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

Grade 8 Unit 4: Providing Solutions to Problems Using Simple Wave Properties

Interpretive Guidance and Instructional Strategies for Educators

May 2025

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

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Purpose

The purpose of this document is to help educators understand their students' performance on the Grade 8 Unit 4 Science Assessment and to provide instructional strategies and resources for planning and adjusting instruction to help students learn, whether it involves reteaching previously addressed concepts and skills from the prior instructional unit or planning additional learning opportunities or interventions in the next unit.

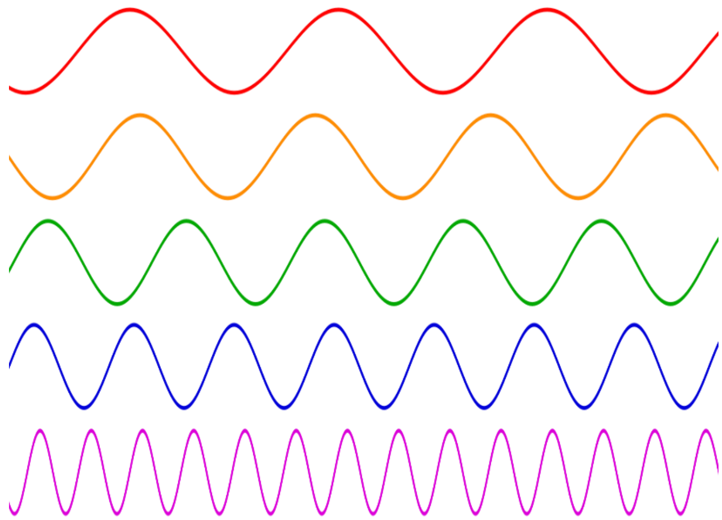

Image: Sine waves different frequences
Credit: LucasVB
Source: https://en.wikipedia.org/wiki/Sound#/media/File:Sine_waves_different_frequencies.svg
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Unit Overview

By engaging in this unit, students deepen their knowledge of properties and types of simple waves and provide design solutions to problems that involve these properties. Students ask questions and define problems, develop and use models, plan and carry out investigations, construct explanations and design solutions, and use mathematical and computational thinking to build an understanding of sound waves and how properties of matter affect light.

Instructions for Educators

1. Based on your analysis of student work from the assessment, in combination with additional assessment evidence gathered over the course of the instructional unit, consider themes or trends in your students' performance. Refer to your students' scores on the Classroom Roster Report to determine the degree to which students in your classroom require additional instructional support based on their instructional needs levels—red, yellow, or green—for each performance category.

2. For each performance category, use the provided interpretive guidance (i.e., *What These Results Mean*, *Next Instructional Steps*, and *Example Scored and Annotated Student Work* located in the Grade 8 Unit 4 EOU Assessment Scoring Guide) to understand what your students likely know and are able to do and to consider next instructional steps based on their instructional needs levels. Scored and annotated student work samples are provided for each performance category to demonstrate the evidence students might demonstrate in response to each prompt for each possible score point. The student responses represent the full range of score points possible for each prompt based on the scoring rubric.

3. For each performance category, use the *Instructional Strategies and Resources* organized by Universal Design for Learning (UDL) principle to support the design and delivery of accessible instruction and learning opportunities for all students based on their performance on the Grade 8 Unit 4 Assessment and their recommended instructional needs. These instructional recommendations can be selected and used to intentionally plan instruction and learning opportunities for students across the range of instructional needs levels (i.e., red, yellow, green).

Universal Design For Learning

The instructional strategies and resources provided in this document are organized by the Universal Design for Learning (UDL) principles. UDL is a framework to improve and optimize teaching and learning for all people based on scientific insights into how humans learn." (CAST, 2022). Taking time to reflect on prior instruction when planning for accessible, differentiated, and culturally responsive instruction for diverse learners and culturally diverse classrooms serves to identify ways to improve future instructional practices. The UDL Guidelines provide a framework for this reflection. The guidelines include three principles: Multiple Means of Engagement, Multiple Means of Representation, and Multiple Means of Action & Expression as ways to focus on variety and flexibility in instructional practices.

Multiple Means of Engagement	*The WHY of Learning* - provide options for recruiting student interest, sustaining effort, and promoting motivation.
Multiple Means of Representation	*The WHAT of Learning* - provide options for displaying information, including alternatives for auditory and visual information, use multi-media, clarify vocabulary and symbols, support comprehending text, and guide information processing and visualization.
Multiple Means of Action & Expression	*The HOW of Learning* – vary the methods for student responses and collection of evidence of their learning, optimize access to tools and technologies, use multiple tools for construction and composing responses, facilitate managing information and resources, and enhance student capacity for monitoring progress.

By examining instruction and instructional materials through the lens of each of these principles, we can identify and thus reduce or remove barriers to diverse learners to promote accessible and equitable teaching and learning opportunities. Application of UDL guidelines and principles allows all students to engage with and be provided with multiple means of representing instructional content and expressing what they know and can do, which is similarly the purpose of the use of accommodations for students receiving special education, students who have a 504 plan, and emerging Bilinguals.

Performance Category 1: Analyze Data to Explain the Relationships Between Properties of Waves and Energy

<table>
<tr><th colspan="3">Interpretive Guidance for Performance Category 1:
Analyze Data to Explain the Relationships Between Properties of Waves and Energy
Task 1, Prompt 2 (4 points); Task 3, Prompt 2, Parts A-B (2 points); Task 1, Prompt 3 (4 points); Task 3, Prompt 1 (2 points); Task 3, Prompt 2, Part C (2 points)</th></tr>
<tr><td>Red (0-4 score points earned)
➢ Extensive additional instruction and reteaching of these skills is recommended.
➢ The student needs significant opportunities to reinforce and apply these skills in future learning.</td><td>Yellow (5-10 score points earned)
➢ Moderate additional instruction on these skills is recommended.
➢ The student needs additional opportunities to strengthen these skills in future learning.</td><td>Green (11-14 score points earned)
➢ Minimal to no additional instruction on these skills is recommended.
➢ The student is ready to extend these skills in future learning.</td></tr>
<tr><th colspan="3">What These Results Mean</th></tr>
<tr><td>This student is likely able to:
• Attempt to plot and utilize data to develop an incomplete and/or inaccurate description of the relationship between the energy and amplitude of a wave.
• Use some data as evidence to support a partial conclusion about the relationship between energy and the amplitude of a sound wave.
• Complete a diagram with little or no accuracy to attempt to explain a phenomenon with insufficient evidence based on the relationship between frequency and wavelength of light.
• Partially complete a mathematical model/graph with multiple inaccuracies to represent relationships between amplitude,</td><td>This student is likely able to:
• Plot data with minor inaccuracies to develop a description of the relationship between the energy and amplitude of a wave.
• Attempt with minor errors to complete a data table to communicate information obtained from graphs to explain the relationship between energy and the amplitude of a sound wave.
• Attempt with minor errors to complete a diagram of forms of electromagnetic waves and/or use some relevant information to develop a partial explanation of a phenomenon based on the relationship between frequency and wavelength of light waves with minor errors.</td><td>This student is likely able to:
• Accurately plot and interpret data to identify and describe the relationship between the energy and amplitude of a light wave.
• Correctly complete a data table to develop complete and accurate explanations of the relationship between energy and the amplitude of a sound wave.
• Accurately complete a diagram comparing wave properties of visible light to other forms of electromagnetic waves and develop an accurate and complete explanation of a phenomenon based on the relationship between frequency and wavelength of light waves.</td></tr>
</table>

