this because the energy transported by a wave is directly proportional to the square of the amplitude of the wave. The graph shows that changing the amplitude from 2 units to 4 units represents a 2-fold increase in the amplitude and is accompanied by a 4-fold increase in the energy from 8 to 32 units. This means that a doubling of the amplitude results in a quadrupling of the energy.

Task 1 Prompt 2 Parts A and B Complexity		
Degree and Nature of Sensemaking	**Moderate**	**This task…** • Requires integration of two dimensions in the service of sense-making
Complexity of the Presentation	**Moderate**	• The amount and type of information provided in the scenario supports multiple evident connections among ideas or concepts
Cognitive Demand of Response Development	**Moderate**	• Response requires a moderate level of sophistication with typical but relatively complex representation of ideas and application of skills
Cognitive Demand of Response Production	**High**	• Responses include multiple paragraphs, multiple graphics of at least moderate complexity, or multiple steps in a complex process

Task 1 Prompt 2 Parts A and B Connections to the Instructional Framework	
Integration of Knowledge and Skills for Response Development	
• Students graph data and use their results to describe the mathematical relationship between amplitude and energy. • Students refer to Table 1 to complete Graph 1 with accurate labels and scales. • Students analyze and interpret data by observing patterns that support scientific conclusions about how the amplitude of a wave is related to the energy in a wave. • In their explanation, students indicate that energy is proportional to the square of the amplitude using data.	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 9-10 *Informal Assessment: All About Waves (A4)* • Students accurately describe how a simple mathematical wave model corresponds to the properties of a physical phenomenon. • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations.	**Segment 1, pp. 26-27** *What is a Wave? (A3*, A4)* • 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 provides pairs or small groups of students with Slinkies to create longitudinal and transverse waves and observations which they record in their science notebooks.

Task 1 Prompt 2 Parts A and B Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 10-11 *Formal Assessment: What is a Wave? (A3*, A4, A6*)* • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations. • Students 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. • Students 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.	

Task 1 Prompt 2 Parts A and B Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 11-12 *Formal Assessment: Representing Wave Properties Mathematically (A4, A6*)* • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations. • Students 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. • Students 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.	

Task 1 Prompt 3 – Parts A and B

Performance Category: Analyze Data to Explain the Relationships Between Properties of Waves and Energy

Acquisition Goals

- **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.
- **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. *

Prompt 3 Parts A and B measures students' ability to:

- Analyze and interpret models, data, and graphs to support conclusions about properties of electromagnetic waves and the segment of the electromagnetic spectrum that the human eye can view.

Prompt 3

The light humans can see is called visible light. This light, also known as white light, consists of a collection of colors. Humans see different wavelengths of visible light in different colors such as red, orange, yellow, green, blue, and violet.

Part A.

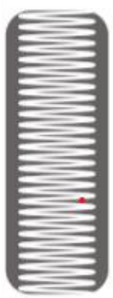
Table 2 shows examples of electromagnetic waves of various wavelengths.

Table 2. Examples of Electromagnetic Waves

Wave Types	Gamma Radiation	Ultraviolet	Visible Light	Infrared	Radio
Wave Diagram	B	A		D	C
Increasing Wavelength (in meters)	10^{-12}	10^{-8}	5×10^{-6}	10^{-5}	10^{3}

In **Table 2**, correctly place the letters from **Table 3** to represent the wave diagrams for the following types of waves: Gamma Radiation, Ultraviolet, Infrared, and Radio.

Table 3. Wave Diagrams

Wave Diagram				
	A	B	C	D

Part B.

A group of snakes, called pit vipers, can detect infrared light as thermal energy. Thus, pit vipers can easily see rodents and birds, even when their prey is hiding in grass or bushes.

A student makes the following claim:

Because pit vipers can detect infrared wavelengths, they must also be able to see light waves with higher frequencies than humans are able to see.

Circle if you agree or disagree with the claim. Include evidence from **Table 2** and your scientific knowledge to support your response.

	Evidence
Agree	Infrared waves are longer waves than visible light as shown in Table 2. The frequency and wavelength of a wave are indirectly proportional to each other. The longer the wavelength, the lower the frequency. That means pit vipers can see light at a lower frequency than humans. This does not support the claim that pit vipers see light at a higher frequency, like those of Gamma Radiation or Ultraviolet.
Disagree	

Task 1 Prompt 3 Parts A and B Complexity		
Degree and Nature of Sensemaking	**High**	**This prompt…** • Requires integration of three dimensions in the service of sense-making
Complexity of the Presentation	**Moderate**	• The amount and type of information provided in the scenario supports multiple evident connections among ideas or concepts
Cognitive Demand of Response Development	**High**	• Requires selection and application of multiple complex ideas and practices
Cognitive Demand of Response Production	**Moderate**	• Responses include one or more sentences or a paragraph, a moderately complex graphic, or multiple steps in a simple or moderately complex process

Task 1 Prompt 3 Parts A and B Connections to the Instructional Framework	
Integration of Knowledge and Skills for Response Development	
• Students complete a model of the electromagnetic spectrum to make connections between the light humans cannot see as opposed to what is seen by a species of snake. • Students complete Table 2 by matching the correct wavelengths with the types of electromagnetic waves. • Students select "disagree," using information from Table 2 as evidence to support their response and relating frequency and wavelength.	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 10-11 *Formal Assessment: What is a Wave? (A4)* • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations. • Students 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. • Students 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.	**Segment 1, pp. 26-27** *What is a Wave? (A4)* • 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 provides pairs or small groups of students with Slinkies to create longitudinal and transverse waves and observations which they record in their science notebooks.

Task 1 Prompt 3 Parts A and B Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 11-12 *Formal Assessment: Representing Wave Properties Mathematically (A4, A5)* • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations. • Students 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. • Students 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.	**Segment 1, pp. 27-28** *Wave Properties Investigation (A5)* • Students design and conduct an experiment to find the relationship between the speed, frequency, and wavelength of the wave by collecting numerical data. • 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. **Segment 3, p. 33** *What do we See? (A12)* • Students experiment with the full box model to explore factors involved in the reflection of light, finding that the mirror reflects the room with brighter light, that light travels in straight lines (rays), and that to see something, light must travel from the source to the object to our eyes.

Task 1 Prompt 3 Parts A and B Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 3, pp. 15-16 *Informal Assessment: Light Waves (A12*)* • Students 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. • Students 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 that bend at material transitions.	**Segment 3, pp. 33-34** *Bending and Bouncing Light Rays (A12)* • Students observe and experience reflection, refraction, absorption, transmission, dispersion, and addition of light at a series of stations. • 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.

Future Learning Connected to evidence elicited in Task 1
Crosscutting Concepts • Unit 4 CCCs focus on using Cause and Effect, Patterns, and Structure & Function to describe wave properties and to identify cause and effect relationships as they pertain to how the presence or absence of a medium influences wave behavior. In future high school learning experiences related to wave properties, students will use empirical evidence to differentiate between cause and correlation in wave properties and make claims about specific causes and effects (HS-PS4-1). **Disciplinary Core Ideas** • Unit 4 focuses extensively on understanding the properties and types of simple waves, the wave model of light, how the presence or absence of a medium influences their behavior, and how engineering design problems can be solved by determining success criteria and constraints related to wave properties. Students' learning and understanding increase in sophistication beyond grade 8, where they extend their knowledge to resonance in speech and music and how information can be digitized by combining waves of different frequencies, thereby encoding and transmitting. The wave model introduced in this unit is useful for explaining many features of electromagnetic radiation in later grades. The criteria and constraints they specify in this unit are later quantified and applied to global challenges facing humanity for potential solutions. **Science and Engineering Practices** • Unit 4 SEPs focus predominantly on asking questions and defining problems, using mathematical and computational thinking, and developing and using models, but also include planning and carrying out investigations, analyzing and interpreting data, constructing explanations, and designing solutions. Students will again visit these practices in their future learning experiences by using mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations (HS-PS-4-1). They will also evaluate questions that challenge an argument's premise(s), the interpretation of a data set, or the suitability of a design (HS-PS4-2).

SIPS Grade 8 Unit 4 EOU Assessment Task 2: Color My World

Task 2 Prompt 1 – Part A

Performance Category: Use Models to Describe Interactions Between Light Waves and Materials

Acquisition Goals

- **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. *
- **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. *
- **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.
- **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.

Prompt 1 – Part A measures students' ability to:

- Develop or use models to support descriptions of how properties of waves are affected by the medium through which they are passing.

Student Worksheet

This task is about wave characteristics of light.

Task

On a rainy day, nature can put on one of its greatest displays—a rainbow—that appears as a multi-colored arc across the sky! A rainbow is composed of all the colors of visible light: red, orange, yellow, green, blue, indigo, and violet.

What is the connection between rain, light, and the colors of visible light in a rainbow?

Prompt 1

Part A.

Rainwater is transparent which allows light to be transmitted through it. However, whenever light travels from one medium to another, like from air to water during a rainstorm, the speed of light changes.

When light passes from air to water, does it change wavelength, frequency, or both? Explain your answer.

When the light wave moves from air to a denser medium like water, its speed decreases. So, the wavelength of the wave also decreases. The frequency of the light wave remains constant in any medium.

Task 2 Prompt 1 Part A Complexity		
Degree and Nature of Sensemaking	**Moderate**	**This task…** • Requires integration of two dimensions in the service of sense-making
Complexity of the Presentation	**Low**	• The amount and type of information provided in the scenario supports limited simple connections among ideas or concepts • Provides few, simple graphics/data/models
Cognitive Demand of Response Development	**Moderate**	• Requires application of ideas and practices given cues and guidance • Requires drawing relationships and connecting ideas and practices
Cognitive Demand of Response Production	**Moderate**	• Responses include one or more sentences or a paragraph, a moderately complex graphic, or multiple steps in a simple or moderately complex process

Task 2 Prompt 1 Part A Connections to the Instructional Framework	
Integration of Knowledge and Skills for Response Development	
• Students are presented with a scenario that introduces rainbows in the sky and transitions to the properties of light waves, which include the frequency-dependent bending of light at a surface between media. • Students interpret a scenario in which a light wave experiences a change in properties after experiencing a change in medium. • Students describe the relationship between wavelength and the speed of light, including that the frequency of light does not change when passing through different mediums.	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 9-10 *Informal Assessment: All About Waves (A2*)* • Students accurately describe how a simple mathematical wave model corresponds to the properties of a physical phenomenon. • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations.	**Segment 1, p. 27** *Observing Mechanical Waves in Action (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.

Task 2 Prompt 1 Part A Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 11-12 *Formal Assessment: Representing Wave Properties Mathematically (A5*)* • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations. • Students 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. • Students 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.	**Segment 1, p. 27** *Wave Properties Investigation (A5*)* • Students design and conduct an experiment to find the relationship between the speed, frequency, and wavelength of the wave by collecting numerical data. • 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. **Segment 3, p. 32** *A Mirror and A Window? (A11)* • Students observe the phenomenon of a one-way mirror and begin to generate questions about the phenomenon. 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.

Task 2 Prompt 1 Part A Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 1, p. 12 *Formal Assessment: Observing Waves in Action (A2*)* • Students carry out an investigation to determine that light waves can be reflected, absorbed, transmitted, or refracted when they collide with new matter. **Segment 3, pp. 16-17** *Informal Assessment: Light Waves (A11, A13)* • Students 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. • Students use observations and/or data to generate a conclusion about frequency-dependent bending of light at a surface between media.	**Segment 3, pp. 32-33** *Light vs. Sound (A11)* • Students compare and contrast different types of waves and how electromagnetic waves do not require a medium. Students generate a series of observations of light and sound about a familiar phenomenon. • Students build on the 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. **Segment 3, p. 33** *What do we See? (A11)* • Students experiment with the full box model to explore factors involved in the reflection of light, finding that the mirror reflects the room with brighter light, that light travels in straight lines (rays), and that to see something, light must travel from the source to the object to our eyes.

Task 2 Prompt 1 Part A Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 3, pp. 17-18 *Formal Assessment: Plan and Carry Out an Investigation on the Bending of Light Waves (A11, A13)* • Students 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. • Students 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.	**Segment 3, pp. 33-34** *Bending and Bouncing Light Rays (A11, A15)* • Students observe and experience reflection, refraction, absorption, transmission, dispersion, and addition of light at a series of stations. 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. • 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.

Task 2 Prompt 1 – Part B

Performance Category: Use Models to Describe Interactions Between Light Waves and Materials

Acquisition Goals

- **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. *
- **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. *
- **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. *
- **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.

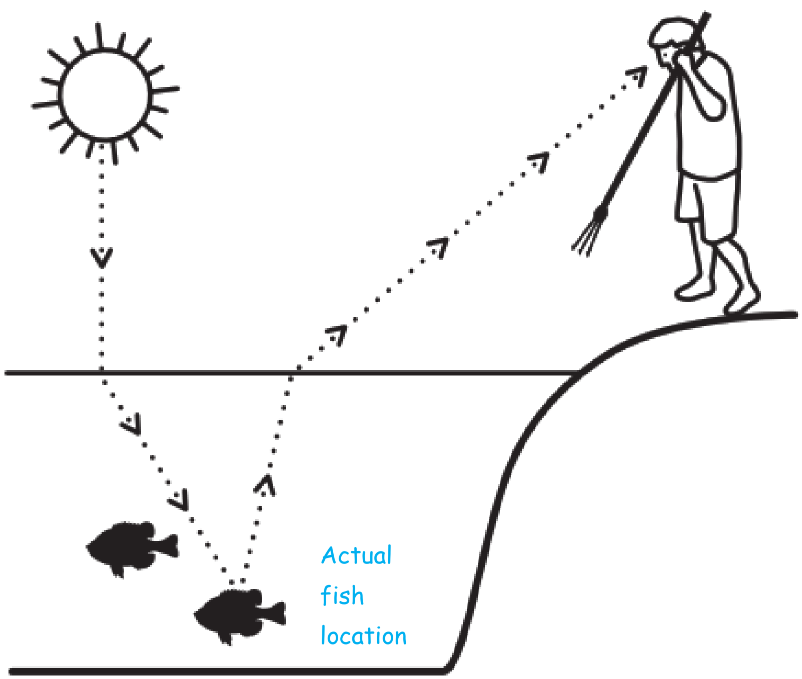
Prompt 1 Part B measures students' ability to:

- Develop or use models to support descriptions of the path light travels at surfaces between transparent materials (e.g., air and water) where the light path bends.