Interpretive Guidance for Performance Category 1: Analyze Data to Explain the Relationships Between Properties of Waves and Energy *Task 1, Prompt 2 (4 points); Task 3, Prompt 2, Parts A-B (2 points); Task 1, Prompt 3 (4 points); Task 3, Prompt 1 (2 points); Task 3, Prompt 2, Part C (2 points)*		
Red (0-4 score points earned) ➢ **Extensive** additional instruction and reteaching of these skills is recommended. ➢ The student needs significant opportunities to reinforce and apply these skills in future learning.	**Yellow (5-10 score points earned)** ➢ **Moderate** additional instruction on these skills is recommended. ➢ The student needs additional opportunities to strengthen these skills in future learning.	**Green (11-14 score points earned)** ➢ **Minimal to no** additional instruction on these skills is recommended. ➢ The student is ready to extend these skills in future learning.
wavelength, and energy transmitted by a sound wave in a given time. • Use **no or limited** evidence or information to **inaccurately** describe the relationship between pitch and frequency of sound waves.	• **Complete** a mathematical model with **few inaccuracies** to represent relationships between amplitude, wavelength, and energy transmitted by a sound wave in a given time. • Use **some relevant** evidence to **partially** communicate information related to the relationship between pitch and frequency of sound waves.	• **Accurately** complete a mathematical model with **no inaccuracies** to represent relationships between amplitude, wavelength, and energy transmitted by a sound wave in a given time. • **Completely and effectively** combine **and** communicate information related to the relationship between pitch and frequency of sound waves.

Interpretive Guidance for Performance Category 1: Analyze Data to Explain the Relationships Between Properties of Waves and Energy *Task 1, Prompt 2 (4 points); Task 3, Prompt 2, Parts A-B (2 points); Task 1, Prompt 3 (4 points); Task 3, Prompt 1 (2 points); Task 3, Prompt 2, Part C (2 points)*		
Red (0-4 score points earned) ➢ **Extensive** additional instruction and reteaching of these skills is recommended. ➢ The student needs significant opportunities to reinforce and apply these skills in future learning.	**Yellow (5-10 score points earned)** ➢ **Moderate** additional instruction on these skills is recommended. ➢ The student needs additional opportunities to strengthen these skills in future learning.	**Green (11-14 score points earned)** ➢ **Minimal to no** additional instruction on these skills is recommended. ➢ The student is ready to extend these skills in future learning.
Next Instructional Steps		
Provide opportunities for the student to: • Match various mathematical displays (line graphs, bar graphs, and/or diagrams) to provided data sets to identify and, with support, describe the relationships between frequency, wavelength, wave speed, and energy transmitted in a given time. • Match a provided labeled graph to given data points and/or plot a few data points on a line or bar graph on a provided labeled graph to show the relationship between the energy and amplitude of a wave. • With guided support, use both qualitative and quantitative information to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.	**Provide opportunities for the student to:** • Analyze provided data sets and various graphical displays related to a given phenomenon using written or oral procedural supports to describe patterns in data related to relationships between frequency, wavelength, wave speed, and energy transmitted over time. • Plot multiple data points on a line graph or bar graph to show the relationship between the energy and amplitude of a wave. • Identify and explain a mathematical representation of the relationship between pitch and frequency of sound waves. • Use mathematical representations as evidence to support scientific conclusions about how the amplitude of a wave is related to the energy in a wave.	**Provide opportunities for the student to:** • Use and/or create graphical displays (charts, graphs, and/or tables) of large data sets to describe multiple patterns related to relationships between frequency, wavelength, wave speed, and energy transmitted over time. • Research scientific scenarios to explain how evidence can or cannot support a conclusion about properties of sound and light waves. • Use a mathematical model to identify how the energy of a wave changes based on a change in another wave property and make predictions about the physical phenomenon.

Interpretive Guidance for Performance Category 1: Analyze Data to Explain the Relationships Between Properties of Waves and Energy *Task 1, Prompt 2 (4 points); Task 3, Prompt 2, Parts A-B (2 points); Task 1, Prompt 3 (4 points); Task 3, Prompt 1 (2 points); Task 3, Prompt 2, Part C (2 points)*		
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• Collaboratively discuss the mathematical relationships between wavelength, frequency, and wave speed.		

Interpretive Guidance for Performance Category 1:
Analyze Data to Explain the Relationships Between Properties of Waves and Energy

Task 1, Prompt 2 (4 points); Task 3, Prompt 2, Parts A & B (2 points); Task 1, Prompt 3 (4 points); Task 3, Prompt 1 (2 points); Task 3, Prompt 2, Part C (2 points)

Instructional Strategies and Resources

	Teaching Strategies	***Resources***
	Data Analysis through Discourse Provide varied opportunities (stations, small groups, partners, whole class) for students to engage in an interactive discourse. Students build on ideas to optimize using a range of tools for tabulation, graphical representation, visualization, and statistical analysis to analyze and interpret data. Opportunities for scientific discourse should be situated in authentic, interest-driven science investigations.	Use any resources about generating scientific discourse with any resources about wave properties to design a collaborative opportunity for students to engage with real data about waves and energy. ***Discussion Tools:*** • Talk Activities Flowchart – This flowchart can help structure activities so that students' talk is more equitable, scientific, and focused on sensemaking in support of a classroom culture based on curiosity and learning. [https://stemteachingtools.org/sp/talk-flowchart] • The Dialog Toolkit – This toolkit provides self-facilitated ways for students to engage with stimuli. Students can use the strategies listed to start engaging with the provided data. [https://pz.harvard.edu/sites/default/files/DigDil%20and%20OOEL%20Dialogue%20Toolkit.pdf] ***Data Sources:*** • The Science of Sound Waves – These videos and graphics may be used to explore types of waves and their various properties. Build conceptual understanding before diving into comparative data. [https://www3.nasa.gov/specials/Quesst/science-of-sound.html] • Science of Color – This NASA-provided lesson plan may be used to demonstrate how light is absorbed and reflected. As is, this