Part B.

The change in the speed of light can also cause light to change direction. This is called refraction. Consider the example in Figure 1 of a spear fisher looking over a lake. From where he is standing on land, the water is clear enough to see a fish in the water. The fish in the picture represents the location of the fish as it appears to the spear fisher.

Figure 1. Spear Fisher and Fish in Lake



Complete the model to show the **actual** relationship between the spear fisher and the fish in **Figure 1**. Be sure to:

- Draw and label the **actual** location of the fish
- Use arrows to show the direction of the path of light from the light source (sun) to the **actual** location of the fish **AND** the path of light from the **actual** location of the fish to the spear fisher's eyes

Task 2 Prompt 1 Part B Complexity		
Degree and Nature of Sensemaking	**Moderate**	**This prompt…** • Requires integration of two dimensions in the service of sense-making
Complexity of the Presentation	**Moderate**	• The amount and type of information provided in the scenario supports multiple evident connections among ideas or concepts • Provides graphics/data/models • Limited use of definitions or examples
Cognitive Demand of Response Development	**Moderate**	• Requires application of ideas and practices given cues and guidance • Requires drawing relationships and connecting ideas and practices
Cognitive Demand of Response Production	**High**	• Responses include multiple paragraphs, multiple graphics of at least moderate complexity, or multiple steps in a complex process

Task 2 Prompt 1 Part B **Connections to the Instructional Framework**	
Integration of Knowledge and Skills for Response Development	
• Students review the scenario of light traveling between different transparent materials (air and water) and Figure 1. • Students complete a model to show the path that light travels at surfaces between different transparent materials (e.g., air and water) where the light path bends. • Students draw and label the fish's actual location, including directional arrows showing the path of light from the sun to the fish's location and from the fish's location to the spear fisher's eyes.	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 9-10 *Informal Assessment: All About Waves (A2*)* • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations. **Segment 1, p. 12** *Formal Assessment: Observing Waves in Action (A2*)* • Students carry out an investigation to determine that light waves can be reflected, absorbed, transmitted, or refracted when they collide with new matter.	**Segment 1, p. 27** *Observing Mechanical Waves in Action (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. **Segment 3, p. 32** *A Mirror and A Window? (A11*, A16)* • Students observe the phenomenon of a one-way mirror and begin to generate questions about the phenomenon.

Task 2 Prompt 1 Part B **Connections to the Instructional Framework, Continued**	
Formative Assessments	**Opportunities to Learn**
• Students 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. **Segment 3, p. 18** *Formal Assessment: I Can See You, but You Can't See Me! (A16)* • Students 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.	**Segment 3, p. 34** *Light Waves and Their Properties (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. **Segment 3, p. 34** *I Can See You, but You Can't See Me* • 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.

Task 2 Prompt 1 – Part C

Performance Categories: Use Models to Describe Interactions Between Light Waves and Materials

Acquisition Goals:

- **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. *
- **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. *
- **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. *
- **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.

Prompt 1 Part C measures students' ability to:

- Develop or use models to support descriptions of the relationship between density of a medium and its effect on the speed light travels.

Part C.

Why does the fish appear to be at a different position in the water compared to where it **actually** is in the water?

In the model, the spear fisher sees a fish that appears to be directly in his line of vision. But the light coming from the fish refracts when it hits the surface. A change in density changes the angle of bend when light travels from one medium to another. This is refraction, which is the reason why the fish appears to be nearer the surface of the water than it actually is.

OR

In the model, the spear fisher sees a fish as if the light travels from the fish to his eyes in a straight line. But, the speed of light changes when it passes from one medium to another. This change in speed can cause light to change direction. This phenomenon is known as refraction. That is the reason why an object immersed in water appears to be closer to the surface than it actually is.

Task 2 Prompt 1 Part C Complexity		
Degree and Nature of Sensemaking	**Moderate**	**This prompt…** • Requires integration of two dimensions in the service of sense-making
Complexity of the Presentation	**Low**	• The amount and type of information provided in the scenario supports limited simple connections among ideas or concepts • Provides few, simple graphics/data/models
Cognitive Demand of Response Development	**Moderate**	• Requires application of ideas and practices given cues and guidance • Requires drawing relationships and connecting ideas and practices
Cognitive Demand of Response Production	**Low**	• Responses include selection from a small set of options presented as text (e.g., word, short phrase) or other formats (e.g., or a simple graphic or process)

Task 2 Prompt 1 Part C Connections to the Instructional Framework	
Integration of Knowledge and Skills for Response Development	
• Students apply their model to describe the bending of light and the position of the fish in the water. • Students explain the relationship between the density of the medium and its effect on the speed light travels.	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 9-10 *Informal Assessment: All About Waves (A2*)* • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations. **Segment 1, p. 12** *Formal Assessment: Observing Waves in Action (A2*)* • Students carry out an investigation to determine that light waves can be reflected, absorbed, transmitted, or refracted when they collide with new matter.	**Segment 1, p. 27** *Observing Mechanical Waves in Action (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. **Segment 3, p. 32** *A Mirror and A Window? (A11*, A16)* • Students observe the phenomenon of a one-way mirror and begin to generate questions about the phenomenon. • Students create an initial, multimodal explanatory model. Using the phenomenon as a segment phenomenon, students generate a driving question board focused on light and the properties of light.

Task 2 Prompt 1 Part C Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 3, pp. 15-16 *Informal Assessment: Light Waves (A11*, A15*, A16)* • Students 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. • Students 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 that bend at material transitions. **Segment 3, pp. 17-18** *Formal Assessment: Plan and Carry Out an Investigation on the Bending of Light Waves (A11*, A13*, A15*)* • Students 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.	**Segment 3, pp. 33-34** *Bending and Bouncing Light Rays (A11*, A16)* • Students observe and experience reflection, refraction, absorption, transmission, dispersion, and addition of light at a series of stations. 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. **Segment 3, p. 34** *I Can See You, But You Can't See Me! (A16)* • 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.