Interpretive Guidance for Performance Category 1: Analyze Data to Explain the Relationships Between Properties of Waves and Energy *Task 1, Prompt 2 (4 points); Task 3, Prompt 2, Parts A & B (2 points); Task 1, Prompt 3 (4 points); Task 3, Prompt 1 (2 points); Task 3, Prompt 2, Part C (2 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
		activity can be used as an extension for students scoring green and can easily be modified and scaffolded for students scoring yellow or red. [https://www.jpl.nasa.gov/edu/teach/activity/the-science-of-color/] • NASA Radiowave Data – This NASA data can be used to analyze how radiowaves are used in our solar system. [https://science.nasa.gov/ems/05_radiowaves/]
	Critiquing and Refining Data Interpretation Use spoken and written examples to model scientific interpretation of data, including significant features, observable patterns, and/or relationships between variables, by identifying strengths and weaknesses, such as sources of error.	• PhET Wave Intro Lab – This virtual lab allows students to learn multidimensionally using a digital media resource. In this lab, students will observe models of waves with water, sound, and light to explain relationships among wavelength, frequency, and amplitude. Students will identify and describe how changing frequency and amplitude affect the characteristics of a wave by designing an experiment to measure the speed of the wave. [https://phet.colorado.edu/en/simulations/waves-intro] • PhET Sound Wave Simulation – This simulation encourages students to design ways to determine the speed, frequency, period, and wavelength of sound waves by using models. They will analyze the different sounds and how they are modeled, described, and produced. [https://phet.colorado.edu/en/simulations/sound-waves] • PhET Wave Interference Lab – This lab experience involves students making waves with water, sound, and light and designing an experiment to measure the speed of the wave.

Interpretive Guidance for Performance Category 1: Analyze Data to Explain the Relationships Between Properties of Waves and Energy *Task 1, Prompt 2 (4 points); Task 3, Prompt 2, Parts A & B (2 points); Task 1, Prompt 3 (4 points); Task 3, Prompt 1 (2 points); Task 3, Prompt 2, Part C (2 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
		Students must create an interference pattern and find constructive and destructive interference points. This is a great extension for students whose scores place them in the green band. [https://phet.colorado.edu/en/simulations/wave-interference]
	Determining Relevant Data Needed for Particular Conclusions Foster data interpretation and inform inferences by highlighting the utility and relevance of learning and demonstrating that relevance through authentic, meaningful activities.	Use any resources about determining relevant data with any resources about wave properties to design a collaborative opportunity for students to engage in real data about waves and energy. ***Determining Relevance of Evidence*** • Moving with Data – This website allows students to work together to create live data visualizations of a dataset about Marvel movies. The data allows students to organize numeric and categorical data sets using bar graphs, histograms, and scatter plots. [https://www.youcubed.org/tasks/moving-with-data/] • Interpreting Data and Looking for Relationships – This video [6:09] shows a high school teacher engaging students in multidimensional learning using a digital media resource for ideas about engaging students in interpreting data representation and building consensus. The teacher models scientific interpretation and allows students to look for and explain the patterns.

Interpretive Guidance for Performance Category 1: Analyze Data to Explain the Relationships Between Properties of Waves and Energy *Task 1, Prompt 2 (4 points); Task 3, Prompt 2, Parts A & B (2 points); Task 1, Prompt 3 (4 points); Task 3, Prompt 1 (2 points); Task 3, Prompt 2, Part C (2 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
		[https://aptv.pbslearningmedia.org/resource/buac21-pd-sci-tommy/in-the-science-classroom-interpreting-data-and-looking-for-patterns/] ***Data Sources*** • Visible Light – This NASA website can be used to inspire students to look at visible light in a new way. Look at data and graphs about real-world phenomena such as the solar eclipse, temperature of stars, and wavelengths of different Earth features (e.g., soil, water, vegetation). [https://science.nasa.gov/ems/09_visiblelight/] • Visualization of Energy – This NASA website can be used to engage students in how photographs capture energy from light waves and how we visualize light we can't see. This would encourage extension or remediation of how energy and light are related. [https://science.nasa.gov/ems/04_energytoimage/] • How are sounds viewed and analyzed? – This website by *Discovery of Sound in the Sea* may be used to investigate sound waves and how data is collected and analyzed. Throughout this website, visualizations are used to help describe sound. [https://dosits.org/science/measurement/how-are-sounds-viewed-and-analyzed/]

Interpretive Guidance for Performance Category 1:
Analyze Data to Explain the Relationships Between Properties of Waves and Energy

Task 1, Prompt 2 (4 points); Task 3, Prompt 2, Parts A & B (2 points); Task 1, Prompt 3 (4 points); Task 3, Prompt 1 (2 points); Task 3, Prompt 2, Part C (2 points)

Instructional Strategies and Resources

	Teaching Strategies	***Resources***
	Promoting Engagement through Interactive, Collaborative Games Use interactive games and collaborative formats to reinforce disciplinary core ideas, demonstrating the different types of waves and their properties.	• The Yard Game - Waves – This interactive game allows students to manipulate the shapes of waves to understand their properties better and presents challenges as they master content. [https://theyardgames.org/game/waves.html] • The Simple Wave Simulator Interactive – This simulator provides the learner with a virtual wave machine for exploring the nature of a wave, quantitative relationships between wavelength, frequency, and speed, and comparisons between transverse waves, such as those traveling through a rope, and longitudinal waves, such as sound. [https://www.physicsclassroom.com/Physics-Interactives/Waves-and-Sound/Simple-Wave-Simulator] • Human Eye Optics – This interactive simulation allows students to investigate how humans interact with objects and light. It also shows how the optics change when a person has vision loss. [https://ophysics.com/l16.html] (Additional information about how lenses create images and a laboratory activity involving light rays is here.) [https://knowledge.carolina.com/discipline/life-science/anatomy-and-physiology/optics-of-the-human-eye/] • Wave Interactive – This simulation allows students to use the sliders to adjust the wave speed, amplitude, and wavelength of each wave. Step through the animation with the step animation

Interpretive Guidance for Performance Category 1: Analyze Data to Explain the Relationships Between Properties of Waves and Energy *Task 1, Prompt 2 (4 points); Task 3, Prompt 2, Parts A & B (2 points); Task 1, Prompt 3 (4 points); Task 3, Prompt 1 (2 points); Task 3, Prompt 2, Part C (2 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
		button or press the animation button in the lower left corner to run the animation. [https://ophysics.com/w3.html]

Performance Category 2: Use Models to Describe Interactions Between Light Waves and Materials