Task 2 Prompt 2 – Parts A and B

Performance Categories: Use Models to Describe Interactions Between Light Waves and Materials

Acquisition Goals:

- **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.
- **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.*
- **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. *

Prompt 2 Parts A and B measure students' ability to:

- Use models to support descriptions of how the relationship between wavelength and speed of light are connected to different and predictable colors of visible light.

Prompt 2

Part A.

Refraction is the principle that underlies the behavior of prisms. When light is transmitted through a prism, the effect is a rainbow of colors. This is called the visible light spectrum, or white light. The human eye perceives wavelengths ranging roughly from 400 nanometers (violet) to 700 nanometers (red).

The wavelengths of visible light are:

- Violet: 380–450 nm
- Blue: 450–495 nm
- Green: 495–570 nm
- Yellow: 570–590 nm
- Orange: 590–620 nm
- Red: 620–750 nm

Whenever light passes into one side of a triangular prism, it causes violet light to travel slower through the prism than red light. Upon exiting from the other side of the triangular prism, the separation becomes even greater, and a rainbow of colors is observed.

How are the speed of the light as it travels through the prism **AND** the different wavelengths of the colors of visible light related to the angle of refraction for red and violet?

Colors of the visible light spectrum that have shorter wavelengths (BIV) will deviate more from their original path than the colors with longer wavelengths (ROY). The violet light bends a bit more than the red light. I know this because the violet light has traveled further downward when passing through the prism. So, the speed of violet light is slowed down to a greater extent by the absorption and re-emission process than red light. That is why violet light refracts more than red light.

Task 2 Prompt 2 Part A Complexity		
Degree and Nature of Sensemaking	**Moderate**	**This prompt…** • Requires integration of two dimensions in the service of sense-making
Complexity of the Presentation	**Moderate**	• The amount and type of information provided in the scenario supports multiple evident connections among ideas or concepts • Provides graphics/data/models
Cognitive Demand of Response Development	**Moderate**	• Requires application of ideas and practices given cues and guidance • Requires drawing relationships and connecting ideas and practices
Cognitive Demand of Response Production	**Moderate**	• Responses include one or more sentences or a paragraph, a moderately complex graphic, or multiple steps in a simple or moderately complex process

Part B.

One of nature's most amazing sights is the rainbow. A rainbow is one more piece of evidence that visible light is composed of a spectrum of wavelengths.

Why does the color pattern always appear as red, orange, green, blue, and violet from the top to bottom of a rainbow?

Whenever light passes into one side of a triangular prism, it causes violet light to travel slower through the prism than red light. Upon exiting from the other side of the triangular prism, the separation becomes even greater, and a rainbow of colors is observed.

How are the speed of the light as it travels through the prism **AND** the different wavelengths of the colors of visible light related to the angle of refraction for red and violet?

When white light from the sun passes through the raindrops the speed of light slows down related to colors' characteristic wavelength, with red moving fastest and violet moving slowest. The shorter wavelengths of blue and violet light refract a slightly greater amount than the longer wavelength of red light. So, the colors in a rainbow are always in order of their wavelength, from longest to shortest: red, orange, yellow, green, blue, and violet. That is why the pattern always appears as red, orange, green, blue, and violet from top to bottom.

Task 2 Prompt 2 Part B Complexity		
Degree and Nature of Sensemaking	**Moderate**	**This prompt…** • Requires integration of two dimensions in the service of sense-making
Complexity of the Presentation	**Low**	• The amount and type of information provided in the scenario supports limited simple connections among ideas or concepts • Provides few, simple graphics/data/models
Cognitive Demand of Response Development	**High**	• Requires selection and application of multiple complex ideas and practices • Requires high degree of sense making, reasoning, and/or transfer
Cognitive Demand of Response Production	**Moderate**	• Responses include one or more sentences or a paragraph, a moderately complex graphic, or multiple steps in a simple or moderately complex process

<table>
<tr><th colspan="2">Task 1 Prompt 2 Parts A and B
Connections to the Instructional Framework</th></tr>
<tr><td colspan="2">Integration of Knowledge and Skills for Response Development</td></tr>
<tr><td colspan="2">Part A
• Students recall the effects of shining a light through a prism and the relationship between the speed of light and wavelength to determine the reason the colors of light spread out.
• Students use mathematical and computational thinking to explain the effect of shining light through a prism in terms of the visible spectrum, wavelength, and speed in terms of the bending of light using patterns in a data set.
Part B
• Students make the connection between the properties of light waves and the production of rainbows in the sky.
• Students use the data and the scenario to explain the phenomenon that has occurred, the production of a rainbow in the sky.</td></tr>
<tr><td>Formative Assessments</td><td>Opportunities to Learn</td></tr>
<tr><td>Segment 1, pp. 9-10
Informal Assessment: All About Waves (A4*)
• Students accurately describe how a simple mathematical wave model corresponds to the properties of a physical phenomenon.
• Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations.</td><td>Segment 1, pp. 26-27
What is a Wave? (A4*)
• 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 provides pairs or small groups of students with Slinkies to create longitudinal and transverse waves and observations which they record in their science notebooks.</td></tr>
</table>

Task 1 Prompt 2 Parts A and B Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 11-12 *Formal Assessment: Representing Wave Properties Mathematically (A4*, A5)* • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations. • Students 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. • Students 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.	**Segment 1, pp. 27-28** *Wave Properties Investigation (A5)* • 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. • After collecting their data, students analyze the data to find the linear relationship between frequency and wavelength. Following their experiment and analysis, students write a conclusion based on their data. **Segment 3, p. 33** *What do we See? (A12)* • Students experiment with the full box model to explore factors involved in the reflection of light, finding that the mirror reflects the room with brighter light, that light travels in straight lines (rays), and that to see something, light must travel from the source to the object to our eyes.

Task 1 Prompt 2 Parts A and B Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 3, pp. 15-16 *Informal Assessment: Light Waves (A12, A13*)* • Students 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. • Students 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 that bend at material transitions. **Segment 3, p. 18** *Formal Assessment: I Can See You, but You Can't See Me! (A16*)* • Students 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.	**Segment 3, pp. 33-34** *Bending and Bouncing Light Rays (A12, A13*, A16*)* • Students observe and experience reflection, refraction, absorption, transmission, dispersion, and addition of light at a series of stations. 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. • 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.