<table>
<tr><th colspan="3">Interpretive Guidance for Performance Category 2:
Use Models to Describe Interactions Between Light Waves and Materials
Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)</th></tr>
<tr><td>Red (0-6 score points earned)
➢ Extensive additional instruction and reteaching of these skills is recommended.
➢ The student needs significant opportunities to reinforce and apply these skills in future learning.</td><td>Yellow (7-11 score points earned)
➢ Moderate additional instruction on these skills is recommended.
➢ The student needs additional opportunities to strengthen these skills in future learning.</td><td>Green (12-15 score points earned)
➢ Minimal to no additional instruction on these skills is recommended.
➢ The student is ready to extend these skills in future learning.</td></tr>
<tr><th colspan="3">What These Results Mean</th></tr>
<tr><td>This student is likely able to:
• Use a model to develop an incomplete explanation of the pathway of light as it travels through air.
• Inaccurately describe which properties of a light wave change and which do not after passing from an original medium to a second medium.
• Develop an incomplete model showing the pathway of light passing from an original medium (air) to a second medium (water) and then back, including an inaccurate location of a visible object under the water.
• Present a limited or inaccurate description of the interactions contributing to the pathway of light and the actual location of an object underwater as seen from the</td><td>This student is likely able to:
• Use a model to accurately identify or explain the pathway of light as it travels in air using the law of reflection.
• Accurately describe which properties of a light wave change or which do not after passing from an original medium to a second medium.
• Develop a mostly complete and accurate model showing the pathway of light passing from an original medium (air) to a second medium (water) and then back, showing both transitions (from m_1 to m_2 and from m_2 back to m_1) and including an approximate location of a visible object under the water.
• Use a model to identify interactions</td><td>This student is likely able to:
• Use a model to accurately identify and explain the pathway of light as it travels in air using the law of reflection.
• Accurately describe which properties of a light wave change and which do not after passing from an original medium to a second medium.
• Develop and complete an accurate model showing the pathway of light passing from an original medium (air) to a second medium (water) and then back, showing both transitions (from m_1 to m_2 and from m_2 back to m_1) and including the accurate location of a visible object under the water.
• Use a model to correctly identify and describe interactions contributing to an</td></tr>
</table>

Interpretive Guidance for Performance Category 2: Use Models to Describe Interactions Between Light Waves and Materials *Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)*		
Red (0-6 score points earned) ➢ **Extensive** additional instruction and reteaching of these skills is recommended. ➢ The student needs significant opportunities to reinforce and apply these skills in future learning.	**Yellow (7-11 score points earned)** ➢ **Moderate** additional instruction on these skills is recommended. ➢ The student needs additional opportunities to strengthen these skills in future learning.	**Green (12-15 score points earned)** ➢ **Minimal to no** additional instruction on these skills is recommended. ➢ The student is ready to extend these skills in future learning.
surface. • Use a prism as a model to **present a limited or inaccurate description** of the color and the frequency-dependent bending of light at a surface between media. • Present a **limited or inaccurate** description of how the sequence of colors in a rainbow is formed.	contributing to an event (e.g., the relationship between the density of the medium and its effect on the speed light travels). • Use a prism as a model to **accurately describe the** color and the frequency-dependent bending of light at a surface between media. • **Correctly** apply relationships between **at least two** wave properties (e.g., wavelength, frequency, amplitude, color, etc.) to support a description related to the predictable sequence of colors in a rainbow.	event (e.g., the relationship between the density of the medium and its effect on the speed light travels). • Use a prism as a model to develop a **convincing and valid description of how** color and the frequency-dependent bending of light at a surface between media can be used to explain wave behavior. • **Correctly and accurately** apply relationships among **multiple** wave properties (e.g., wavelength, frequency, amplitude, color, etc.) to support a description of the predictable sequence of colors in a rainbow.

Interpretive Guidance for Performance Category 2: Use Models to Describe Interactions Between Light Waves and Materials *Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)*		
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Next Instructional Steps		
Provide opportunities for the student to: • Identify frequency, wavelength, and amplitude in a simple wave model. • Identify and/or sort components of a provided model of a wave passing from an original medium to a second medium. • Match provided definitions to scientific vocabulary related to how waves can interact with material (reflection, absorption, and transmission). • Select an accurate description of how waves can interact with material (reflection, absorption, and transmission). • With guidance and support, develop and use models to demonstrate that waves are reflected, absorbed, or transmitted through various materials.	**Provide opportunities for the student to:** • Develop a model to describe how light shines on an object and is reflected, absorbed, or transmitted through it, depending on the object's material and the frequency (color) of the light. • Complete a partial model to support an explanation of a wave-related phenomenon. • Observe the interactions of light waves with different transparent materials using a penlight and tracing the path that light travels (e.g., air and water, air and glass) or by shining a light through a prism onto a screen or piece of paper.	**Provide opportunities for the student to:** • Use models of wave behavior to demonstrate that waves are reflected, absorbed, or transmitted through various materials. • Use a wave model of light for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. • Use a model of the electromagnetic spectrum to make connections between the brightness and color of light and the frequency of the light.

Interpretive Guidance for Performance Category 2: Use Models to Describe Interactions Between Light Waves and Materials *Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)*		
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• With support, use a model of the electromagnetic spectrum to make connections between the brightness and color of light and the frequency of the light.		

Interpretive Guidance for Performance Category 2:
Use Models to Describe Interactions Between Light Waves and Materials

Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)

Instructional Strategies and Resources

	Teaching Strategies	***Resources***
	Data Analysis through Discourse Provide varied opportunities (stations, small groups, partners, whole class) for students to engage in an interactive discourse where they build on ideas to optimize the use of a range of tools for tabulation, graphical representation, visualization, and statistical analysis to analyze and interpret data. Opportunities for scientific discourse should be situated in authentic, interest-driven science investigations.	Use any resources about generating scientific discourse with any of the resources about changes in traits over time to design a collaborative opportunity for students to engage with real data about changing populations. ***Discussion Tools:*** • The Dialog Toolkit – This toolkit provides self-facilitated ways for students to engage with stimuli. Students can use the strategies listed to start engaging with provided data. [https://pz.harvard.edu/sites/default/files/DigDil%20and%20OOEL%20Dialogue%20Toolkit.pdf] ***Data Sources:*** • The Evolution of Kangaroos – PBS's video [3:43] presents information for students to discuss. The data is being used to explain the evolution of kangaroos in Australia. [https://wyoming.pbslearningmedia.org/resource/nvaus.sci.bio.kangaroos/the-evolution-of-kangaroos/] • Genetic Drift Lab – This lesson includes a *Genetic Drift* portion for students to complete. Ask students to explain how future populations would differ from the original if their small group of six candies were cut off from the rest of the population. [https://teaching.betterlesson.com/lesson/637446/genetic-drift-lab?from=mtp_lesson]