Future Learning Connected to evidence elicited in Task 2
Crosscutting Concepts • Unit 4 CCCs focus on using Cause and Effect, Patterns, and Structure & Function to describe wave properties and to identify cause and effect relationships as they pertain to how the presence or absence of a medium influences wave behavior. In future high school learning experiences related to wave properties, students will use empirical evidence to differentiate between cause and correlation in wave properties and make claims about specific causes and effects (HS-PS4-1). **Disciplinary Core Ideas** • Unit 4 focuses extensively on understanding the properties and types of simple waves, the wave model of light, how the presence or absence of a medium influences their behavior, and how engineering design problems can be solved by determining success criteria and constraints related to wave properties. Students' learning and understanding increase in sophistication beyond grade 8. Students extend their knowledge to resonance in speech and music and how information can be digitized by combining waves of different frequencies thereby encoding and transmitting. The wave model introduced in this unit is useful for explaining many features of electromagnetic radiation in later grades. The criteria and constraints they specify in this unit are later quantified and applied to global challenges facing humanity for potential solutions. **Science and Engineering Practices** • Unit 4 SEPs focus predominantly on asking questions and defining problems, using mathematical and computational thinking, and developing and using models, but also include planning and carrying out investigations, analyzing and interpreting data, constructing explanations, and designing solutions. Students will again visit these practices in their future learning experiences by using mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations (HS-PS-4-1). They will also evaluate questions that challenge an argument's premise(s), the interpretation of a data set, or the suitability of a design (HS-PS4-2).

SIPS Grade 8 Unit 4 EOU Assessment Task 3: Sounds of Silence

Task 3 Prompt 1

Performance Category: Analyze Data to Explain the Relationships Between Properties of Waves and Energy

Acquisition Goals:

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

Prompt 1 measures students' ability to:

- Analyze and interpret models, data, and graphs to support conclusions about the relationship between energy and the displacement of waves.

Student Worksheet

This task is about sound waves.

Task

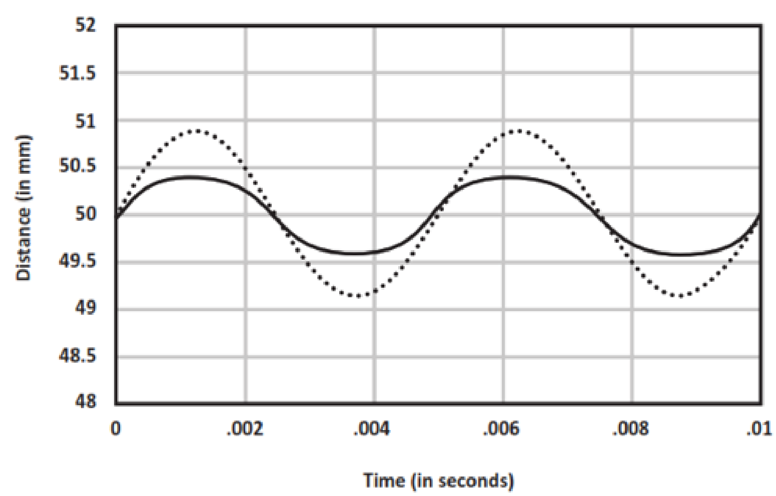
You are part of a team designing a recording studio for a local band. The design solution must demonstrate an understanding of the properties of sound waves. It must also consider materials, costs, and testing of the proposed solution.

Prompt 1

A guitarist controls the loudness of a single note on a guitar by changing the force used to pluck a string, causing it to vibrate.

Graph 1 shows a position versus time graph for a vibrating guitar string. The position of the sound wave is shown by the displacement distance from the resting position of the vibrating string.

Graph 1. Position vs. Time for a Vibrating Guitar String



Draw another sound wave on **Graph 1** to show **the same note** plucked **with less force.**

Task 3 Prompt 1 Complexity		
Degree and Nature of Sensemaking	**Moderate**	**This prompt…** • Requires integration of two dimensions in the service of sensemaking • Requires a combination of previously learned ideas or concepts and newly presented information
Complexity of the Presentation	**Moderate**	• The amount and type of information provided in the scenario supports multiple evident connections among ideas or concepts
Cognitive Demand of Response Development	**Moderate**	• Requires application of ideas and practices given cues and guidance • Requires drawing relationships and connecting ideas and practices
Cognitive Demand of Response Production	**Moderate**	• Responses include one or more sentences or a paragraph, a moderately complex graphic, or multiple steps in a simple or moderately complex process

Task 3 Prompt 1 Connections to the Instructional Framework	
Integration of Knowledge and Skills for Response Development	
• Students review the task background, which provides a description of what a recording studio is used for and the design problem of how to minimize unwanted noise in a local recording studio. • Students interpret and modify a position vs. time graph related to the sound waves produced by playing different music notes on a guitar, demonstrating their understanding of loudness and amplitude. • Students include a new sound wave with a decreased amplitude and a new sound wave with the same wavelength.	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 9-10 *Informal Assessment: All About Waves (A4)* • Students accurately describe how a simple mathematical wave model corresponds to the properties of a physical phenomenon. • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations.	**Segment 1, pp. 26-27** *What is a Wave? (A3, A4)* • 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 provides pairs or small groups of students with Slinkies to create longitudinal and transverse waves and observations which they record in their science notebooks.

Task 3 Prompt 1 Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 10-11 *Formal Assessment: What is a Wave? (A3, A4, A6)* • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations. • Students 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. • Students 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.	**Segment 1, p. 28** *Earthquakes: Waves of Danger (A6)* • 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 discusses why earthquakes are dangerous even when the epicenter is far away. **Segment 2, p. 29** *Chladni Plates (A6)* • Students watch a video of a Chladni plate in action then they share questions they have about the video. Students draw an annotated drawing of what they think is occurring with the plate and sound. **Segment 2, p. 29** *Experiencing Sound (A6)* • Students explore sound demonstrations/activities using a stations model. Students are provided enough time to visit each station and make and record observations in their scientific notebooks or by using handouts from the teacher.

Task 3 Prompt 1 Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 11-12 *Formal Assessment: Representing Wave Properties Mathematically (A4, A6)* • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations. • Students 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. • Students 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.	**Segment 2, p. 30** *How Does Sound Move? (A6)* • The teacher opens the class by asking students, "What does sound look like?" and watching a video. 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 the density change is moving. **Segment 2, p. 30** *How Do Chladni Plates Work? (A6)* • 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.

Task 3 Prompt 1 Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 2, p. 13 *Informal Assessment: Modeling Sound (A6)* • Students accurately model how sound waves transfer energy through a medium through oscillation of the particles. **Segment 2, pp. 13-14** *Formal Assessment: Modeling Sound in Action (A6)* • Students accurately model how sound waves transfer energy through a medium through oscillation of the particles. **Segment 2, pp. 14-15** *Formal Assessment: How Does Sound Move? (A6)* • Students use observations and/or data to generate a conclusion about the longitudinal nature of sound waves.	

Task 3 Prompt 2 – Parts A and B

Performance Category: Analyze Data to Explain the Relationships Between Properties of Waves and Energy

Acquisition Goals

- **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. *

Prompt 2 – Parts A and B measure the students' ability to:

- Analyze and interpret models, data, and graphs to support conclusions about the mathematical relationship between the amplitude of light and sound waves and energy.

Prompt 2

Part A.