Interpretive Guidance for Performance Category 2: Use Models to Describe Interactions Between Light Waves and Materials *Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
	Modeling through Discourse Provide varied opportunities (stations, small groups, partners, whole class) for students to engage in interactive discourse. Students build on others' ideas to optimize the use of a range of models to understand light waves and how they interact with materials. Opportunities for scientific discourse should be situated in authentic, interest-driven science investigations.	• Promoting Discourse in Science Class – This article by *Carolina Knowledge Center* explains the difference between discourse and science discourse. It supports teachers in moving away from focusing on correct answers and toward the use of supporting evidence. [https://knowledge.carolina.com/professional-growth/promoting-discourse-in-science-class/] • How Can I Get My Students to Learn Science by Productively Talking With Each Other? – This one-page article can help teachers support their students' sense-making through talk. It includes links to various STEM teaching tools. [https://stemteachingtools.org/assets/landscapes/STEM-Teaching-Tool-6-ProductiveScienceTalk.pdf]
	Foster Collaboration and Community When Modeling Provide opportunities for students to work effectively with peers when collaborating to model interactions between light waves and materials. Provide a range of ways for students to engage in collaborative learning experiences (e.g., think-pair-share, jigsaw, round robin) with diverse groupings of students.	• What is Interactive Modeling? – This article by *Responsive Classroom* guides effectively using interactive modeling to actively engage students in their learning and better understand what is expected of them when carrying out procedures or routines or when engaged in collaborative learning. [https://www.responsiveclassroom.org/what-interactive-modeling/] • Teaching Kids to Give and Receive Quality Peer Feedback – This article by *Edutopia* supports teachers in developing a classroom culture with kind, helpful, and specific peer feedback at the

Interpretive Guidance for Performance Category 2: Use Models to Describe Interactions Between Light Waves and Materials *Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
		center, another important norm for building toward non-teacher-centric learning. [https://www.edutopia.org/article/teaching-kids-give-and-receive-quality-peer-feedback/] • How to Use Cooperative Learning – This practice brief by *Pedagogy in Action* provides a general instructional flow for classroom collaboration with low, medium, and high time commitment modifications. [https://serc.carleton.edu/sp/library/cooperative/howto.html] • Assessing by Group Work – This practice brief by *UNSW Sydney* provides insight into when to assess student learning using group work tasks and its benefits and challenges, as well as provides implementation strategies. [https://www.teaching.unsw.edu.au/assessing-group-work] • Exploring Light – This site includes a hands-on activity in which students explore light’s absorption properties, reflection, transmission, and refraction properties. The activity includes assessments, extensions, a vocabulary list, and scaling ideas for lower and upper-grade learners. [https://www.teachengineering.org/activities/view/van_troll_lesson02_activity1]

Interpretive Guidance for Performance Category 2: Use Models to Describe Interactions Between Light Waves and Materials *Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
	Modeling and Critiquing Scientific Models Use spoken and written examples to model how to evaluate and refine models by comparing predictions with the real world. Encourage students to adjust and refine the model by identifying its strengths and weaknesses to describe the interactions between light waves and materials.	• 3-D Model of an Electromagnetic Wave – Students can use this interactive 3-D model to compare to static mechanical wave models and/or critique. [https://sketchfab.com/3d-models/an-electromagnetic-wave-a7e7f0e0b22d4828bbadf3717541d7d2] • How to Reflect on Your Use of Models – This article by *RSC Education* suggests using the FAR (Focus, Action, and Reflection) approach to help students evaluate models in the classroom. This method promotes students' *understanding* of models. Once students understand why models are necessary, they can develop the skills to critique them. [https://edu.rsc.org/feature/reflect-on-your-use-of-models/3010509.article] • Models: Bringing Real-World Phenomena to School – This article demonstrates how teachers can use real-world phenomena to highlight the importance and limits of scientific models. [https://smithsonianstc.com/models-bringing-real-world-phenomena-to-school-whitepaper/] • Models, Critique, and Descriptive Feedback – This website by *PBLife* offers ideas for examining models that make standards real and tangible and building a culture that teaches students the value of critique and constant improvement.

Interpretive Guidance for Performance Category 2: **Use Models to Describe Interactions Between Light Waves and Materials** *Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
		[https://pblife.edublogs.org/2016/03/20/68-models-critique-descriptive-feedback/] • How to Make a Good Scientific Model – This brief article by the *Carolina Knowledge Center* offers a simple way to begin critiquing student models. It includes a “Good Model” checklist. [https://knowledge.carolina.com/professional-growth/ngss/developing-and-using-models/] • Modeling in Science Instruction – This NSTA article provides feedback stems for models when critiquing students’ work. It also provides guidance about the revision process and examples of how the teacher uses models during her unit of instruction. [https://www.nsta.org/blog/modeling-science-instruction]
	Promoting Engagement through Interactive, Collaborative Games Use interactive games and collaborative formats to reinforce disciplinary core ideas to support descriptions of the interactions between light waves and materials.	• Rainbow Mechanic – This challenging game by *Wow Science* allows students to use the Law of Reflection to move a light beam around barriers to a prism. [https://www.coolmathgames.com/0-rainbow-mechanic] • Light Waves: Let There Be Light – This interactive lesson by *PBS Learning Media* has 11 instructional pages, including interactive reviews. Page 2 includes brief videos of each vocabulary word related to light waves. [https://aptv.pbslearningmedia.org/resource/iluntv18-sci-illightwaves/light-waves-interactive-lesson-unc-tv-science/]

Interpretive Guidance for Performance Category 2:
Use Models to Describe Interactions Between Light Waves and Materials

Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)

Instructional Strategies and Resources

	Teaching Strategies	***Resources***
		• Electromagnetic Waves Questions – These interactive quizzes by *Footprints Science* score immediately, allowing students to repeat and improve their time. [https://www.footprints-science.co.uk/index.php?quiz=Electromagnetic_waves]
	Scaffolds, Feedback, and Strategies to Assist Learners Making Models Students understand modeling and how to model, a meta-cognitive processing activity that requires them to predict and depict information they have never seen. Use scaffolds and feedback to teach this meta-cognitive process. • Provide scaffolds and guidance to “chunk” information about how to model. • Give prompts for organization methods and feedback that support information processing in models. • Provide strategies for multiple entry points to modeling with optional pathways to explore how to express their conceptual understandings.	• It’s Not All Visible – This 5-E Lesson Plan includes a *Spectrum Model Rubric* on Page 10. The lesson also includes a card sort and assessment. [https://science4inquiry.com/LessonPlans/EarthScience/Electromagnetic/ElectromagneticLesson.pdf] • Wavelength Calculator – This online calculator can be used when assigning individual students or groups a specific wavelength of light to model. Students can draw and label the wave and explain the relationships between variables and/or research uses of the specific wavelength of light. This activity can be used as an extension for students scoring green and can be modified and scaffolded for students scoring yellow or red. [https://www.omnicalculator.com/physics/wavelength#main-properties-of-waves] • Differentiated Feedback – This article offers tips for providing differentiated feedback when formatively assessing, which can be a tool for developing fluencies such as scientific modeling. [https://assessmarter.weebly.com/differentiated-feedback.html]