You need to figure out how loud the guitar sounds from different locations in the recording studio. You collect measurements from different locations in the recording studio to know where to place a microphone when you are ready to record.

Graph 2 shows the data from your collected measurements.

Graph 2. Amount of Energy Transmitted vs. Amplitude

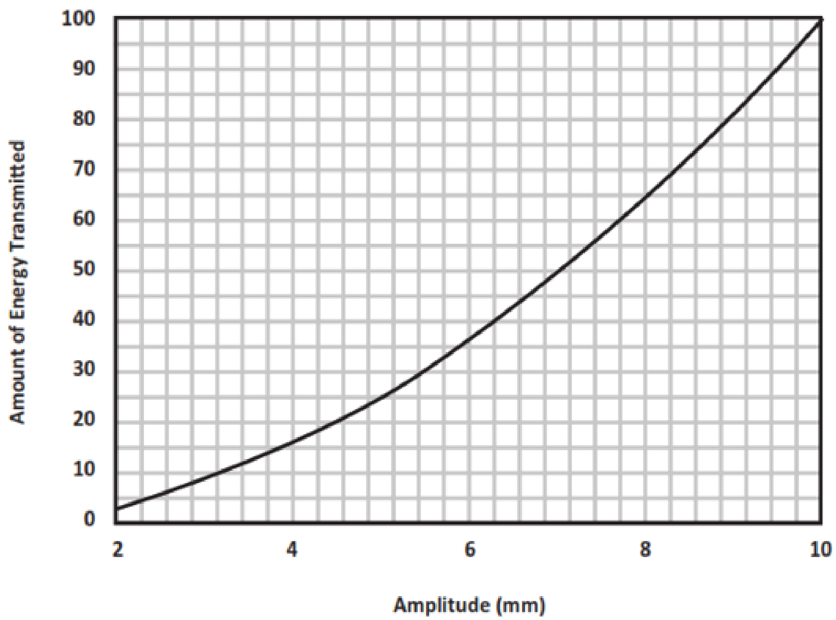


Table 1 shows some of the collected data.

Fill in the missing data points for **Locations B, D, and E** in **Table 1** using data from **Graph 2.**

Table 1. Amount of Energy Transmitted vs. the Amplitude

Location	Amplitude of Sound Wave (in mm)	Amount of Energy Transmitted (in energy units)
A	2	4
B	4	16
C	5	25
D	8	64
E	9	81
F	10	100

Part B.

Describe the relationship between the amount of energy and the amplitude of the sound produced by plucking the guitar string using information from **Graph 2** and **Table 1**.

The amount of energy carried by a wave is related to the amplitude of the wave. A high-energy wave is characterized by a high amplitude; a low-energy wave is characterized by a low amplitude.

Task 3 Prompt 2 Parts A and B Complexity		
Degree and Nature of Sensemaking	**Low**	**This prompt…** • Requires one or two dimensions • One dimension may have a greater degree of emphasis than another
Complexity of the Presentation	**Moderate**	• The amount and type of information provided in the scenario supports multiple evident connections among ideas or concepts • Provides graphics/data/models
Cognitive Demand of Response Development	**Moderate**	• Requires application of ideas and practices given cues and guidance • Requires drawing relationships and connecting ideas and practices
Cognitive Demand of Response Production	**Moderate**	• Responses include one or more sentences or a paragraph, a moderately complex graphic, or multiple steps in a simple or moderately complex process

Task 3 Prompt 2 Parts A and B Connections to the Instructional Framework	
Integration of Knowledge and Skills for Response Development	
• Students are asked to describe and mathematically support the relationship between a wave's energy and amplitude. • Students interpret the graph and use the mathematical relationship between amplitude and energy to complete a data table and describe the relationship between amplitude and energy (energy is proportional to the square of the amplitude).	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 9-10 *Informal Assessment: All About Waves (A4)* • Students accurately describe how a simple mathematical wave model corresponds to the properties of a physical phenomenon. • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations.	**Segment 1, pp. 26-27** *What is a Wave? (A3*, A4)* • 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 provides pairs or small groups of students with Slinkies to create longitudinal and transverse waves and observations which they record in their science notebooks.

Task 3 Prompt 2 Parts A and B Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 10-11 *Formal Assessment: What is a Wave? (A3*, A4, A6*)* • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations. • Students 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. **Segment 2, pp. 13-14** *Formal Assessment: Modeling Sound in Action (A6*)* • Students explain how sound transfers energy and causes a phenomenon, such as sand moving on Chladni plates. • Students present their models to the class in a multimodal presentation in a way that makes sense for them.	**Segment 2, p. 29** *Chladni Plates (A6*)* • Students make observations as they watch a video of a Chladni plate in action.

Task 3 Prompt 2 – Part C

Performance Category: Analyze Data to Explain the Relationships Between Properties of Waves and Energy

Acquisition Goals:

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

Prompt 2 Part C measures students' ability to:

- Analyze and interpret models, data, and graphs to support conclusions about the relationship between the pitch of a sound wave detectable by a human ear and its frequency.

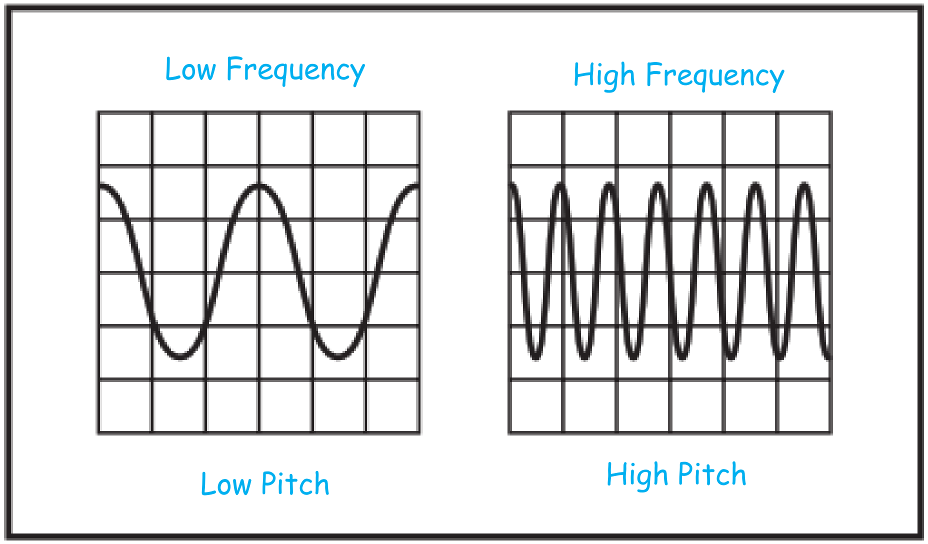
Part C.

A guitarist knows that the different strings on the guitar make different notes when they are plucked. The guitarist wonders how the movement of the string that produces a high-pitch note compares to the movement of the string that produces a low-pitch note.

Compare and explain the pattern of motion of two different strings after each is plucked with the same force. In your response, include a written description, model, **OR** graph to show your understanding.

When you pluck a string or anything that makes sound, it is going to vibrate. To make a low note you need to vibrate less than you would with a high-pitch note. So, a high-pitch string will vibrate more or have a higher frequency than a low-pitch string.

OR



Task 3 Prompt 2 Part C Complexity		
Degree and Nature of Sensemaking	**Moderate**	**This prompt…** • Requires integration of two dimensions in the service of sensemaking • Requires a combination of previously learned ideas or concepts and newly presented information
Complexity of the Presentation	**Low**	• The amount and type of information provided in the scenario supports limited simple connections among ideas or concepts • Provides few, simple graphics/data/models
Cognitive Demand of Response Development	**High**	• Requires selection and application of multiple complex ideas and practices
Cognitive Demand of Response Production	**High**	• Responses include multiple paragraphs, multiple graphics of at least moderate complexity, or multiple steps in a complex process

Task 3 Prompt 2 Part C Connections to the Instructional Framework	
Integration of Knowledge and Skills for Response Development	
• Students are asked to develop a model of a sound wave and/or mathematically support an explanation that relates to the concept that an increase in energy results in an increase in the amplitude of the wave. • Students provide a written description, model, or graph to show a comparison of a high-pitch note to a low-pitch note.	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 9-10 *Informal Assessment: All About Waves (A4)* • Students accurately describe how a simple mathematical wave model corresponds to the properties of a physical phenomenon. • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations.	**Segment 1, pp. 26-27** *What is a Wave? (A4)* • 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 provides pairs or small groups of students with Slinkies to create longitudinal and transverse waves and observations which they record in their science notebooks.

Task 3 Prompt 2 Part C Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 10-11 *Formal Assessment: What is a Wave? (A4, A6*)* • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations. • Students 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. • Students 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.	**Segment 1, pp. 27-28** *Wave Properties Investigation (A5)* • 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. • After collecting their data, students analyze the data to find the linear relationship between frequency and wavelength. Following their experiment and analysis, students write a conclusion based on their data.

Task 3 Prompt 2 Part C Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 1, pp. 11-12 *Formal Assessment: Representing Wave Properties Mathematically (A4, A5, A6*)* • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations. • Students 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. • Students 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.	**Segment 2, p. 29** *Experiencing Sound (A6*, A8)* • 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. **Segment 2, p. 30** *How Does Sound Move? (A6*, A8*)* • The teacher opens class by asking students, “What does sound look like?” and watch a video. 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.

Task 3 Prompt 2 Part C Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 2, p. 13 *Informal Assessment: Modeling Sound (A6*, A8*)* • 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 accurately describe how sound waves are pressure waves and can be either transverse or longitudinal. **Segment 2, pp. 13-14** *Formal Assessment: Modeling Sound in Action (A6*, A8*)* • Students 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.	**Segment 2, p. 31** *How Do Chladni Plates Work? (A6*, A8*)* • 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.

Task 3 Prompt 3 – Part A

Performance Category: Design the Best Solution to a Problem Involving Properties of Sound Waves and Materials

Acquisition Goals:

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

Prompt 3 Part A measures students' ability to:

- Design a solution to a problem involving sounds using properties of waves by describing the relationship among different materials and the transmission of sound waves.

Prompt 3

Part A.

You visit the room where you are asked to design a recording studio. There is an open window, and you hear the noise of cars passing by on the street. After you close the window, you notice the noise of the passing cars is quieter, but you can still hear cars' honking horns.

Explain why you can still hear outside noises even in a room that is surrounded by solid materials, such as walls and a closed window.

The sound coming from the road traffic goes through the solid materials. This is because sound energy can be transmitted through any type of matter. This is because sound needs a medium in order to be transmitted.

Task 3 Prompt 3 Part A Complexity		
Degree and Nature of Sensemaking	**Low**	**This prompt…** • Requires one or two dimensions • One dimension may have a greater degree of emphasis than another
Complexity of the Presentation	**Low**	• The amount and type of information provided in the scenario supports limited simple connections among ideas or concepts • Provides few, simple graphics/data/models
Cognitive Demand of Response Development	**Low**	• Requires well-defined set of actions or procedures • Requires a connection or retrieval of factual information
Cognitive Demand of Response Production	**Moderate**	• Responses include one or more sentences or a paragraph, a moderately complex graphic, or multiple steps in a simple or moderately complex process

Task 3 Prompt 3 Part A Connections to the Instructional Framework
Integration of Knowledge and Skills for Response Development
• Students are a given description of sources of unwanted noise in a recording studio and given a description of the setting. • Students explain why certain materials, such as sound absorbers, are good for certain functions. • Students construct an explanation using evidence from materials in the room and the surroundings to show that sound can travel through solid materials and that sound waves need a medium through which to travel.

Formative Assessments	Opportunities to Learn
Segment 1, pp. 9-10 *Informal Assessment: All About Waves (A2*)* • Students accurately describe how a simple mathematical wave model corresponds to the properties of a physical phenomenon. • Students accurately apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations.	**Segment 2, p. 30** *How Does Sound Move? (A10)* • The teacher opens the class by asking students, “What does sound look like?” and watching a video. • 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, that the air particles are staying near the same place, and that the density change is moving.

Task 3 Prompt 3 Part A Connections to the Instructional Framework, Continued	
Formative Assessments	**Opportunities to Learn**
Segment 2, p. 13 *Informal Assessment: Modeling Sound (A10)* • Students 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. **Segment 2, pp. 13-14** *Formal Assessment: Modeling Sound in Action (A10)* • Students 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. • Students identify information that explains how sound waves require the presence of a medium to travel. **Segment 2, pp. 14-15** *Formal Assessment: How Does Sound Move? (A10)* • Students identify information that explains how sound waves require the presence of a medium to travel.	**Segment 2, p. 30** *How Do Chladni Plates Work? (A10)* • 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.

Task 3 Prompt 3 – Parts B and C

Performance Category: Design the Best Solution to a Problem Involving Properties of Sound Waves and Materials

Acquisition Goals:

- **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.

Prompt 3 Parts B and C measure students' ability to:

- Design a solution to a problem involving sounds using properties of waves by identifying the aspects of a solution to a problem related to properties of sound waves and providing justification for the importance of considering each when developing the solution.

Part B.

Decibels (dB) measure the intensity or amplitude of sound. The decibel scale increases by ten as the sound gets louder. For example, a 60 dB sound, such as normal speech, is six powers 10 times (i.e., 1,000,000) more intense than a 1 dB sound, such as a faint whisper.

A recording studio should be very quiet, only as loud as 25 to 30 decibels, or as loud as a library. You can use a decibel meter to measure the noise in the room at different locations and times of day.