Interpretive Guidance for Performance Category 2: Use Models to Describe Interactions Between Light Waves and Materials *Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
		• Engaging Students in Scientific Practices: What does constructing and revising models look like in the science classroom? – This article provides an in-depth look at the scientific practice of developing, evaluating, and revising scientific models to explain and predict phenomena and what that means for classroom teaching. More importantly, it breaks down the steps in teaching modeling to "chunk" relevant parts of a model to help students depict what they imagine about things we cannot see. [https://static.nsta.org/ngss/resources/201203_Framework-KrajcikAndMerritt.pdf] • Developing and Using Models – This video [8:21] explains the importance of modeling in science and engineering to explain phenomena. Students will be able to understand different models and what they are used for, which will assist them in choosing the right type of model. [https://www.bozemanscience.com/ngs-developing-using-models] • What is Meant by Engaging Youth in Scientific Modeling? – This STEM teaching tool explains how helping students develop and test models supports their learning and helps them understand important aspects of science and engineering. [https://stemteachingtools.org/brief/8]

Interpretive Guidance for Performance Category 2:
Use Models to Describe Interactions Between Light Waves and Materials

Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)

Instructional Strategies and Resources

	Teaching Strategies	***Resources***
	Presenting Information in Different Modalities Provide information using a variety of multimedia (e.g., videos, interactives, simulations), informational texts, and formats to teach and reinforce disciplinary core ideas related to a scientific phenomenon involving the interactions between light waves and materials.	• The Electromagnetic Spectrum – This webpage comprehensively explains the electromagnetic spectrum, including examples and models of each type of electromagnetic radiation. [http://science8sc.weebly.com/the-electromagnetic-spectrum.html] • Light Waves, Visible and Invisible – This animated video [5:57] by *TedEd* explains why the human eye sees certain wavelengths of light, how we can detect the wavelengths that we cannot see, and how light is important to studying the rest of the universe. [https://www.youtube.com/watch?v=O0PawPSdk28] • The Electromagnetic Spectrum – This dynamic infographic by WBGH Digital has three pages. The *Introduction* includes a student-friendly video [5:03] about the topic. *Everyday Impacts* allows students to interact with the types of radiation. The third page explains the *Astronomical Uses* of the types of radiation. [https://dynamicinfographic.wgbhdigital.org/en/instances/the-electromagnetic-spectrum/] • Stations of Light – These hands-on activities by *Teach Engineering* are designed to be set up in four stations. Each activity has a corresponding worksheet. Includes a brief video demonstration of each [2:40], recommendations for assessment, extension, and scaling.

Interpretive Guidance for Performance Category 2: Use Models to Describe Interactions Between Light Waves and Materials

Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)

Instructional Strategies and Resources

	Teaching Strategies	***Resources***
		[https://www.teachengineering.org/activities/view/cub_energy2_lesson03_activity1] • Tour of the EMS 05 - Visible Light Waves – This *NASA* video [4:49] thoroughly explains light waves with interesting examples and models. [https://www.youtube.com/watch?v=PMtC34pzKGc&t=10s]
	Maximizing Transfer of Information Provide information that guides learners and supports generalization and knowledge transfer by employing explicit strategies such as accessing prior knowledge, embedding in familiar contexts, using mnemonic devices, applying to new situations, and using graphic organizers.	• EM Spectrum, Chart, Uses, and Dangers – This webpage by *Storyboard That* provides a visual organizer, a mnemonic device, and a storyboarding assignment to aid students in transferring knowledge about the electromagnetic spectrum. [https://www.storyboardthat.com/lesson-plans/electromagnetic-spectrum/properties] • Activating Prior Knowledge – This website provides ideas and strategies for activating students' thinking about their prior knowledge about a topic before engaging in a conceptual model. [https://teaching.vt.edu/teachingresources/adjustinginstruction/priorknowledge.html] • 10 Strategies and Tools to Activate Knowledge – This article by *The Teaching Factor* offers ten strategies and modalities for accessing students' prior knowledge. [https://theteachingfactor.wordpress.com/2021/08/24/10-strategies-and-tools-to-activate-knowledge/]

Interpretive Guidance for Performance Category 2: Use Models to Describe Interactions Between Light Waves and Materials *Task 1, Prompt 1 (2 points); Task 2, Prompt 1, Part A (2 points); Task 2, Prompt 1, Part B (3 points); Task 2, Prompt 1, Part C (2 points); Task 2, Prompt 2, Part A (3 points); Task 2, Prompt 2, Part B (3 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
		• Learning by Inquiry – This website offers methods to activate prior knowledge using a constructivist mindset to help learners integrate new information. [https://www.learningbyinquiry.com/simple-strategies-to-activate-students-prior-knowledge/] • Increasing the Value of Graphic Organizers – This *Edutopia* article explains the importance of allowing students to take ownership of learning by creating their graphic organizers. [https://www.edutopia.org/article/increasing-value-graphic-organizers/]

Performance Category 3: Design the Best Solution to a Problem Involving Properties of Sound Waves and Materials

Interpretive Guidance for Performance Category 3: Design the Best Solution to a Problem Involving Properties of Sound Waves and Materials *Task 3, Prompt 3, Part A (2 points); Task 3, Prompt 3 Part B (3 points); Task 3, Prompt 3, Part C (3 points)*		
Red (0-3 score points earned) ➢ **Extensive** additional instruction and reteaching of these skills is recommended. ➢ The student needs significant opportunities to reinforce and apply these skills in future learning.	**Yellow (4-5 score points earned)** ➢ **Moderate** additional instruction on these skills is recommended. ➢ The student needs additional opportunities to strengthen these skills in future learning.	**Green (6-8 score points earned)** ➢ **Minimal to no** additional instruction on these skills is recommended. ➢ The student is ready to extend these skills in future learning.
What These Results Mean		
This student is likely able to: • **Use insufficient information to** evaluate the aspects of a design problem involving sound waves, supported by limited or unrelated evidence regarding the behavior of sound waves with different media. • Address **one or no** aspects of a design solution with **little to no relevance** to properties of sound waves**.** • **Attempt** to describe a method **or** data needed to test the functioning of a design solution with **limited connection** to relevant criteria or constraints of the problem.	**This student is likely able to:** • Evaluate **and** articulate the **aspects** of a design solution with minor errors or omissions involving sound waves by **clearly** describing their behavior with different media and the impact on the sound. • **Accurately** describe **at least two** aspects of a solution **and** provide **information** to support the importance of considering each when developing a design solution related to properties of sound waves. • Describe an **appropriate** method for testing a design solution and the **necessary** data to draw conclusions about its functioning.	**This student is likely able to:** • **Accurately** evaluate and **clearly** articulate the **components and interactions** that result in a design problem involving sound waves by effectively describing their behavior with different media and the impact on sound. • **Accurately** describe **three** aspects of a solution **and** provide **relevant** information to justify the importance of considering each when developing a design solution related to properties of sound waves. • Describe an **appropriate and systematic** method for testing the functioning of a proposed solution and accurately describe the expected patterns or trends in data that reflect a successful solution.