Table 2 provides a selection of noise reduction products, their costs, Noise Reduction Coefficients (NRC), and uses to consider for the design of the recording studio. The NRC rating is a scale from 0 to 1 that indicates the amount of noise a material can absorb with 1 being best.

Table 2. Noise Reduction Products

Product	Cost	Noise Reduction Coefficient (NRC)	Description
Product A	$2.50 per sq ft	0.90	• must be installed inside the walls • will require a lot of time and effort
Product B	$26.00 per sq ft	0.95	• easy to install on walls or ceilings • thick and heavy material
Product C	$11.00 per sq ft	0.40	• easy to install on walls or ceilings • light material, easily tears
Product D	$8.00 per sq ft	0.55	• ceiling or wall covering • strong material
Product E	$60.00 per pair	0.85	• acoustic curtains for windows • curtains must remain closed if studio is in use

Based on the **three** aspects of each of the noise reduction products (cost, NRC, and description), explain why you should evaluate **each** aspect when evaluating products to provide a very quiet environment inside the recording studio. Use the information about the different types of noise reduction products in **Table 2** to support your response.

1. The cost should be considered because I will probably have a limited budget and some products are much more expensive than others. Product B is very expensive compared to the others.
2. The NRC rating is also important because I want to ensure that I maximize the amount of noise the different products can provide as some products have higher ratings. Products A, B, and E are the best.
3. Descriptions of how easy the products are to work with, where to install, and how strong the materials are is important. Product A should go into walls but other products would require a lot less work and can be used right on the walls of the studio or on the windows like Product E.

Part C.

You need to develop a testing plan to evaluate the effectiveness of your proposed recording studio design regarding the noise levels in the room.

Explain where you would measure the intensity of sound in the studio and what scale you would use to test your proposed design.

It is important to use a decibel meter to record the noise levels in different parts of the room to be sure all the unwanted noise has been blocked appropriately. I would be sure to measure the sound levels by the window and use the decibel scale to check that it is between 25-30 dB.

Task 3 Prompt 3 Part B Complexity		
Degree and Nature of Sensemaking	**Moderate**	**This prompt…** • Requires integration of two dimensions in the service of sense-making • Requires integration of same or different combinations of dimensions as represented in the PE bundle
Complexity of the Presentation	**Moderate**	• The amount and type of information provided in the scenario supports multiple evident connections among ideas or concepts
Cognitive Demand of Response Development	**Moderate**	• Requires application of ideas and practices given cues and guidance • Requires drawing relationships and connecting ideas and practices
Cognitive Demand of Response Production	**Moderate**	• Responses include one or more sentences or a paragraph, a moderately complex graphic, or multiple steps in a simple or moderately complex process

Task 3 Prompt 3 Part C Complexity		
Degree and Nature of Sensemaking	**Moderate**	**This prompt…** • Requires integration of two dimensions in the service of sense-making • Requires integration of same or different combinations of dimensions as represented in the PE bundle
Complexity of the Presentation	**Low**	• The amount and type of information provided in the scenario supports limited simple connections among ideas or concepts
Cognitive Demand of Response Development	**High**	• Requires selection and application of multiple complex ideas and practices
Cognitive Demand of Response Production	**Moderate**	• Responses include one or more sentences or a paragraph, a moderately complex graphic, or multiple steps in a simple or moderately complex process

<table>
<tr><th colspan="2">Task 3 Prompt 3 Parts B and C
Connections to the Instructional Framework</th></tr>
<tr><td colspan="2">Integration of Knowledge and Skills for Response Development</td></tr>
<tr><td colspan="2">Part B
• Students are given a description of sources of unwanted noise in a recording studio given a description of the setting.
• Students use a list of products available to improve the recording studio to determine the constraints of a design problem (i.e., cost, materials, and noise reduction ratings).
Part C
• Students determine considerations for testing the solution.
• Students describe the need for multiple measurements/locations in the room, using a decibel meter to measure sound levels, and the required scale or dB range of sound.</td></tr>
<tr><td>Formative Assessments</td><td>Opportunities to Learn</td></tr>
<tr><td>Segment 4, pp. 18-19
Informal Assessment: Criteria and Constraints of a Design Solution (A17, A18*, A19* A20)
• Students identify the major components, including their relationships within the system and the system boundaries, in order to clarify the definition of the problem.
• Students explain how to complete a design specification in terms of all criteria, constraints, and the different conditions for its performance.</td><td>Segment 1, p. 28
Earthquakes: Waves of Danger (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 discusses why earthquakes are dangerous even when the epicenter is far away.</td></tr>
</table>

<table>
<tr><th colspan="2">Task 3 Prompt 3 Parts B and C
Connections to the Instructional Framework, Continued</th></tr>
<tr><th>Formative Assessments</th><th>Opportunities to Learn</th></tr>
<tr><td>Segment 4, pp. 20-21
Formal Assessment: Final Design Specification (A17, A18*, A19*, A20)
Students identify the major components, including their relationships within the system, and the system boundaries to clarify the problem's definition.
Students explain how to complete a design specification in terms of all criteria, constraints, and the different conditions for its performance.</td><td>Segment 4, pp. 34-35
Using Waves to Help People (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 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.
Segment 4, p. 36
Into The Shark Tank (A17, A18*, A19*, A20)
Students work in their groups to finalize their project with the goal of presenting their idea to a panel of expert “investors.”</td></tr>
</table>

Future Learning Connected to evidence elicited in Task 3
Crosscutting Concepts • Unit 4 CCCs focus on using Cause and Effect, Patterns, and Structure & Function to describe wave properties and to identify cause and effect relationships as they pertain to how the presence or absence of a medium influences wave behavior. In future high school learning experiences related to wave properties, students will use empirical evidence to differentiate between cause and correlation in wave properties and make claims about specific causes and effects (HS-PS4-1). **Disciplinary Core Ideas** • Unit 4 focuses extensively on understanding the properties and types of simple waves, the wave model of light, how the presence or absence of a medium influences their behavior, and how engineering design problems can be solved by determining success criteria and constraints related to wave properties. Students' learning and understanding increase in sophistication beyond grade 8, where they extend their knowledge to resonance in speech and music and how information can be digitized by combining waves of different frequencies, thereby encoding and transmitting. The wave model introduced in this unit is helpful in explaining many features of electromagnetic radiation in later grades. The criteria and constraints they specify in this unit are later quantified and applied to global challenges facing humanity for potential solutions. **Science and Engineering Practices** • Unit 4 SEPs focus predominantly on asking questions and defining problems, using mathematical and computational thinking, and developing and using models, but also include planning and carrying out investigations, analyzing and interpreting data, constructing explanations, and designing solutions. Students will again visit these practices in their future learning experiences by using mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations (HS-PS-4-1). They will also evaluate questions that challenge an argument's premise(s), the interpretation of a data set, or the suitability of a design (HS-PS4-2).