Interpretive Guidance for Performance Category 3: Design the Best Solution to a Problem Involving Properties of Sound Waves and Materials *Task 3, Prompt 3, Part A (2 points); Task 3, Prompt 3 Part B (3 points); Task 3, Prompt 3, Part C (3 points)*		
Red (0-3 score points earned) ➢ **Extensive** additional instruction and reteaching of these skills is recommended. ➢ The student needs significant opportunities to reinforce and apply these skills in future learning.	**Yellow (4-5 score points earned)** ➢ **Moderate** additional instruction on these skills is recommended. ➢ The student needs additional opportunities to strengthen these skills in future learning.	**Green (6-8 score points earned)** ➢ **Minimal to no** additional instruction on these skills is recommended. ➢ The student is ready to extend these skills in future learning.
Next Instructional Steps		
Provide opportunities for the student to: • Collaboratively match potential design solutions to meet design requirements. • Identify from provided evidence a possible solution for a given design requirement. • Given a design solution, identify design requirements not met by the solution from a provided list. • From a list, discuss and identify a correct explanation of a phenomenon using the relationship between the amplitude of a light or sound wave and the wave's energy and/or that waves are reflected, absorbed, or transmitted through various materials. • From a list, identify the correct explanation of a phenomenon using properties of waves.	**Provide opportunities for the student to:** • From a list of potential design solutions, identify the most effective design using data provided in a table to justify the selection. • From a list of data with varying degrees of relevance, identify the most relevant pieces of data to support selecting one design solution over another for a given design requirement. • Collaboratively construct an explanation of a phenomenon using the relationships between the amplitude of all waves and the wave's energy and that waves are reflected, absorbed, or transmitted through various materials by filling in the blanks of an explanation using a word bank.	**Provide opportunities for the student to:** • Evaluate the strengths and limitations of a design solution across each design requirement. • Utilize evidence from a table, as well as the relationship among different materials and the transmission of sound waves, in the evaluation for multiple design requirements. • Design a procedure to determine the effectiveness of a design solution, including the type of data needed to evaluate the design's strengths and limitations. Connect the methodology to the relationship between energy, sound, the types of media that sound passes through, and how these different media impact the sound.

Instructional Strategies and Resources for Performance Category 3: Design the Best Solution to a Problem Involving Properties of Sound Waves and Materials

Task 3, Prompt 3, Part A (2 points); Task 3, Prompt 3 Part B (3 points); Task 3, Prompt 3, Part C (3 points)

Instructional Strategies and Resources

	Teaching Strategies	***Resources***
	Optimize Individual Choice and Autonomy Offer learners choices to develop self-determination and pride in accomplishment and increase the degree to which they feel connected to their learning. Engineering design/problem-solving provides many opportunities for student choice and autonomy.	• Student Autonomy and Empowerment – This article describes how empowering students results in increased engagement and connectedness. It provides skills and example strategies. [https://www.cdc.gov/classroom-management/approaches/student-autonomy-empowerment.html] • Science Digital Choice Menus – This article from Science Penguin offers ideas for choices that students could pick from to revisit sound topics for remediation and/or extension. [https://thesciencepenguin.com/2023/04/science-digital-choice-menus.html]
	Optimize Relevance, Value, and Authenticity Foster a culturally relevant and responsive community, drawing from and respecting students' cultural resources, backgrounds, and personal experiences to promote interest in engineering. Engineering practices can aid in solving community-based problems and engage the interest of students who may not see the relevance of engineering in their lives.	• Biography-Driven Phenomenon – This short video [1:18] describes asset-based ways to mine for student culture, identity, and knowledge facets to avoid assuming cultural relevance. [https://www.youtube.com/watch?v=NuCe47fbnTQ] • Exploratorium Snacks – This bank of sound-related links is a tool you can use once you know what your students might find interesting or compelling. The activities situate learning within real-world phenomena. The link opens to the Sound search. There are several activities to help students link the science of sound to engineering with sound that are relevant depending on your students. [https://www.exploratorium.edu/search?live_explo_search%5Bquery%5D=sound%20]

Instructional Strategies and Resources for Performance Category 3: Design the Best Solution to a Problem Involving Properties of Sound Waves and Materials *Task 3, Prompt 3, Part A (2 points); Task 3, Prompt 3 Part B (3 points); Task 3, Prompt 3, Part C (3 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
		• STEM Teaching Tool – Practice Brief 7 – This brief explores how promoting a broad view of "engineering" in the classroom can be a powerful entry point into science learning. Many youths have extensive experience observing or engaging in design projects that develop solutions to everyday problems or interests that matter to them. The design knowledge and identities of youth can be leveraged in instruction to help other students. [https://stemteachingtools.org/brief/7] • STEM Teaching Tools – Practice Brief 2 – This brief explains why students should investigate contemporary science, not just "settled" science. Students can use contemporary science issues to address their community interests or needs, making science more engaging and meaningful than "confirmatory lab" instruction. [https://stemteachingtools.org/brief/2]
	Constructing Explanations and Designing Solutions through Discourse and Modeling Provide varied opportunities (stations, small groups, partners, whole class) for students to engage in an interactive discourse where they build on each other's ideas the identification of constraints and criteria, the selection of design characteristics, and refinement of design ideas to see which ones best meet the criteria and constraints of the problem. Opportunities for	• Argumentation Tool Kit – This resource provides teachers with a tool kit to help them understand and teach scientific argumentation. Relative to engineering, these strategies can be used when evaluating criteria and constraints and/or results of prototype tests. There are links to support students' critical thinking, productive argumentative talk, and ability to argue evidence, as well as to provide a platform that gets students actively involved in a way that promotes respect and safety. [https://argumentationtoolkit.lawrencehallofscience.org/]

Instructional Strategies and Resources for Performance Category 3:
Design the Best Solution to a Problem Involving Properties of Sound Waves and Materials

Task 3, Prompt 3, Part A (2 points); Task 3, Prompt 3 Part B (3 points); Task 3, Prompt 3, Part C (3 points)

Instructional Strategies and Resources

	Teaching Strategies	***Resources***
	scientific discourse should be situated in authentic, interest-driven science investigations.	
	Culturally Responsive Design Solutions Foster asking questions and solving meaningful problems through engineering in local, culturally responsive contexts, drawing from and respecting students' cultural resources, backgrounds, and personal experiences. Provide a range of ways for students to engage in cooperative learning (e.g., think-pair-share, jigsaw, round robin) with diverse groupings of students. Utilize interesting phenomena and relevant contexts to build conceptual understanding applicable to design challenges.	• Stem Teaching Tool – Practice Brief 31 – This article explores the strategy of self-documentation to invite aspects of students' cultural lives and communities to select phenomena and design learning opportunities that are engaging and inclusive of all students. [https://stemteachingtools.org/assets/landscapes/STEM-Teaching-Tool-31-Building-on-Student-Interest.pdf] • The JuST Framework: An Interview With Dr. April Luehmann – This video [6:29] describes the JuST framework as an outgrowth from Ambitious Science Teaching (AST) — expanding each core practice to support meaningful, culturally sustaining work and social transformation. [https://ambitiousscienceteaching.org/the-just-framework-an-interview-with-dr-april-luehmann/]
	Foster Collaboration and Community Construct communities of learners engaged in common interests or activities. In the 21st century, all learners must be able to communicate and collaborate effectively within a community of learners. An essential part of engineering design is the ability to work with a team. Options should be provided on how learners build and utilize these important skills.	• 10 Teambuilding Games That Promote Collaborative and Critical Thinking – This article provides team-building games that can promote cooperation and communication, help establish a positive classroom environment, and hone students' skills to get along with their peers and work well with others. This is not something that can be cultivated through rote memorization or with strategically placed posters.

Instructional Strategies and Resources for Performance Category 3: Design the Best Solution to a Problem Involving Properties of Sound Waves and Materials *Task 3, Prompt 3, Part A (2 points); Task 3, Prompt 3 Part B (3 points); Task 3, Prompt 3, Part C (3 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
		[https://www.teachthought.com/pedagogy/team-building-games/] • How Can Teachers Guide Classroom Conversations to Support Students' Science Learning? – This article highlights the importance of helping students unfamiliar with how to talk to peers to make sense of phenomena and, in this case, to communicate with peers during the design process. It includes links to a range of different classroom resources. [https://stemteachingtools.org/news/2017/new-tool-how-can-teachers-guide-classroom-conversations-to-support-students-science-learning] • Building a Culture of Classroom Collaboration – This article from the *National Education Association* provides rationale and strategies for developing collaboration in the classroom. [https://www.nea.org/nea-today/all-news-articles/building-culture-classroom-collaboration]
	Presenting Information in Different Modalities Provide information using a variety of multimedia (e.g., videos, interactives, simulations), informational texts, and formats to teach and reinforce disciplinary core ideas related to sound waves and materials.	• Flexi AI Tutor – This site presents information through different modalities. Search sound waves for a multitude of informational formats. Take advantage of the AI tutor! [https://www.ck12.org/student/] • Sound Wave Interactive Lesson – This interactive lesson from PBS can help build background and reinforce disciplinary core ideas about sound waves, which can be applied to engineering design solutions related to waves and wave properties.

Instructional Strategies and Resources for Performance Category 3:
Design the Best Solution to a Problem Involving Properties of Sound Waves and Materials

Task 3, Prompt 3, Part A (2 points); Task 3, Prompt 3 Part B (3 points); Task 3, Prompt 3, Part C (3 points)

Instructional Strategies and Resources

	Teaching Strategies	***Resources***
		[https://nebraskapublicmedia.pbslearningmedia.org/resource/ilunctv18-sci-ilsoundwaves/sound-waves/] • Designing Scientific Investigations – This interactive quizlet reinforces the SEP of Designing Investigations. While the focus is on scientific investigations, students could be asked to relate this to engineering design tests. [https://quizlet.com/229604812/designing-scientific-investigations-flash-cards/]
	Vocabulary Provide varied opportunities for students to learn and apply vocabulary in diverse situations and contexts. Vocabulary retention improves when academic terminology is layered on conceptual understanding. To maximize vocabulary building, support students in conceptual understanding and apply the academic terminology using the strategies outlined below. • Build understanding of domain-specific vocabulary using a multi-sensory approach or having students participate in simulations. • Make connections between vocabulary and real-life or future opportunities. • Explain, describe, give real-world examples, or provide concrete representations of vocabulary words rather than formal definitions.	• STEM Teaching Tools – Practice Brief 66 – This article relates to supporting emerging multilingual learners as they develop language that interprets and explains phenomena and design challenges. [https://stemteachingtools.org/brief/66] • Three Strategies for Teaching Academic Vocabulary – This article provides strategies for teaching academic vocabulary. Engineering design includes many two and 3-tier domain, or content-specific, vocabulary. [https://www.middleweb.com/42075/3-strategies-for-teaching-academic-vocabulary/] • Free Science Flashcards about Sound – This interactive site allows students to build domain-specific vocabulary using a multi-sensory approach. While it is not encouraged for students to memorize vocabulary terms, this would be good reinforcement for students who are struggling with language.

Instructional Strategies and Resources for Performance Category 3: Design the Best Solution to a Problem Involving Properties of Sound Waves and Materials *Task 3, Prompt 3, Part A (2 points); Task 3, Prompt 3 Part B (3 points); Task 3, Prompt 3, Part C (3 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
		[https://www.studystack.com/flashcard-3215523]
	Guide Information Processing and Visualization Provide graduated scaffolds that support information processing strategies for designing solutions to problems involving properties of sound waves and materials. Give explicit prompts for each step in the design process.	• Engineering Design Talk Moves – This document from *Science For All* includes cognitive and metacognitive questions to support students with design thinking. Regarding engineering design, teachers need different questions and talk moves to guide students as they process information and collaborate to solve problems. [https://teachscience4all.org/2014/11/05/engineering-design-talk-moves/] • What is Design Thinking? – This blog from *Edutopia* provides a model for approaching design thinking. Each step of the 4C model is explicitly described for teachers. [https://www.edutopia.org/what-is-design-thinking-for-educators#:~:text=Design%20Thinking%20is%20an%20approach,classroom%2C%20school%2C%20and%20community]
	Maximize Transfer and Generalization Provide explicit, supported opportunities to generalize learning to new situations. Using analogies of familiar experiences can help students transfer their learning to new situations. • Offer opportunities over time to revisit key ideas and linkages between ideas.	• Engineering For Good – Identifying Criteria and Constraints – This mini-lesson provides practice as students generalize their learning to new situations. The design problem relates to bringing fish up from the deep, but students can connect the concepts of criteria and constraints to their sound design problem. [https://rmpbs.pbslearningmedia.org/resource/criteria-constraints/identify-criteria-and-constraints-engineering-for-good/]

Instructional Strategies and Resources for Performance Category 3: Design the Best Solution to a Problem Involving Properties of Sound Waves and Materials *Task 3, Prompt 3, Part A (2 points); Task 3, Prompt 3 Part B (3 points); Task 3, Prompt 3, Part C (3 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
		• The Engineering Design Process: Taco Party – This video [3:37] from *KQED Quest* uses the analogy of making tacos to help students see how engineers set out to solve real-world problems. [https://www.youtube.com/watch?v=MAhpfFt_mWM&list=RDCMUCNVJhdLLn3zkudE5VbAf-wg&index=10] • What is Sound? The Fundamental Science Behind Sound – This video [9:40] by *Branch Education* provides students with an engaging way to revisit key ideas and linkages about sound properties. [https://www.youtube.com/watch?v=24yESm63tSY]